The Demand for Hired Labor in Rural Madagascar

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Abstract: This paper estimates structural labor demand equations separately for farm and non-farm enterprises in rural Madagascar. We adapt recent labor supply estimation methods that address the general unobservability of both wage rates – due to widespread self-employment – and employers' non-wage costs of hiring workers in order to fill a significant void in the existing literature. Labor demand in rural Madagascar appears strongly increasing in enterprise owners' educational attainment, in enterprises' capital stock, and in community-level public goods. Furthermore, labor demand appears wage inelastic, especially in the non-farm sector where government labor market policies, such as minimum wage laws, are more commonly enforced.

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1. Introduction

Improvement in living standards in low-income countries invariably depends on increasing labor market earnings due to rising wages, increasing labor demand, or both. Social and political stability likewise depend on steady growth in market demand for labor in order to absorb a growing working-age population into remunerative jobs. Thus understanding the determinants of wages and labor demand are of first-order policy importance, perhaps especially in rural areas where a large majority of the poor live, where population growth rates are highest, and where a transition out of agriculture and into non-farm employment is inevitable and desirable in the course of economic development (Timmer 1988).

A vast literature exists on wage determinants in developing countries – Behrman (1999) provides an excellent review – and there is likewise a significant literature on labor supply behavior in developing countries (Jacoby 1993, Newman and Gertler 1994, Skoufias 1994, Behrman 1999, Barrett et al. 2008, Laszlo 2008). By contrast, patterns of labor demand remain markedly understudied in developing countries (Hammermesh 1993), especially in rural areas and above all in the rural non-farm economy. There is scant empirical evidence as to what factors expand employment, both at the extensive margin (i.e., creating new jobs) and at the intensive margin (i.e., increasing hours worked for potentially underemployed workers), nor of how rural labor demand responds to exogenous changes in wage rates. This gap is problematic. Poverty reduction strategies typically aim to stimulate rural labor demand because the poorest members of any society generally own little other than their own labor power and thus enjoy the fruits of economic growth only to the extent that it increases their wages, employment, or both. The welfare effects of wage-based policies – such as minimum wage laws, the contractual terms underpinning employment guarantee schemes and food-for-work programs – turn fundamentally on how labor demand responds to policy-induced changes in wage rates.

The empirical study of labor demand in rural areas of developing countries is substantially complicated by at least three different factors. First, most labor is demanded by small farms and non-farm enterprises (NFEs) that employ mainly household members who are not paid a wage but, rather, have some residual claim on the profits of the enterprise. Put differently, most labor transactions occur outside the market; therefore, researchers observe no wage payments. Lacking observations of the factor price of labor, the wage rate, it becomes difficult to estimate labor demand patterns – especially the wage elasticity of labor demand – without making heroic assumptions (e.g., that those not working for wages would be paid the same as observationally-similar individuals who do).

Second, even when wages are observed, they typically represent only a portion of the costs of employing workers. Search, supervision and other transactions costs, along with the risk premia associated with employing workers, are not only considerable, they also typically vary markedly among different farm and non-farm enterprises, creating major unobserved heterogeneity problems in labor demand estimation.[4] One needs to control for systematic variation in the true shadow cost of labor to production units in order to estimate labor demand consistently.

Third, while unskilled labor typically flows between the farm and non-farm sectors relatively easily, labor market regulations related to minimum wage, employment security, etc. commonly apply differentially – mainly in the non-farm sector – and thus may cause structural differences in labor demand patterns between the two sectors. Studies of just one or the other

[4] These costs are a major reason for the well-known imperfect substitutability between hired and family labor (Hamermesh 1993).

sector may therefore provide only partial, and potentially misleading, information on broader rural labor market patterns.

This study aims to help fill the void in empirical labor demand studies in low-income rural areas by estimating structural labor demand equations separately for farm and non-farm enterprises in rural Madagascar. The analysis uses data from a 2001 nationwide household survey that includes quite detailed data on labor use patterns in both farm and non-farm enterprises, enabling us to estimate and compare labor demand patterns in both sectors. In order to address the econometric challenges just enumerated, we take the labor supply estimation methods developed by Jacoby (1993) and extended by Barrett et al. (2008) and adapt them to the estimation of labor demand in low-income rural communities. This approach and these data allow us to generate statistically consistent estimates of labor demand parameters for both the farm and non-farm sectors of a low-income rural economy. This has not been done before, to the best of our knowledge. Our findings reveal several empirical characteristics of rural labor demand that matter to the design of development policy in Madagascar and potentially in other low-income, heavily rural economies.

2. Background and Data Description

Since the mid-1980s, Madagascar has pursued a series of market-oriented economic reforms aimed promoting and facilitating investment by private entrepreneurs with the intent of stimulating economic growth and labor demand, especially in rural areas of this predominantly rural country. More than 80% of rural Malagasy are active in agriculture. But the country's agriculture is overwhelmingly small-scale, with few opportunities for skilled, high-productivity employment. While the demand for labor in urban areas experienced some increase, due especially to the emergence of an Export Processing Zone (EPZ) and the development of communication and tourism sectors, private investment and employment growth in rural areas has remained low, especially among non-farm enterprises (NFE). Less than 21% of Malagasy households today operate at least one NFE activity, and only 11% of rural adults are employed as non-family hired workers in NFEs (Stifel et al, 2007). Because NFEs are an important route to escape from rural poverty (Barrett et al. 2001, Van de Walle and Cratty 2004), stimulating growth in rural labor demand, perhaps especially in the NFE sector, is a high policy priority in Madagascar, as in many other low-income countries.

2.1. Data Description

The analysis we undertake uses data from the 2001 nationally-representative, cross-sectional household survey, the *Enquête Permanent auprès des Ménages* (EPM). The EPM followed a stratified two-stage design with six main strata comprised of each of the nation's six provinces, which were further stratified into urban and rural areas. The urban areas include both large cities (*Grand Centre Urbain*) and smaller towns and secondary cities (*Centre Urbain Secondaire*, CUS). The current analysis combines data from strictly rural zones with the CUS, which are typically closely linked to, and surrounded by, rural areas from which they draw non-migrant labor. In the first stage, *Zones de Dénombrement* (ZD) were randomly selected with probability proportional to population size in each province. The second stage involved the selection of a random sample of households within the selected ZDs. Overall, 5,080 households were interviewed in the EPM. We exploit only the data from the 3,302 households residing in rural areas and CUS.

In this analysis, non-farm enterprises are defined as activities other than primary agricultural production, managed by individual members of a rural household. We categorize these enterprises into four groups: agricultural processing, manufacturing, trade, and services. Among the 3,302 households of the total EPM household sample, we identified 860 individual NFEs belonging to 758 different households. Meanwhile, 76% of households are involved in agricultural production, with or without other non-farm activities.[5] These households cultivate approximately 8,000 distinct agricultural plots. More than 86% of the workers are self-employed, mostly in agriculture. This raises the methodological challenge of estimating the (unobserved) shadow wage rate that guides labor allocation behavior. Labor inputs are mostly provided by the family, with only 21% of farms employing hired workers. NFEs are slightly more likely to employ hired labor; 25% of households operating a NFE hired workers. Labor inputs are measured in days spent in farm production, and in months employed for NFEs, where casual day employment is uncommon. Equipment value is measured as the current (depreciated) value of the equipment owned by the farms/NFE and used for production during the last 12 months. The recall period reported by household heads covers the last 12 months of activity of the NFE. For farm production, the data collected cover the most recent agricultural seasons (both the main rainy season and the most recent dry season), which vary across the island.

We supplement the household-level and community survey module information from the EPM with community-level characteristics collected by the *Ilo*/Cornell commune census that ran virtually simultaneously with the EPM in 2001 (Minten et al, 2003). Together, these sources generate a rich set of community-level information. Because they are likely to influence the true economic cost of labor and substitute inputs, we look in particular at the level of physical

[5] Among the 3,302 households, 14.6% are engaged in neither farm nor non-farm activities. Sources of income for these households derive from employment as civil servants, NGO employees, religious institutions employees, and the landless working as hired labor on farms or NFEs. 12.0% of the sample is made up of households engaged in both NFE and farm activities. 64.1% are strictly farmers and 9.8% strictly NFE owners.

insecurity, access to financial services, access to broadcast media (radio or television), and transportation costs.

Basic public goods are widely unavailable in rural Madagascar. In the course of the commune census, village-specific focus groups categorized their location as secure or insecure based on the subjective probability of cattle theft and violence. We use this delimitation to identify the secure and the unsecure villages and from this classification. In these data, 29% of the NFEs and 20% of the agricultural plots fall within the insecure zones (Tables 1 and 2). Access to financial services is measured by the existence within the commune of a bank or a micro-finance institution office. In our sample, only 11% of NFEs and 8% of agricultural plots are located in a village with access to financial services. Financial services access is significantly greater for export crops (15% of plots) than for other crops (Table 2). Access to broadcast media – radio or television – facilitates the acquisition of information important to productivity growth, market expansion and other factors that influence labor demand and the non-wage costs of hiring workers. Within this sample, 57% of the NFEs and 43% of farm plots have access to broadcast media.

We measure transportation costs as the expense involved in moving a 50 kg bag of rice to the nearest main urban center during the dry season. This reflects costs faced by entrepreneurs for both input supply (most modern inputs, such as machinery, fertilizer or chemicals, are imported through urban centers) and output evacuation. The average transportation cost is MGF 10,600 for agricultural production units, MGF 10,194 for NFEs, underscoring that the NFEs in the sample really are from rural areas and associated small towns. But there is marked variation within the NFE sector, with services located much closer to major cities (service sector NFE transport costs averaged only MGF 5,785) while agribusiness and manufacturing NFEs faced average transport costs of over MGF 12,000 (Table 1 and Table 2).

2.2. The NFE Sector in Rural Madagascar

The main characteristics of NFE in rural Madagascar are summarized in Table 1.[6] NFEs are small, with average annual gross revenue of only MGF 8.1 million – approximately $1,360[7] – and average net earnings (gross revenue less hired worker payment and owner auto-consumption) of just MGF 6.9 million – roughly $1,144/year. Rural NFEs largely operate informally. Only 15% were formally registered with government, only 4% in the agribusiness and manufacturing sectors but 26-27% in the trade and services sectors. Most NFEs operate year-round, but roughly one-quarter operated for less than six months in the previous year and the average number of months of operation was only 9.3 for all NFEs. The average NFE has been in operation for 6.5 years, but with large variability. Half had operated for less than three years and only 23% had operated more than ten years. The percent of NFEs with more than 10 years of experience is even lower for the trade and service sectors – 16% and 12%, respectively.

We categorize NFEs into four main groups: agribusiness is by far the largest at 40.5% of all NFEs, followed by trade (37.2%), manufacturing (11.6%) and services (10.7%). The trade and services sectors have larger firms in terms of gross revenue, earning 3-4 times the average for agribusiness or manufacturing.[8]

Almost 80% of all NFE workers come from the family and are not paid an explicit wage, on average 13.4 of the 17.1 total person months employed by the NFE in the past year. Hired

[6] Observations are weighted by sample selection probabilities which were computed by INSTAT and based on the latest population census (1993).
[7] Average exchange rate US$ 1 = MGF 6,000.
[8] Gross revenue is calculated as Sales + Home consumption of produced good – Salaries and wages paid – Intermediate goods purchased.

workers are least common in the trade sector, and most common in services. NFE workers are paid on average MGF 63,230 per month, with manufacturing sector workers earning 50% more than those in the agribusiness sector. Overall, significantly fewer children (ages 6-14) worked in households operating NFEs than in households engaged in agricultural production, although families with manufacturing enterprises were significantly more likely to have working children than in any other NFE sector or in agriculture.

Nearly 80% of NFEs are male-run. Those NFEs managed by women are significantly smaller scale, more informal, possess less equipment and use less hired labor, on average, than do male-run NFEs (Table 3). The marital status of female NFE proprietors is also markedly different than that of their male counterparts. While only 5% of the men are unmarried, the corresponding percentage for women is 86%.

While 72% of EPM respondents did not complete primary school, the share of NFE owners with similarly low educational attainment was significantly less, at just 60.8% (Table 4). Proprietors with more education tend to operate NFEs with greater gross annual revenues. NFEs run by owners who have completed at least secondary school have significantly greater equipment investments in their NFEs and are more likely to hire labor. More than one-third of their total labor use is hired from outside the family. NFEs run by more educated proprietors are also far more likely to be formally registered with government and therefore more likely subject to any labor laws or regulations that might be enforced.

2.3. Farm Production in Rural Madagascar

Table 2 summarizes the main characteristics of on-farm production in this sample. We categorize them by four crop types: rice production (41.3% of the plots), non-rice food crops (36.7%) which is mainly cassava and maize, cash crops (15.3%) such as beans, groundnuts, potatoes and vegetables that are grown mainly for sale within the domestic economy, and export crops (7.6%) such as vanilla, cloves, coffee and cocoa, which are grown mainly in coastal areas. The average farm spans 1.65 hectares and consists of 4.1 distinct cultivated plots. 90% of the plots are owned[9] by the cultivating farmer. The average revenue per hectare was only MGF 3.93 million, with high variability across commodities, ranging from MGF 3.15 million to MGF 12.35 million for non-rice food crops and export crops, respectively.

Rice, the staple crop throughout Madagascar, uses significantly greater labor, both family and hired, than any other crop, with an average of 111 days per hectare compared to 59 days per hectare for export crops, the next most labor intensive. Daily wages on farms are quite similar across crops, as one would expect, with an average of MGF 5,515 per day. On-farm production is also characterized by numerous technical constraints ranging from eroded or sandy plots (29% of the plots) to climatic shocks that include either flooding or drought (44% of the plots).

Unlike in the NFE sector, there is no significant difference between male and female managed plots. In this sample, 15.2% of plots are operated by women, who in most cases are also the head of the household (Table 3). Where male proprietors hire appreciably more labor in NFEs, female plot managers hire slightly more labor than males do (5.37 days vs. 4.48 days per plot), although the difference is not statistically significant.

Agricultural enterprises are more likely to be managed by individuals who have not completed primary school (79%) compared to the share of the rural adult population with similar schooling levels (70%) (Table 4). Although there is no significant difference in farm revenue, plot size, land holdings or family labor use between more highly educated plot managers – those with at least secondary education – and the rest, they do possess and use more equipment and

[9] Land ownership is characterized by the existence of legal (formal title) or traditional agreement among households.

they hire roughly twice as much labor from outside the family. Thus, at a very casual level, proprietor education appears strongly, positively related to hired labor demand in both the rural farm and non-farm economy.

3. Empirical Strategy

The theoretical foundation for modeling demand for hired labor in rural areas is based on a household enterprise model in which the household maximizes utility subject to a budget constraint. In addition to hiring labor for on- and/or off-farm production, these households choose the consumption of market and home-produced goods as well as the allocation of time among household members (among own farm work, market wage work, home production, and leisure).

Three issues arise when estimating hired labor demand in this context. First, the market wage may not represent the true cost of hiring labor if there are search, supervision, risk or other employment costs. In other words, the market wage may deviate from the marginal revenue product of hired labor (MRP_L) in ways that reflect either allocative inefficiency or optimal resource allocation (Barrett, et al., 2008). This violation of the textbook equilibrium condition $MRP_L = w$ might be termed "naïve allocative inefficiency", with the "naïve" modifier indicating that this reflects inefficiency only relative to a naïve model that includes no uncertainty, no transactions costs, etc. and does not necessarily imply managerial error.

Second, in the presence of labor supervision problems (i.e., family and hired labor are not perfectly substitutable[10]), the household's hiring decisions are not separable from their consumption and time allocation decisions (Singh et al. 1986, Hammermesh, 1993). As such,

[10] See Deolalikar and Vijverberg (1987) for evidence of heterogeneity of family and hired labor.

household enterprise labor demand decisions generally cannot be treated as profit-maximizing firm decisions made independently of – and logically prior to – other household decisions. This implies a need to control for household attributes, such as demographic composition and proprietor educational attainment, as well as more traditional firm characteristics in estimating enterprise labor demand.

Third, most households do not hire labor for their farm or non-farm enterprises. Only 21 (25) percent of rural farming households (NFEs) in Madagascar hired non-family labor in 2001. Aside from the obvious issue of censored observations for households that rely solely on family labor, the additional, serious complication is that the shadow wages for hired workers are not observed for the majority of households that do not hire labor.

To address these three issues, we adapt the method of labor supply estimation for rural households developed by Jacoby (1993) and extended by Barrett et al. (2008) to accommodate the above problems of nonseparability, censoring, unobserved wages and naïve allocative inefficiency. The same basic techniques can be applied to labor demand estimation. The core model of interest is the demand for hired labor. Given that some households do not hire labor, we ultimately wish to estimate a censored regression (Tobit) model of the following form:

$$d_i^* = \varphi_0 + \varphi_1 w_i + \varphi_2 C_i + \nu_i$$

$$d_i = \begin{cases} d_i^* & if \quad d_i^* > 0 \\ 0 & if \quad d_i^* \le 0 \end{cases}, \tag{1}$$

where d_i^* is the unobserved latent demand for hired labor, measured as log of months for NFEs and log of days for farming, and d_i is the observed demand; w_i is the wage rate reflecting the price of hired labor; C_i is a vector of the characteristics of the enterprises, the owners and the community; and ν_i is an error term assumed to be i.i.d. normal.

The key estimation issue is identifying the appropriate wage rate, especially for non-hiring household enterprises for which w_i is not observed. The use of village level average wage misses the oftentimes-considerable non-wage costs of hiring workers and the considerable heterogeneity in such costs among enterprises. The alternative approach of using wage rates imputed directly from observations of labor hiring relies on untenably strong separability assumptions and likewise ignores unobserved heterogeneity problems.

Jacoby's (1993) estimated structural models of labor supply based on a nonseparable household model that permits estimation of the marginal revenue product of labor, which he uses as the shadow wage rate in labor supply estimation under the maintained naïve allocative efficiency hypothesis that $M\hat{R}P_L = w$. Barrett et al.'s (2008) extension to the Jacoby model relaxes the assumption of naïve allocative efficiency, allowing for systematic cross-sectional (or inter-temporal) variation in the costs of labor market participation. We adapt the Jacoby-Barrett et al. approach to address the unobserved wage rate problem on the demand side of the labor market without having to resort to strong and untenable assumptions of separability and naïve allocative efficiency.

Briefly, the multi-step estimation strategy is as follows. (1) We estimate production (revenue) functions for farm and non-farm enterprises to estimate the enterprise-specific marginal revenue product of labor, $M\hat{R}P_L$. (2) Among the subsample of enterprises that hire labor, we compute enterprise-specific naïve allocative inefficiency (*AI*) – defined as $AI \equiv \ln(w/M\hat{R}P_L)$ – and regress *AI* on a set of enterprise and owner characteristics that do not appear in the first-stage production function. This enables us to explain systematic patterns of deviation of the marginal product of labor from wage costs, enabling us to control directly for patterns of naïve allocative inefficiency. (3) We impute shadow wages (w^*) for the sample of enterprises that do not hire labor using the first-stage $M\hat{R}P_L$ results along with the second-stage $\widehat{AI}$ results – that is $w^* = \exp^{\widehat{AI}} \cdot M\hat{R}P_L$. (4) Finally, we estimate household enterprise-level models of demand for hired labor using the log of imputed shadow wages as an explanatory variable. In what follows, we map out the details for each step.

Step 1: *Estimating* MRP_L

In the first step, we estimate separate farm and non-farm enterprise stochastic total revenue frontiers using the entire sample. The dependent variable used here is total annual revenue, defined as total earnings for NFEs and as total agricultural revenue per plot for on-farm production. Using revenue instead of physical production units permits aggregation among goods and services for NFEs and among crops for farming, reflecting the multi-output nature of most of the enterprises in rural Madagascar.

We adopt the primal approach and thus use as covariates the quantities of the main inputs: family and hired labor and equipment, with additional inputs such as land and chemical fertilizers for on-farm production. The alternative, dual approach derived from a profit function would require not only output prices based on *ex ante* expectations (Mundlak, 1996) – which are complicated considerably by the heterogeneity of output in these data[11] – it would also require input price data. Since the unobserved nature of wages is precisely the problem we must overcome, this approach is infeasible. Thus the primal production frontier approach is the only feasible one, in spite of its obvious drawbacks, given likely endogeneity of input application rates and the lack of good instruments to fully obviate this problem.

[11] NFEs in our sample produce bread, charcoal, oil, tables, etc. Prices for such products vary markedly by quality and are generally unobserved in the survey data. Similarly, many plots are intercropped with multiple commodities.

We estimate a stochastic revenue frontier (Aigner, Lovell, and Schmidt, 1977) with a non-negative technical inefficiency parameter, which we assume is distributed half-normal.[12] Given the existence of many zero values for input quantities (e.g., hired labor) we use a Generalized Leontief functional form:

$$TR^{1/2} = \alpha_0 + \sum_{i-1}^{m} \alpha_i x_i^{1/2} + \frac{1}{2}\sum_{i-1}^{m}\sum_{j=1}^{m} \alpha_{ij} x_i^{1/2} x_j^{1/2} + \beta Z - \mu + \varepsilon\,, \qquad (2)$$

where TR is total enterprise revenue for the enterprise or plot, x_i is the quantity used of each of the m inputs;[13] Z is a vector of enterprise, household, and community characteristics that directly affect production; μ is the non-negative, systematic deviation from the frontier that accounts for enterprise technical inefficiency; and ε is an i.i.d. symmetric error term. In order to preserve degrees of freedom, we allow for separability between the vector of inputs (***x***) and other controls (Z).[14] Dummy variables obviously appear only in first-order terms since second-order terms would be perfectly collinear.

Letting the subscript L denote hired labor, the MRP_L for each NFE or plot can be estimated by evaluating the partial derivative of equation (2) with respect to hired labor (x_h) for each observation using the estimated parameters:

$$M\hat{R}P_L = \frac{\partial \hat{T}R}{\partial x_L} = \frac{TR}{x_L}\left[\hat{\alpha}_L + \sum_{j=1} \hat{\alpha}_{Lj} x_L^{1/2} x_j^{1/2}\right] \qquad (3)$$

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[12] We also experimented with other distributional assumptions about the μ parameter (e.g., truncated normal), but found the half-normal fit the data best, generated the most sensible results, and converged reliably on a set of robust parameter estimates when not all other distributions would.

[13] For NFEs m = 3 (hired and family labor, and equipment), while for farm production m = 5 (hired and family labor, equipment, land and chemical fertilizers). Equipment value enters as a series of quintile dummy variable because while we have confidence in the orderings among enterprises in these values, the problems of accurate capital stock valuation almost surely generate considerable measurement error (the first quintile is left out). Given we use only dummies for equipment, the squared terms are dropped, but the interaction terms remain.

[14] Barrett et al (2008) employ a very similar approach.

Step 2: *Estimating Naïve Allocative Inefficiency*

The second step involves estimating the naïve allocative inefficiency for hired labor for each NFE or plot in the subsample that employs hired labor, and thus for which we observe a cash wage rate. Using the estimated MRP_L from the first stage and the observed wage (w),[15] naïve allocative inefficiency (AI) can be defined as the log deviation of w from $M\hat{R}P_L$:

$$AI = \ln\left(\frac{w}{M\hat{R}P_L}\right). \tag{4}$$

In order to predict systematic deviations of $M\hat{R}P_L$ from the market wage rate across different enterprises, we then regress AI on a set of enterprise and owner characteristics (H) that do not appear in the production frontier (equation (2)):

$$AI = \gamma_0 + \gamma_1 H + \zeta \tag{5}$$

These characteristics include household demographics (e.g., number of working adults by gender and the number of working children), information about the household head (e.g., age, gender, migration status, and year of schooling), and geographical indicators (e.g., dummy variables for province, access to financial institutions and physical insecurity as well as average transport costs). While the results of this regression provide insights into the correlates of AI, they are mainly used here to predict $\widehat{AI}$ for household enterprises that rely solely on household labor. Put differently, we use observed deviations between the marginal revenue product of hired labor and the wage rate paid those workers, explained as a function of enterprise and owner characteristics, to predict the naïve allocative inefficiency of enterprises that do not hire workers.

[15] In those cases where the NFE or plot employs more than one hired worker, we use the average wage paid.

Step 3: *Imputing Shadow Wages (w*)*

In the third estimation stage, we impute shadow wages ($\widehat{w}*$) for households who did not hire labor for their NFEs or farm enterprises. Based on the predicted $M\hat{R}P_L$ from step 1 and the predicted $\widehat{AI}$ from step 2, we impute $\widehat{w}*$ for non-hiring household enterprises as:

$$\widehat{w}* = \exp^{\widehat{AI}} \cdot M\widehat{R}P_L \quad (6)$$

As Jacoby (1993) notes, the shadow wage is as sufficient statistic to address the nonseparability of household production and consumption decisions. And as Barrett et al. (2008) explain, allowing for $\widehat{AI}$ fully generalizes for the likely existence of factors that might drive a wedge between the cash wage and the full economic costs of hired labor.

Step 4: *Estimating Labor Demand*

Finally, we estimate the demand for hired labor as outlined in equation (1) using imputed shadow wages, $\widehat{w}*$, for non-hiring households. In doing so, we estimate the determinants of labor demand in the context of short to medium-term decision for existing enterprises, i.e., taking household composition, equipment, land and livestock holdings as fixed. To address the econometric problems associated with sequential multi-step regressions, we follow Barrett et al. (2008) and bootstrap the standard errors of the Tobit regressions, using 500 replications, to obtain consistent estimates of the coefficients and their standard errors.

Because the Tobit model provides one point estimate for each independent variable coefficient despite there being two distinct types of dependent variables (censored and uncensored – i.e., non-hiring and hiring), we report three distinct marginal effects for these models, following Moffitt and McDonald (1980): (a) changes in the unconditional expected value of the observed dependent variable $\left(\partial E(d_i) / \partial x_i \right)$; (b) changes at the *intensive* margin or changes in the expected value of the observed hiring conditional on labor being hired $\left(\partial E(d_i \mid d_i > 0) \big/ \partial x_i \right)$; and (c) changes at the *extensive* margin or changes in the probability of labor being hired $\left(\partial P(d_i > 0) \big/ \partial x_i \right)$.[16]

4. Results

4.1. Production frontier and MRP_L estimates

In this subsection, we briefly discuss the results of the stochastic revenue frontier estimation. The estimated frontiers explain the observed data well. The NFE revenue frontier adjusted r^2 was 0.41 over 860 NFE observations (Table 5), while the farm production frontier adjusted r^2 was 0.64 over 8,203 plots (Table 6). The estimated coefficients on the main input variables of interest – family and hired labor – are positive and statistically significant.[17] In the discussion that follows, we begin with the objects of interest – the estimated marginal revenue product of labor, MRP_L, for both NFE and farming – having dropped 109 farm plot observations (less than 1.5% of the subsample) for which MRP_L estimates were (implausibly) negative.

Marginal Revenue Product of Labor (MRP_L)

Table 7 presents the estimated revenue elasticities and MRP_L for both NFEs and on-farm production. For NFEs, every 1% increase in the quantity of family labor results in an estimated 1.8% increase in revenues. The elasticity for hired labor is much lower at 0.42. Family labor is an estimated 33% more productive at the margin than hired labor, on average — MGF 287,796

[16] These marginal effects are calculated in Stata using the *dtobit* command. See Cong (2000) for more details.
[17] A joint test was performed for each main variable, testing whether at least one of the coefficient estimates are not equal to zero. For family labor, hired labor and equipment, the test rejected the null hypothesis which is that all the coefficient estimates of each individual term and its interaction with other variables are equal to zero.

(roughly US$48) per month of family labor as compared to MGF 214,996 for hired labor – although the difference is not statistically significant. The magnitude of the estimated MRP_L for hired labor is slightly (but statistically insignificantly) higher than the 2001 official minimum wage of MGF 172,000 per month including taxes, even though it nearly 2.5 times larger than the average salary paid to workers by NFE owners in the sample (MGF 87,055). The higher marginal productivity of family labor in NFEs is consistent with Deolalikar and Vijverberg's (1987) finding that family and hired labor are not perfect substitutes due to supervision costs and differential worker incentives – and thus effort levels – for workers who are residual claimants on enterprise profits, relative to those who are not.

In contrast to the NFE results, the average MRP_L for family labor in farm production is statistically significantly lower than for hired labor: MGF 1,500 versus MGF 8,910 per day, respectively. This is not surprising given the seasonal nature of hired labor in agriculture. Hired labor is typically employed during peak labor demand periods (i.e., in field preparation, planting, transplanting, and harvest), whereas family labor is employed throughout the year, including the slack season. As Nath (1973) points out, estimates of MRP_L on an annual basis generally are higher for hired labor than for family because the latter are used during both the high-productivity busy period and the low-productivity slack period. Furthermore, as Barrett et al. (2008) point out, smallholder households routinely "oversupply" labor on-farm as a means of hedging against price risk and there are likely locational preferences and labor market frictions that cause households to over-self-provision with labor relative to the marginal product of hired labor.

Other Covariates

The remaining covariates in the NFE model are generally as expected (Table 5). Revenue is increasing in equipment value, although this effect is statistically significant only for the 3rd through 5th equipment value quintiles. NFEs in the trade and services sector tend to outperform those in agribusiness, the omitted category, with roughly 7% higher revenues, while revenues in manufacturing average 5% less than those in agribusiness.

Community-level provision of public goods has a positive effect on NFE revenues. NFEs in communities with access to broadcast media or financial services enjoy NFE revenues that are roughly 6% greater, on average, than in communities without such access. Our measure of security risk has no statistically significant effect on NFE revenues, but higher transport costs are negatively associated with total revenue, ceteris paribus.

Turning to plot-level agricultural production,[18] the estimated coefficients on the key non-labor inputs – area and equipment – have statistically significant positive signs. Chemical fertilizers and pesticides,[19] which are used on only a small minority of observed plots, had no statistically significant effect on revenue. Although revenues are higher for export crops than rice, ceteris paribus, they are lower on average for non-rice food crops.[20] Secure land tenure[21] is associated with slightly higher agricultural revenue. Community-level public goods have a significant effect on agricultural revenues. Access to broadcast media is positively associated with agricultural revenue, while access to finance has a surprisingly negative effect. Higher transportation costs have a surprisingly mixed effect on farm revenue, ceteris paribus.

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[18] We conduct this analysis at plot level because of the importance of controlling for detailed plot characteristics, which undoubtedly affect agricultural productivity (Sherlund et al., 2002).
[19] The chemical variable is a computed by adding expenditures on fertilizer and pesticides used on the plot.
[20] This pattern could follow from farmers producing food crops instead of export crops for food security purposes in the presence of segmented agricultural market. Further, despite controlling for soil quality and climatic conditions, these factors may affect the choice of which crops to grow (e.g. cassava is easier to grow on upland plots than rice).
[21] Defined as land ownership with title or with only customary land rights of ownership.

4.2. Estimating Naïve Allocative Inefficiency (*AI*)

The production frontier estimates allow us to generate observation-specific estimates of $M\hat{R}P_L$, which we can then compare to observed wage rates paid to employees by enterprises that hired workers. That comparison, described above as a test for naïve allocative inefficiency, *AI*, as in equation (4), enables us to recover estimated unobserved costs associated with hiring workers.

First we test for deviations of $M\hat{R}P_L$ from observed wage rates from the same enterprises by running a simple regression of log-wages on log-$M\hat{R}P_L$:

$$\ln(w) = \alpha + \beta \ln\left(M\hat{R}P_L\right) + \varepsilon . \tag{7}$$

Based on the definition of *AI* in equation (4), the null hypothesis of naïve allocative efficiency, $\alpha = 0$ and $\beta = 1$, implies that *AI* is zero. As Table 8 shows, we reject the null hypothesis of naïve allocative efficiency hypothesis overwhelmingly for both NFEs and farm production. This supports the hypothesis that enterprise owners face risks and search or transactions costs in hiring workers. Jacoby (1993), Skoufias (1994) and Barrett et al. (2008) run similar regression for the analysis of labor supply in agricultural sector and reach similar conclusions.

In order to adjust $M\hat{R}P_L$ for those unobserved costs of hiring workers, we regress *AI* on a set of enterprise and owner characteristics as in equation (5), separately for NFEs and farm enterprises. The results appear in Table 9. As in Barrett et al. (2008), we find considerable, systematic variation in the enterprise-specific *AI* values, with an r^2 of 0.68 in the NFE regression and 0.17 in the farm regression. Hence the need to impute $\widehat{AI}$ in estimating shadow wages for households that do not hire non-family labor. For more than 90% of the sample, *AI* was negative, implying (per equation (4)) that enterprises routinely pay wages less than the marginal revenue product of hired labor, suggesting the routine existence of nontrivial non-wage costs of employing workers.

As reported in Table 9, we find that AI is increasing in equipment value and the years of operation for NFEs, but is significantly lower in the trading sector, perhaps reflecting concerns about employee theft reported in trader surveys in Madagascar (Fafchamps and Minten 2001). In farming, *AI* is increasing in land holdings, livestock and the age and educational attainment of the plot manager, and is higher for rice than other crops. Interpretation of these *AI* regressions is not directly of interest. Mainly we need these in order to estimate more accurately the shadow wages faced by household enterprises that might consider hiring workers, per equation (6).

4.3. Shadow Wages and the Estimated Demand for Hired Labor

Estimating shadow wages for enterprises that do not hire workers as in equation (6), using the estimated $M\hat{R}P_L$ and $\widehat{AI}$ from the first and second stage regressions, respectively, we find that average shadow wages are significantly lower for non-hiring than for hiring enterprises by 6% and 12% for farm enterprises and NFEs, respectively (Table 10). Average shadow wages in agricultural production are an estimated MGF 5,692 per day, which corresponds to an average shadow wage of MGF 85,380 per month assuming that temporary workers are employed for 15 days per months, almost exactly equal to average monthly payments to hired non-family labor in NFEs (MGF 86,763 per month).

Table 11 presents the bootstrapped marginal effects and standard errors from the Tobit estimates of demand for hired labor in NFEs and farming, both unconditional and based on a McDonald-Moffitt (1980) decomposition of the extra- and infra-marginal labor demand effects. Controlling for other household and geographic attributes, we find that the demand for labor unambiguously decreases as wages rise, but labor demand is quite wage inelastic.[22] In NFEs, wage growth of 10% results in only an estimate 1.9% decrease in demand for labor. Further, the decomposition results suggest that roughly one-third of this effect is at the extensive margin, with the other two-thirds are at the intensive margin. In other words, in the unlikely event that wages were to double with no change in enterprise, owner and community characteristics, employment rates in NFEs would fall by only about 6%, while the intensity of work for those still employed would fall by less than 15%. The wage inelasticity of labor demand appears similar for farming. Although the elasticities are roughly double those in NFEs, demand for hired labor on the farm remains inelastic (-0.38), also coming mainly from the intensive margin (-0.27), not the extensive margin (-0.13).

This result is important. Concerns about the employment-reducing effects of wage growth appear to be relatively unfounded in these data. Similarly, there is no support in these data for concerns that food-for-work or employment guarantee schemes that use market or even slightly above-market wages for workers will have adverse employment effects through any induced local labor market wage effects.

Turning now to other factors affecting labor demand, we find that enterprise capital, as measured by value of equipment, and hired labor are complements in both NFEs and farming. For example, NFEs with a capital stock in the top two quintiles hire 40-80% more labor than the bottom quintile, ceteris paribus. In farming the effects for the same equipment value quintiles are likewise statistically significant, albeit smaller in magnitude, ranging from 13% to 18%.

For farming, land holdings also appear to complement hired labor. Demand for hired labor is positively associated with total household land holdings, with an elasticity of 0.25. This

[22] Note that since both the labor and shadow wage variables are in logs, the marginal effect is interpreted as an elasticity.

comes largely from the intensive margin, employing casual workers for more days rather than employing hired workers on farms that otherwise use just family labor.

For NFEs, there is a negative association between the number of months per year that the enterprise is active and hired labor. Note that this effect is independent of the number of years the NFE has operated and the number of NFEs owned by the households (neither has a significant effect). This suggests that enterprises that operate seasonally are more likely characterized by peak labor demand periods, while those with activity throughout the year have a more steady demand for labor that can be satisfied by household labor.

Controlling for other determinants, demand for hired labor by NFEs in the trade and services sectors is no different from those in agribusiness. However, manufacturing enterprises hire 40% more labor, on average. With approximately a quarter of this coming from the extensive margin, manufacturing NFEs hire 12% more labor than all other sectors in rural areas. As noted in Table 1, not only do enterprises in this sector hire more labor, but the wages paid are highest on average (MGF 79,281). Rural manufacturing appears a promising area for non-farm employment growth in Madagascar.

Transport costs are a key limiting factor, however. NFEs in communes with higher transport costs employ 28-58% less labor than those in communes in the lowest transport cost quintile. NFEs located in high security risk communes likewise employ fewer workers – 29% less than those in secure communes. The transport cost effects are similar but of considerably smaller magnitude in the farm sector, while insecurity stimulates farm labor demand. Workers in fields serve as protection against theft of livestock and standing crops during the harvest period. Access to broadcast media stimulates labor demand in both the farm and non-farm sectors. Although the impact is largest at the intensive margin, access to radio or television is nonetheless associated with 6% greater employment in both sectors as broadcast media facilitates access to important information about markets, prices, productivity and other factors that influence labor demand and the non-wage costs of hiring workers.

In the farm sector, demand for labor in rice cultivation is significantly and substantially greater than for all other crops whether it be in terms of days of labor demanded among those employed, or in terms of employment. This could partially follow from extension services in Madagascar encouraging labor-oriented technologies for rice production. For example, the System of Rice Intensification (SRI) pioneered in Madagascar is markedly labor intensive during the transplantation and weeding periods (Barrett et al. 2004).

The educational attainment of the enterprise owner strongly affects demand for hired labor in rural Madagascar. In the farming sector, the effect is observed to be monotonically increasing with the level of schooling. For example, compared to owners with little or no primary schooling, those with completed primary education demand 16% more hired labor, those with completed secondary education demand 39% more, and those with post secondary education demand 77% more. Most of this effect is at the intensive margin. In the non-farm sector, the positive effect of education is only observed at the completed secondary level.

To account for family preferences and characteristics and, implicitly, the non-separability assumption, we include household demographics in the hired labor demand models. We find that family structure plays an important role for both farm and non-farm enterprises, justifying the non-separability assumption that motivates the estimation approach followed. For example, in farming, the number of adult men and the number of children in the household have negative and significant effects on the demand for hired labor. This indicates that the availability of family labor reduces the need for additional hired workers on the farm. Interestingly, the number of women in the household does not affect demand for non-family labor. In the non-farm sector, the opposite is the case; the number of adult men and children have no effect on demand for hired labor, the number of women has a positive effect on labor demand. With an elasticity of 0.31, an additional woman in the average household (a 72% increase from 1.38 women; see Table 1) results in a 22% increase in demand for marketed labor.

5. Conclusions and Policy Implications

In this paper, we generated estimates for labor demand by both farm and non-farm enterprises in rural Madagascar, controlling for the unobservability of wages for most (self-employed) workers and for the often-considerable unobserved, non-wage costs of hiring workers. This is a novel and important empirical contribution to the literature on rural development and labor markets in developing countries.

Our findings show that the labor demand in rural Madagascar is strongly increasing in the enterprise owner's educational attainment, especially at the extensive margin, uncovering a heretofore overlooked externality effect of education in rural economies. Labor demand is likewise increasing in the value of equipment owned by the enterprise, indicating complementarities between capital and labor that are often understated. Stimulating capital investment by small business owners and farmers need not imply a move towards labor-saving organization of production; it can actually stimulate employment. Improved physical security, lower transportation costs and greater access to broadcast media also increase labor demand, signaling important labor market multiplier effects from public goods provision in rural areas. Current policy by the Government of the Republic of Madagascar emphasizes these core areas: education, transport, improved security and stimulus to private business investment.

Perhaps most importantly, while the most effective labor market strategies are plainly those that increase worker productivity, wage growth is estimated to have only modest employment reducing effects in rural Madagascar, in either the farm or non-farm sectors. Labor demand is rather wage inelastic, with an estimated elasticity of -0.19 in the NFE sector and -0.38 in agricultural production enterprises, with roughly one-third of the effect coming at the intensive margin of employing non-family labor or not, and two-thirds at the intensive margin, in adjusting hours worked among existing employees. Even in the unlikely event that wages were to double with no change in enterprise equipment stock, public goods availability, proprietor educational attainment, etc., employment rates would fall only 6-13 percent. Concerns about the employment-reducing effects of rural wage growth appear thus relatively unfounded in these data. Finally, there appears a difference in wage responsiveness across sectors – on-farm labor demand is twice as wage-responsive as the more regulated NFE sector, controlling for enterprise attributes, location and other factors – that likely reflects labor market policies that, in practice, apply more in the secondary and tertiary sectors than in primary agricultural production.

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Table 1 – Non-Farm Enterprises by Sector

Means	Agri-business		Manu-facturing		Trade		Services		Total
	(40.4%)		(11.6%)		(37.2%)		(10.7%)		(100.0%)
Revenue									
Net annual earnings (MGF x 1,000)	3,828	a	4,051	b	9,296	c	12,896	d	6,862
Gross annual revenue (MGF x 1,000)	5,234	a	3,529	a	10,597	e	15,762	e	8,161
Earnings per month of labor (MGF x 1,000)	218.6	a	191.7	a	597.8	f	875.8	a	427.1
Earnings/capital	60		693		95,734		65		37,133
Household Demographics									
Number of adult women	1.34		1.40		1.35		1.60		1.38
Number of adult men	1.39	g	1.36		1.25	c	1.51	g	1.35
Number of children	1.11	i	1.43	j	1.00	i	1.14		1.11
Number of working adult women	1.09	i	1.22	c	1.14		1.09		1.12
Number of working adult men	1.31	g	1.22		1.07	c	1.27	g	1.20
Number of working children	0.20	e	0.69	e	0.15	d	0.16	d	0.21
Owner Characteristics									
Age (years)	40.9	f	45.7	j	39.4	d	41.4		40.9
Male (=1, 0 otherwise)	0.79		0.71		0.8		0.87		0.79
Migrant (=1, 0 otherwise)	0.17	b	0.11	a	0.23	i	0.23	j	0.19
Years of Education	4.7	a	4.7	a	6.5	e	8.0	e	5.7
None or some primary educ (=1, 0 otherwise)	0.72	a	0.70	a	0.51	d	0.44	d	0.61
Completed primary educ (=1, 0 otherwise)	0.16	g	0.10	g	0.25	e	0.16	g	0.19
Completed secondary educ (=1, 0 otherwise)	0.09	a	0.08	b	0.18	c	0.23	d	0.14
Post-secondary educ (=1, 0 otherwise)	0.03	e	0.12	d	0.06	e	0.16	j	0.07
Community Characteristics									
Transport costs (MGF per 50 kg sack of rice)	12,092	a	13,262	a	8,445	e	5,785	e	10,194
Access to broadcast media (=1, 0 otherwise)	0.43	a	0.47	a	0.67	e	0.84	e	0.57
Access to finance (=1, 0 otherwise)	0.06	a	0.10		0.14	c	0.16	c	0.11
High security risk commune (=1, 0 otherwise)	0.30	k	0.22	e	0.34	k	0.19	d	0.29
Enterprise Characteristics									
Equipment value (MGF x 1,000)	259	k	359	e	532	k	4,401	d	816
NFE is registered† (=1, 0 otherwise)	0.04		0.04	b	0.27	b	0.26	f	0.15
Number of NFEs owned by the HH	1.32	a	1.26	a	1.27	e	1.36	e	1.31
NFE is the only family act. (=1, 0 otherwise)	0.20	a	0.21	b	0.26	k	0.35	e	0.24
Months of activity in a year	8.62	a	7.85	a	10.12	d	10.67	d	9.31
Years in operation	8.15	a	7.02	a	5.08	d	4.67	d	6.5
Labor									
Use hired labor (=1, 0 otherwise)	0.26	k	0.33	e	0.19	k	0.33	d	0.25
Family labor (person months per year)	13.36		10.35	a	13.80	i	15.02	i	13.35
Hired labor (person months per year)	3.91	k	4.96	j	2.61	k	5.71	k	3.74
Total labor (person months per year)	17.26	b	15.32	b	16.40	b	20.73	e	17.09
Avg. wage paid for hired labor (MGF/month)	52,865		79,281		69,545		63,125		63,230

† A registered enterprise is one that has official identification number from INSTAT. Note: The following indicate statistically significant differences from: (a) Trade & Services; (b) Services only; (c) Agribus only; (d) Agribus & Manuf; (e) All others; (f) Manuf & Trade; (g) Trade only; (h) Agribus. & Services; (i) Manuf only; (j) Agribus & Trade; and (k) Manuf. & Services.

Table 2 – Farming by Crop

Means	Rice		Non-Rice Food		Cash		Export		Total
	(41.3%)		(36.7%)		(15.3%)		(7.6%)		(100.0%)
Revenue									
Crop revenue per hectare of land (MGF x 1,000)	3,192	a	3,157	a	3,526	b	12,355	b	3,930
Crop revenue per month of labor (MGF x 1,000)	33.4	b	58.8	c	53.3	c	320.5	b	67.4
Crop revenue / value of equipment	61.9		62.9		26.5	d	130.1	e	62.4
Household Demographics									
Number of adult women	1.37	f	1.31	g	1.38		1.28		1.34
Number of adult men	1.38	f	1.33	h	1.32	f	1.37	e	1.35
Number of children	1.38		1.38		1.32		1.37		1.37
Number of working adult women	1.23		1.23		1.19		1.24		1.22
Number of working adult men	1.28	d	1.23		1.25		1.17	g	1.25
Number of working children	0.38	f	0.46	g	0.41		0.38		0.41
Owner Characteristics									
Age (years)	42.0		42.1	a	41.8	f	44.4	f	42.2
Male (=1, 0 otherwise)	0.85		0.86		0.87		0.86		0.86
Migrant (=1, 0 otherwise)	0.10	c	0.08	g	0.09	d	0.14	h	0.10
Years of Education	3.5	f	3.1	b	3.6	f	3.6	f	3.4
None or some primary educ (=1, 0 otherwise)	0.78	f	0.81	h	0.77	f	0.81		0.79
Completed primary educ (=1, 0 otherwise)	0.15		0.14		0.15		0.14		0.15
Completed secondary educ (=1, 0 otherwise)	0.06	f	0.04	g	0.05		0.04		0.05
Post-secondary educ (=1, 0 otherwise)	0.02	f	0.01	h	0.02	f	0.01		0.01
Community Characteristics									
Transport costs (MGF per 50 kg sack of rice)	11,900	b	9,300	b	6,900	b	16,400	b	10,600
Access to broadcast media (=1, 0 otherwise)	0.43	b	0.39	b	0.49	i	0.47	i	0.43
Access to finance (=1, 0 otherwise)	0.08	d	0.08	d	0.06	d	0.15	b	0.08
High security risk commune (=1, 0 otherwise)	0.20	a	0.21	a	0.17	b	0.25	b	0.20
Farm/Plot Characteristics									
Equipment value (MGF x 1,000)	162.2	f	142.0	b	220.7	f	196.9	f	163.0
Plot size (hectares)	0.45	b	0.31	b	0.22	b	0.53	b	0.37
Chemical fertilizers & pesticides (MGF x 1,000)	31.60	b	4.50	b	10.40	b	0.40	b	16.30
Family owns the plot	0.88	b	0.93	h	0.91	b	0.94	h	0.9
Total landholdings (hectares)	1.66	d	1.49	a	2.07	j	1.33	b	1.65
Number of TLU[†] owned by household	1.89	b	2.25	b	1.32	i	1.37	i	1.37
Distance plot to village (minutes walk)	21.77	b	20.04	b	15.82	b	32.19	b	21.04
Plot eroded or sandy (=1, 0 otherwise)	0.19	b	0.33	b	0.42	b	0.38	b	0.29
Hillside plot (=1, 0 otherwise)	0.07	b	0.31	b	0.25	b	0.56	b	0.22
Hilltop plot (=1, 0 otherwise)	0.02	b	0.19	g	0.22	c	0.17	h	0.12
Pest attack this crop season (=1, 0 otherwise)	0.49	b	0.35	b	0.30	i	0.28	i	0.39
Weather shock this crop season (=1, 0 othwise)[††]	0.57	b	0.39	b	0.31	b	0.24	b	0.44
Labor									
Use hired labor on plot (=1, 0 otherwise)	0.31	b	0.13	c	0.16	c	0.05	b	0.21
Family labor (person days per year)	42.49	b	17.79	c	16.33	c	29.76	b	28.69
Hired labor (person days per year)	7.59	b	2.73	c	2.52	c	1.39	b	4.60
Total labor (person days per year)	50.08	b	20.52	c	18.85	c	31.15	b	33.29
Avg wage paid for hired labor (MGF/day)	5,509	a	5,447	a	4,966	b	6,969	b	5,515

[†] TLU = tropical livestock unit of 250 kg live weight. The TLU is a common unit in which different kinds of livestock (cattle, small ruminants etc) can be compared. [†] Weather shock is defined as flooding or drought affecting the plots and resulting in reduced productivity.

Note: The following indicate statistically significant differences from: (a) Cash & Export; (b) All others; (c) Rice & Export; (d) Export only; (e) Cash only; (f) Non-Rice Food only; (g) Rice only; (h) Rice and Cash; (i) Rice & Non-Rice Food; and (j) Non-Rice Food & Export.

Table 3 – NFEs and Farming by Gender of Owner

	Female	Male		Total
Non-Farm Enterprises	*20.5*	*79.5*		*100.0*
Revenue				
Deflated annual earnings (MGF x 1,000)	2,985	7,862	**	6,862
Annual turnover (MGF x 1,000)	4,190	9,186	**	8,161
Earnings per month labor (MGF x 1,000)	256.8	471.1		427.1
Earnings/capital	2831.0	43793.8		37137.8
Enterprise Characteristics				
NFE is registered† (=1, 0 otherwise)	0.06	0.17	***	0.15
Months of activity in a year	8.91	9.41		9.31
Equipment value (MGF x 1,000)	222	970		816
Labor				
Family labor (person months per year)	10.75	14.02	**	13.35
Hired labor (person months per year)	2.33	4.10	***	3.74
Total labor (person months per year)	13.08	18.12	***	17.09
Avg wage paid for hired labor (MGF per month)	31,428	71,459	***	63,230
Farming	*15.2*	*84.8*		*100.0*
Revenue				
Crop revenue per hectare of land (MGF x 1,000)	3,508	4,001		3,930
Crop revenue per month of labor (MGF x 1,000)	47.792	70.76		67.449
Crop revenue / value of equipment	186.76	40.47	***	62.43
Farm Characteristics				
Total landholding in hectare	1.36	1.71	***	1.65
Plot size in hectare	0.34	0.37		0.37
Equipment value (MGF x 1,000)	106	173		163
Labor				
Family labor (person days per year)	26.81	29.00		28.69
Hired labor (person days per year)	5.37	4.48		4.60
Total labor (person days per year)	32.18	33.48		33.29
Avg wage paid for hiring farm (MGF per day)	5,468	5,523		5,515

† A registered enterprise is one that has official identification number from INSTAT. *, **, *** indicate significant differences between male and female owners at the 10, 5 and 1% levels, respectively.

Table 4 – NFEs and Farming by Education of Owner

	None or Some Primary	Completed Primary	Completed Secondary	Post Secondary	Total
Non-Farm Enterprises	*60.8*	*18.6*	*13.9*	*6.7*	*100.0*
Revenue					
Deflated annual earnings (MGF x 1,000)	2,777 [a]	10,300 [b]	15,300 [b]	16,800 [b]	6,862
Annual turnover (MGF x 1,000)	4,123 [a]	14,400 [b]	16,200 [b]	11,000 [b]	8,161
Earnings per month labor (MGF x 1,000)	200 [a]	675 [b]	943 [b]	734 [b]	427
Earnings/capital	942 [a]	3,163 [a]	199,646 [a]	38 [a]	37,133
Enterprise Characteristics					
NFE is registered[†] (=1, 0 otherwise)	0.08 [a]	0.16 [a]	0.34 [c]	0.36 [c]	0.15
Months of activity in a year	8.80 [a]	10.02 [b]	10.32 [b]	9.90 [b]	9.31
Equipment value (MGF x 1,000)	210 [a]	579 [a]	2,528 [c]	3,443 [c]	816
Labor					
Family labor (person months per year)	13.32	14.64	11.93	13.04	13.35
Hired labor (person months per year)	2.57 [d]	3.27 [d]	7.99 [c]	6.86 [c]	3.74
Total labor (person months per year)	15.88 [a]	17.91 [b]	19.92 [b]	19.91 [b]	17.09
Avg wage paid for hiring NFE (MGF/month)	23,440 [a]	62,587 [a]	180,847 [a]	332,151 [a]	63,230
Farming	*78.8*	*14.7*	*5.0*	*1.5*	*100.0*
Revenue					
Crop revenue per hectare of land (MGF 1,000)	3,970	4,015	3,277	3,186	3,930
Crop revenue per month of labor (MGF 1,000)	68.10	71.72	56.11	29.09	67.45
Crop revenue / value of equipment	71.59	30.39	21.93	15.64	62.43
Farm Characteristics					
Total landholding in hectare	1.66	1.49 [d]	2.07 [a]	1.33 [e]	1.66
Plot size in hectare	0.37 [f]	0.33 [f]	0.42 [a]	0.33 [f]	0.37
Equipment value (MGF 1,000)	163 [d]	142 [d]	221 [c]	197 [c]	163
Labor					
Family labor (person days per year)	29.32 [g]	26.24 [e]	25.03 [e]	31.85 [g]	28.69
Hired labor (person days per year)	4.31 [d]	4.39 [d]	8.54 [c]	8.82 [c]	4.60
Total labor (person days per year)	33.63	30.63 [h]	33.57	40.67 [i]	33.29
Avg. wage paid for hiring farm (MGF per day)	5,466 [f]	5,348 [f]	6,925 [a]	5,040 [f]	5,515

[†] A registered enterprise is one that has official identification number from INSTAT. Note: The following indicate statistically significant differences from: (a) All others; (b) None/Some only; (c) None/Some & Primary; (d) Secondary & Post Secondary; (e) Primary & Secondary; (f) Secondary only; (g) None/Some & Post Secondary; (h) Post Secondary only; and (i) Primary only.

Table 5 – NFE Production (Revenue) Frontier Estimates

Generalized Leontief

	Coef.	Std. Err.	
Inputs			
Family labor (person months per year)	0.145	0.016	***
Hired labor (person months per year)	0.114	0.015	***
Value of equipment quintile dummies (left out = least)			
Q2	0.084	0.012	
Q3	0.195	0.059	***
Q4	0.223	0.053	***
Most	0.296	0.054	***
Family labor squared	-0.010	0.002	***
Hired labor squared	-0.004	0.002	**
Family labor x Hired labor	-0.010	0.002	***
Family labor x Equip Q2	-0.019	0.050	
Family labor x Equip Q3	-0.092	0.031	***
Family labor x Equip Q4	-0.080	0.027	***
Family labor x Equip Q5	-0.092	0.026	***
Hired labor x Equip Q2	-0.045	0.046	
Hired labor x Equip Q3	-0.090	0.030	***
Hired labor x Equip Q4	-0.086	0.024	***
Hired labor x Equip Q5	-0.066	0.021	***
Community Characteristics			
Transportation cost quintile dummies (left out = least costly)			
Q2	-0.025	0.018	
Q3	-0.013	0.017	
Q4	-0.044	0.024	*
Most costly	-0.038	0.019	*
Access to broadcast media (=1, 0 otherwise)	0.056	0.012	***
Access to finance (=1, 0 otherwise)	0.051	0.015	***
High security risk commune (=1, 0 otherwise)	0.007	0.014	
NFE Characteristics			
Sector dummies (left out = Agribusiness)			
Manufacturing	-0.054	0.019	***
Trade	0.071	0.014	***
Service	0.069	0.020	***
Years in operation	0.001	0.001	
σ_v	0.134	0.008	
σ_u	0.147	0.020	
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.040	0.004	
$\gamma = \sigma_u^2 / \left(\sigma_u^2 + \sigma_v^2\right)$	1.102	0.028	
r^2	0.43		
No. of observations	860		

Note: The constant term and province dummies were included in the estimation but are not shown here. *, **, *** indicate significance at the 10, 5 and 1% levels, respectively.

Table 6 – Farm Production (Revenue) Frontier Estimates

Generalized Leontief

	Coef.	Std. Err.	
Inputs			
Family labor (person days per year)	0.0682	0.0018	***
Hired labor (person days per year)	0.0099	0.0020	***
Value of equipment quintile dummies (left out = least)			
Q2	-0.0058	0.0086	
Q3	0.0376	0.0086	***
Q3	0.0455	0.0091	***
Most	0.0389	0.0089	***
Plot size (*ares*)	0.0304	0.0029	***
Chemical fertilizers & pesticides (MGF x 1,000)	0.0001	0.0000	***
Family labor squared	-0.0013	0.0001	***
Hired labor squared	-0.0001	0.0001	
Plot size squared	-0.0005	0.0003	
Chemical squared	0.0000	0.0000	***
Family labor x Hired labor	-0.0004	0.0001	***
Family labor x Equip Q2	-0.0039	0.0020	**
Family labor x Equip Q3	-0.0041	0.0019	**
Family labor x Equip Q4	-0.0068	0.0018	***
Family labor x Equip Q5	-0.0057	0.0018	***
Family labor x Plot size	-0.0016	0.0002	***
Family labor x Chemical	0.0000	0.0000	
Hired labor x Equip Q2	0.0044	0.0023	*
Hired labor x Equip Q3	-0.0011	0.0022	
Hired labor x Equip Q4	-0.0002	0.0021	
Hired labor x Equip Q5	-0.0003	0.0021	
Hired labor x Plot size	-0.0007	0.0002	***
Hired labor x Chemical	0.0000	0.0000	*
Plot size x Equip Q2	0.0014	0.0037	
Plot size x Equip Q3	-0.0005	0.0033	
Plot size x Equip Q4	-0.0023	0.0033	
Plot size x Equip Q5	0.0052	0.0032	
Plot size x Chemical	0.0000	0.0000	
Chemical x Equip Q2	0.0000	0.0000	
Chemical x Equip Q3	-0.0001	0.0000	
Chemical x Equip Q4	-0.0001	0.0001	*
Chemical x Equip Q5	-0.0001	0.0001	*
Community Characteristics			
Transportation cost quintile dummies (left out = least costly)			
Q2	0.048	0.006	***
Q3	0.021	0.005	***
Q3	-0.020	0.005	***
Most costly	0.007	0.006	
Access to broadcast media (=1, 0 otherwise)	0.011	0.004	***

	Coef.	Std. Err.	
Access to finance (=1, 0 otherwise)	-0.012	0.004	***
High security risk commune (=1, 0 otherwise)	0.008	0.005	*
Farm/Plot Characteristics			
Number of TLU[a] owned by household	0.001	0.001	
Farm production dummies (left out = Rice)			
Non-rice food crops	-0.016	0.004	***
Cash crops	-0.003	0.006	
Export crops	0.061	0.009	***
Plot eroded or sandy (=1, 0 otherwise)	-0.011	0.005	**
Pest attack this crop season (=1, 0 otherwise)	-0.005	0.004	
Weather shock this crop season (=1, 0 otherwise)[b]	-0.011	0.004	***
Family owns the plot	0.010	0.005	*
Hillside plot (=1, 0 otherwise)	-0.003	0.004	
Hilltop plot (=1, 0 otherwise)	-0.009	0.006	
σ_v	0.110	0.003	
σ_u	0.168	0.005	
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.041	0.001	
$\gamma = \sigma_u^2 / \left(\sigma_u^2 + \sigma_v^2\right)$	1.524	0.008	
r^2	0.64		
No. of observations	8,203		

[a] TLU = tropical livestock unit of 250 kg live weight. The TLU is a common unit in which different kinds of livestock (cattle, small ruminants etc) can be compared. [b] Weather shock is defined as flooding or drought affecting the plots and resulting in reduced productivity.

Note: The constant term and province dummies were included in the estimation but are not shown here. *, **, *** indicate significance at the 10, 5 and 1% levels, respectively

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Table 7 – Estimated Revenue Elasticities and Marginal Revenue Product (MRPL)
Generalized Leontief

	Non-Farm Enterprise		*Farming*	
	Mean	Std. Dev.	Mean	Std. Dev.
Elasticities				
Family Labor	1.76	0.57	0.17	0.06
Hired Labor	0.42	0.15	0.15	0.04
Land			1.24	0.24
Chemical Fertilizer & Pesticides			0.00	0.01
Marginal Revenue Product (MRP_L)				
Family labor (MGF per month or day)[a]	287,796	94,140	1,500	517
Hired labor (MGF per month or day)[a]	214,996	79,552	8,910	2,454
Land (MGF per *are*)[b]			8,092	1,554
Chemical Fertilizer & Pesticides (MGF per MGF)			0.055	0.162
No. of observations	860		8,203	

[a] Labor is measured in months for NFEs and in days for farming. [b] The conversion is 100 are per hectare.

Table 8 – Testing for Naïve Allocative Inefficiency in Labor Hiring
OLS Estimates

	Non-Farm Enterprise			*Farm Enterprise*		
	Coef.	Std. Err.		Coef.	Std. Err.	
Log of Wage (β)	0.02	0.0249		-0.10	0.0218	***
Constant term (α)	11.98	0.2754	***	9.82	0.1850	***
R-squared	0.003			0.011		
No. of observations	230			1,753		
H_0: $\beta = 1$	F(1,228) =	1893	***	F(1,1751) =	2526	***
H_0: $\beta = 1$ and $\alpha = 0$	F(2,228) =	1855	***	F(2,1751) =	2496	***

Note: *, **, *** indicate significance at the 10, 5 and 1% levels, respectively.

Table 9 – Estimation of Naïve Allocative Inefficiency in Labor Hiring
OLS Estimates

	Non-Farm Enterprise			*Farm Enterprise*		
	Coef.	Std. Err.		Coef.	Std. Err.	
Household Demographics						
Number of working adult women (log)	-0.247	0.184		-0.032	0.041	
Number of working adult men (log)	0.576	0.211	***	-0.046	0.037	
Number of working children (log)	-0.270	0.277		0.022	0.038	
Owner Characteristics						
Age (log years)	-0.095	0.238		0.121	0.041	***
Male (=1, 0 otherwise)	-0.511	0.218	**	0.007	0.043	
Migrant (=1, 0 otherwise)	0.106	0.200		0.067	0.051	
Education dummies (left out = less than completed primary)						
Completed primary education (=1, 0 otherwise)	0.111	0.191		0.013	0.035	
Completed secondary education (=1, 0 otherwise)	0.240	0.206		0.213	0.050	***
Post-secondary education (=1, 0 otherwise)	0.178	0.259		0.056	0.065	
Enterprise/Farm Characteristics						
Number of NFEs owned by the HH	-0.116	0.134				
NFE is the only family activity (=1, 0 otherwise)	0.032	0.167				
On-farm is the only activity (=1, 0 otherwise)						
Years in operation (log)	0.134	0.077	*			
Value of equipment quintile dummies (left out = least)						
Q2	0.373	0.302		0.006	0.050	
Q3	0.606	0.232	***	0.068	0.044	
Q4	1.053	0.190	***	0.213	0.044	***
Most	0.592	0.201	***	-0.112	0.056	**
Number of TLU[a] owned by household				0.031	0.008	***
Land holdings - total for HH (log hectares)				0.112	0.013	***
Distance plot to village (minutes walk)				0.000	0.001	
Sector dummies (left out = Agribusiness)						
Manufacturing	0.147	0.255				
Trade	-0.506	0.182	***			
Service	0.305	0.207				
Farm production dummies (left out = Rice)						
Non-rice food crops				-0.087	0.031	***
Cash crops				-0.218	0.043	***
Export crops				-0.073	0.101	
Constant	-0.462	1.037		-1.352	0.189	***
R-squared	0.68			0.17		
No. of observations	230			1,751		

[a] TLU = tropical livestock unit of 250 kg live weight. The TLU is a common unit in which different kinds of livestock (cattle, small ruminants etc) can be compared.

Note: *, **, *** indicate significance at the 10, 5 and 1% levels, respectively.

Table 10 – Estimated Shadow Wage Rates for Hiring and Non-Hiring Enterprises

	Non-Farm Enterprise		*Farm Enterprise*	
	Mean	Std. Err.	Mean	Std. Err.
Non-hiring enterprises (NHE)	76,067	95,511	5,611	2,924
Hiring enterprises (HE)	86,763*	103,890	5,972***	3,320
All enterprises	78,729	97,728	5,692	3,021

*, *** = statistically significant difference from NHE at 10% and 1% levels, respectively.

Table 11 – Estimated Demand for Hired Labor
Tobit Marginal Effects

	Non-Farm Enterprises							Farms						
	Unconditional		Conditional (*Intensive Margin*)		Probability (*Extensive Margin*)			Unconditional		Conditional (*Intensive Margin*)		Probability (*Extensive Margin*)		
	Marg. Eff.	Std.Err	Marg. Eff.	Std.Err	Marg. Eff.	Std.Err		Marg. Eff.	Std.Err	Marg. Eff.	Std.Err	Marg. Eff.	Std.Err	
Shadow wage (log FMG)	-0.185	0.069	-0.148	0.055	-0.061	0.023	**	-0.378	0.032	-0.266	0.022	-0.127	0.011	***
Household Demographics														
Number of adult women (log)	0.308	0.184	0.246	0.147	0.102	0.061	*	-0.003	0.046	-0.002	0.032	-0.001	0.015	
Number of adult men (log)	0.006	0.145	0.005	0.116	0.002	0.048		-0.237	0.038	-0.166	0.027	-0.079	0.013	***
Number of children (log)	-0.007	0.107	-0.006	0.085	-0.002	0.035		-0.188	0.024	-0.132	0.017	-0.063	0.008	***
Owner Characteristics														
Age (years)	-0.076	0.198	-0.061	0.159	-0.025	0.065		0.024	0.046	-0.017	0.032	0.008	0.015	
Male (=1, 0 otherwise)	0.032	0.158	0.025	0.126	0.010	0.052		-0.163	0.041	-0.115	0.029	-0.052	0.014	***
Educ dummies (left out = less than completed primary)														
Completed primary	-0.023	0.162	-0.018	0.129	-0.008	0.053		0.157	0.039	0.110	0.027	0.050	0.013	***
Completed secondary	0.311	0.154	0.242	0.123	0.097	0.051	**	0.393	0.059	0.279	0.042	0.114	0.020	***
Post-secondary	-0.120	0.226	-0.098	0.181	-0.041	0.074		0.767	0.089	0.556	0.063	0.189	0.030	***
Community Characteristics														
Transport cost quintile dummies (left out = least costly)														
Q2	-0.277	0.170	-0.230	0.136	-0.097	0.056	*	-0.204	0.050	-0.143	0.035	-0.073	0.017	***
Q3	-0.460	0.168	-0.389	0.134	-0.163	0.055	***	0.028	0.045	0.020	0.032	0.009	0.015	
Q4	-0.579	0.232	-0.515	0.186	-0.217	0.077	**	0.080	0.042	0.056	0.029	0.026	0.013	*
Most costly	-0.093	0.181	-0.075	0.145	-0.031	0.060		-0.143	0.053	-0.100	0.037	-0.050	0.018	***
Access to broadcast media (=1, 0 otherwise)	0.184	0.126	0.149	0.101	0.062	0.042		0.214	0.029	0.127	0.021	0.061	0.010	***
Access to finance (=1, 0 otherwise)	-0.283	0.160	-0.237	0.128	-0.099	0.053	*	0.048	0.032	0.002	0.026	0.001	0.012	
High security risk commune (=1, 0 othwise)	-0.291	0.143	-0.241	0.114	-0.101	0.047	**	0.153	0.035	0.082	0.026	0.038	0.012	***

	Non-Farm Enterprises							Farms						
	Unconditional		Conditional (*Intensive Margin*)		Probability (*Extensive Margin*)			Unconditional		Conditional (*Intensive Margin*)		Probability (*Extensive Margin*)		
	Marg. Eff.	Std.Err	Marg. Eff.	Std.Err	Marg. Eff.	Std.Err		Marg. Eff.	Std.Err	Marg. Eff.	Std.Err	Marg. Eff.	Std.Err	
Enterprise/Farm Characteristics														
Number of NFEs owned by the HH	0.019	0.103	0.015	0.082	0.006	0.034								
Months of activity per year (log)	-0.240	0.121	-0.192	0.097	-0.079	0.040	**							
Years in operation (log)	0.067	0.061	0.053	0.048	0.022	0.020								
Value of equipment quintile dummies (left out = least)														
Q2	0.435	0.248	0.331	0.198	0.129	0.082	*	-0.160	0.043	-0.112	0.030	-0.057	0.014	***
Q3	-0.102	0.163	-0.083	0.130	-0.034	0.054		0.054	0.042	0.038	0.030	0.018	0.014	
Q4	0.475	0.158	0.366	0.126	0.144	0.052	***	0.181	0.044	0.128	0.031	0.058	0.015	***
Most	0.800	0.155	0.616	0.124	0.240	0.051	***	0.126	0.045	0.088	0.032	0.041	0.015	***
Number of TLU[a] owned by household								0.000	0.007	0.000	0.005	0.000	0.002	
Land holdings - total for HH (log hectares)								0.254	0.011	0.178	0.008	0.085	0.004	***
Sector dummies (left out = Agribusiness)														
Manufacturing	0.397	0.160	0.306	0.128	0.121	0.053	***							
Trade	-0.029	0.136	-0.023	0.109	-0.010	0.045								
Service	0.254	0.181	0.198	0.144	0.080	0.060								
Farm production dummies (left out = Rice)														
Non-rice food crops								-0.746	0.030	-0.530	0.021	-0.297	0.010	***
Cash crops								-0.755	0.043	-0.544	0.030	-0.338	0.015	***
Export crops								-0.867	0.072	-0.655	0.050	-0.451	0.024	***
Pseudo R-squared	0.07							0.11						
No. of observations	860							8,094						

[a] TLU = tropical livestock unit of 250 kg live weight. The TLU is a common unit in which different kinds of livestock (cattle, small ruminants etc) can be compared.

Note: The constant term and province dummies were included in the estimation but are not shown here. *, **, *** indicate significance at the 10, 5 and 1% levels, respectively.