Rural Nonfarm Employment and Agricultural Modernization and Diversification in Guatemala

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1. Introduction

There has been a long tradition, dating from the farm economy literature in developing countries in the 1960s, to view farm households as relying overwhelmingly on own-farming for their food security, and if the farm could not meet their full needs, households resorted to working on others' farms in farm wage-labor, or sending out migrants who in turn sent back remittances to the farm households. Rural nonfarm employment (RNFE), in local manufactures and services, figured little or not at all in the earlier literature.

That view was, however, reversed in a wave of empirical research starting mainly in the late 1980s. Reardon et al. (2007) review those two decades of RNFE literature, and finds that the literature has been rich in description of trends, and analysis of the determinants of RNFE. They find that RNFE constitutes some 40-50% of rural incomes in Latin America, Asia, and Africa. Moreover, RNFE tends to be, in most countries, more important, even much more important, than migration income and farm wage-labor income, and often more important than cash-cropping as a source of liquidity. Finally, the literature shows mixed results of the farm-level determinants of a farm household undertaking RNFE: sometimes RNFE is undertaken due to "push factors", such as to redress constraints on farming such as from little land or risky agricultural zones; sometimes RNFE is undertaken by "pull factors, such as being fueled at the farm level by investable farming surplus, and at the meso level by production-linkage and consumption-linkage demand in turn fueled by dynamic agriculture or other sources of demand such as tourism.

They find, however, that the literature has treated relatively little the effects of RNFE on agriculture. There have been some exceptions to this dearth, however. There was a strand of literature particularly in the past decade that examined the farm investment effects of RNFE. The reasoning was that as RNFE is a major source of liquidity, it is potentially important as a determinant of farm investments in the typical context where farm households face idiosyncratic credit market failure. This was tested and confirmed in few studies, such as on animal traction investment in Burkina Faso by Savadogo et al. (1995).

But there has been far less in the literature on how participation in RNFE affects the choice of cropping technology simultaneously with crop mix. The potential concern that would motivate an interest in this question is that if RNFE were concentrated in its distribution over household income strata and/or over zones, and yet turns out to be an important determinants of agricultural “modernization” via increase in non-labor variable input intensification and more use of farm capital, more commercialization, and agricultural diversification into higher-value crops such as horticulture, then there could be substantial cause for alarm that constraints to participation in RNFE would translate into constraints to participation by households in a zone or by zone types in agricultural modernization and diversification. That possibility was posited in Reardon et al. (2000) based on a review of evidence of concentration in RNFE over households in poor areas, and a few studies such as Francis and Hoddinott (1993) showing that concentration in RNFE led to incipient concentration of landholdings. Alternatively, the effect of RNFE on agriculture could be to compete for labor and/or capital and thus reduce agricultural intensification and commercialization.

But the step was not taken yet empirically to test whether, if indeed RNFE is concentrated in a particular setting, that it need translate into effects on commercialization, technology, and crop diversification. That stands as a gap in the literature that the present paper addresses.

We address that gap with data from the Living Standards Measurement Survey (LSMS) for 2000 in Guatemala. We address two main research questions: (1) What determines participation in RNFE? (2) How does participation in RNFE condition technology choice and crop choice among cropping households?

We take several steps further, however, by introducing several distinctions and conditioners that have been little used in RNFE analyses and that are particularly enriching to our analysis of the above two questions.

The first innovation is to model all three local off-farm income sources (skilled and unskilled RNFE and farm wage-labor employment), a disaggregation not done before in the RNFE literature. We also control, via an IV, for remittance unearned income. This income source disaggregation is maintained as regressands in the technology and crop mix equations in order to distinguish these effects. Beside the fact that most of the RNFE literature does not carefully distinguish farm wage-labor and RNFE per se in income source determination regressions, no study distinguishes their impacts on crop technology and crop mix. Moreover, to our knowledge no RNFE study, either of income source determinants or their effects on technology, distinguish skilled versus unskilled RNFE. At most, such as in Taylor and Yunez-Naude (2003), there has been a test of the effect of education per se on participation in RNFE, but not distinguishing skilled versus unskilled RNFE. We expect there to be differential determinants of participation, and for this distinction to be important in its effects on cropping technology and diversification, with potential spillover effects of skills in RNFE on cropping modernization and diversification.

The second innovation relative to the RNFE literature is the introduction of spatial effects that are expected to be important in determining participation in different types of RNFE. Spatial effects (specifically, activity distribution in various concentric circles away from the big city) were modeled in a study of RNFE in Nepal (Fafchamps and Shilpi, 2003). We contribute further to this new strand of literature by distinguishing the degree of commercialization of the agricultural zone, as well as its rural population density and the urban share in the zone, that are the contexts for the farm household's choice of labor market participation. We expect these zone factors to condition the opportunities for RNFE activity via production- and consumption-linkages from agriculture, and condition access to RNFE via greater rural population density and the zone's urban share as proxies for transaction costs.

This study proceeds as follows. Section 2 discusses the behavioral model, implementation model, estimation methods, and data. Section 3 presents descriptives. Section 4 presents the econometrics. Section 4 concludes.

2. Behavioral and Econometric Models

Our study focuses on two economic decisions regarding labor allocation to off-farm employment and farm technology. We first model participation in off-farm employment activities, and then model farm technology choice as an economic decision by modeling input use and output produced.

In each section we describe three subsections, one presenting the conceptual model, then a general implementation model that derives from the conceptual model, and then the regression specification model that derives from the general implementation model with some empirical adaptations.

2.1. Participation in off-farm employment

Conceptual Model. We use a farm household utility maximization framework to present our integrated model of labor allocation and farm production decisions. The subsequent model follows Sadoulet and de Janvry (1995) model with adaptations from Lopez (1984, 1986) and Singh et al. (1986). It is a simple non-separable household model where households derive utility from consumption (c_i) and where households can have different preferences for working on and off the farm (E_t-q_f and E_t-q_{of}). The model is written as follows:

A household maximizes the following utility function:

$$\max_{c,q} u(E_t - q_f, E_t - q_{of}, c, z^h) \quad (4.1)$$

Subject to:

(i) $\sum_{i \in T} p_i(q_i - E_i - c_i) + S \geq 0,$ cash constraint,

(ii) $\sum_{i \in TC} p_i(q_i - E_i - c_i) + K \geq 0,$ credit constraint,

(iii) $g(q, z^q) = 0,$ production technology,

(iv) $p_i = \bar{p}_i, \; i \in T,$ exogenous market price for tradables,

(v) $q_i + E_i = c_i, \; i \in NT$ equilibrium conditions for nontradables,

(vi) $q_f + q_{of} + E_t = c_l,$ labor constraint

Where: q>0 represents goods produced, including beans grains and horticultural crops; q<0 represents factors used; c represents goods consumed, including purchased and home-produced goods; E is the household initial endowment; S is net transfers received; K is access to credit for consumables or inputs (this is household specific and not good/commodity specific);); $\overline{p_i}$ is the vector of exogenous effective market prices of outputs and inputs (these prices are net of transaction costs); z^q is the vector of quasi-fixed production assets (both farm and non-farm), and z^h is the vector of household's assets that affect consumption decisions, for example household size, household consumption durables, etc. z^q and z^h include assets that are not normally in the farmer's problem (nonfarm productive assets, and assets that affect consumption decisions) and the reason why these other types of assets are included in the model are: (1) the maximization problem consider all productive possibilities of the household, and therefore is not limited to only own farming; and (2) since this is a non-separable household model, consumption and production decisions are decided jointly, and therefore household assets that affect consumption decisions can also affect production decision.

And for the labor allocation decision to work in and off the farm (E_t-q_f and E_t-q_{of}): q_f is household labor working on-farm; q_{of} is household labor working off-farm; E_t is time available by household members for all activities including leisure; and c_l is consumption of leisure.

Sadoulet and De Janvry show that after the manipulation of the first order conditions of the maximization problem, the production decisions are represented by a system of supply and factor demand functions in the decision prices (p^*), and quasi-fixed production assets(z^q):

$$q = q(p^*, z^q) \qquad (4.2)$$

The decision of supplying off-farm labor can be modeled using the result obtained in equation 4.2, since as seen from the labor constraint in the model, the vector of factor demands and output supply (q), include the derivation of the decision of using their own labor to work in farm (q_f), off farm (q_{of}), and leisure (c_l)

General implementation model. Since the decision prices p^* are functions of the exogenous prices ($\bar{p}$), the household assets associated with production (z^q) and consumption decisions (z^h), exogenous transfers (S) and access to credit[1] (K), then the equation 4.2 can be rewritten as follows:

$$q = q(\bar{p}, z^q, z^h, S, K) \qquad (4.3)$$

Sadoulet and de Janvry (1995) shows that a reduced form of the model can be used, and it allows for the estimation of a subset of input demands and/or the supply functions without having to deal with the full system, and that the household assets that affect consumption decisions (z^h) are what makes this solution different from the one obtained from a pure producer model. Our general implementation model for the decision of allocation of labor in off farm employment is as follows:

$$q_{of} = f(input\ and\ output\ prices, farm\ assets, human\ assets, nonfarm\ assets, \\ community\ assets, exogenous\ transfers, access\ to\ credit, risk)$$

Now following is demonstration of links between the conceptual and the implementation model. First, input and output prices map out directly from the vector of exogenous prices ($\bar{p}$) in our conceptual model. We can subdivide exogenous input prices into the following categories: (1) price of non-labor farm inputs; (2) price of non-farm productive inputs, which are the variable inputs needed for non-farm

[1] We assume that rural households can be credit constrained, it is not the objective of this study to test if rural household are or are not credit constrained. This can be tested by direct (Gillgan et al. 2005) and indirect (Vakis et al, 2005) methods

production; (3) the agricultural wage; and (3) the non-farm wage. Exogenous output prices can also be subdivided into the following categories: (1) the opportunity cost of working in agriculture; and (2) the opportunity cost of working in non-farm activities.

Second, we can subdivide the household assets that affect production (z^q) and consumption (z^h) decisions into the following asset categories: (1) human assets; (2) farm assets; (3) nonfarm assets; and (4) community assets. In our empirical models we have included variables for all asset categories as shown in the next section.

Third, exogenous transfers (S) and access to credit (K) map directly from the conceptual framework. Since transfers can be endogenous in the labor allocation equations, we have used an instrument variables approach.

And fourth, we have included risk as another category of variable in our implementation model. This category does not map directly from the conceptual framework. However in the off-farm employment literature, income diversification models normally include risk measures, since it is necessary to account for the instability of prices, and other climatic and market shocks and the degree of risk aversion of the household (Haggblade et al. 2007) that incentive farm household to diversify into off-farm employment to mitigate agricultural and market risk.

Regression specification model: We estimated three models that have as left hand side variables the participation in different types of off-farm employment; household participation in skilled RNFE, participation in unskilled RNFE, and participation in AWE. The regressands for the three employment categories are the following:

1. Households that participate in skilled rural non-farm employment (RNFE). RNFE is defined as participation in self and/or wage employment in manufactures or services in general, and specifically, per the LSMS list, the following employment categories: mining, manufacturing,

electricity and utilities, construction, commerce, communication, finance and insurance business, and other services (health, social, personal, etc). The skilled occupation category refers to participation in the following types of RNFE: managers and public officers, technical, associate and college degree professionals, and army professionals.

2. Households that participate in unskilled RNFE. The unskilled occupation category refers to participation in the following types of RNFE: office workers, food sellers, service workers, machine operators and other non qualified labor.
3. Households that participate in agricultural wage employment (AWE). AWE is defined as participation in wage employment on other farms than their own farm

The regressors are chosen by the above conceptual and general implementation models. The regressors are the following for the off-farm participation equations:

Vector of exogenous prices:

The variables included are the following

(1) Agricultural wage rate: this wage rate is defined as the average monthly wage rate in US dollars received by households participating in agricultural wage employment at the municipality level. This variable was calculated by: (1) dividing the household's net agricultural wage income received during the last 12 months by the amount of time (in months) that all members in the household have spent working as farm wage earners during the last 12 months; (2) once we had the average agricultural wage at the household level, we calculated the average at the municipality level by doing a simple average across all households that have agricultural wage within the same municipality. The agricultural wage should have a positive effect on participation in AWE, since households will have the incentive to allocate their unskilled labor stock into AWE to increase their income. However, the effect of the agricultural wage in RNFE is ambiguous. On the one hand, as the

agricultural wage increases it could have a negative effect in participation on unskilled RNFE, since both sectors are competing sectors for the household's unskilled labor stock. On the other hand, higher agricultural wage rates are common in areas where there is high production of agricultural products and in accord with the production linkages literature, those areas spur the availability of RNFE (both skilled and unskilled), for example in the high commercial watermelon zones in Guatemala, there is high demand of labor to work in transportation services.

(2) Skilled RNFE wage rate: this wage rate is defined as the average monthly wage rate received by households participating in skilled RNFE at the municipality level in US Dollars. This variable was calculated by: (1) calculating the skilled RNFE income, by aggregating the net incomes from RNF self and wage employment; (2) dividing the household's net skilled RNFE income received during the last 12 months by the amount of time (in months) that all members in the household have spent working in skilled RNF self and wage employment during the last 12 months; and (3) once we had the average skilled RNFE wage rate at the household level, we calculated the average at the municipality level by doing a simple average across all households that have skilled RNFE wage within the same municipality. The skilled RNFE wage should have a positive effect on participation in skilled RNFE. However, the effects of increasing skilled RNFE wages on AWE and unskilled RNFE are not obvious. On the one hand, skilled RNFE should not have an effect on unskilled RNFE and AWE since those sectors use the household's unskilled labor stock, and therefore do not compete for the skilled labor stock. On the other hand, one can hypothesize opposite effect of the skilled RNFE wage on the unskilled sectors: (1) all else equal, households might have a higher preference to work on their farms than working off the farm, then they might under using their skilled labor stock in own farming until the skilled RNFE is high enough to offset the utility from own farming; and (2) higher skilled RNFE wages are common in more "urbanized" rural areas or in

areas with higher agricultural production, these areas have lower transaction costs and greater availability of unskilled RNFE and AWE, therefore skilled RNFE can have a positive effect on both sectors.

(3) Unskilled RNFE wage rate: this wage rate is defined as the average monthly wage rate received by households participating in unskilled RNFE at the municipality level in US Dollars. This variable was calculated in an analogous way to the skilled RNFE wage rate. The effect of the unskilled RNFE wage rate on participation in unskilled RNFE should be positive. However, the effects of the unskilled RNFE on skilled RNFE and AWE are not obvious, and are similar to the ones discussed for the AWE wage rate.

Human capital assets:

(1) Years of education of the HHH (head of household). The effects of education as a determinant on participation in both farm and nonfarm employment has been studied extensively in the economic literature. We hypothesize that education is one of the most important barriers that household face in order to participate in skilled RNFE, hence education should have a positive effect on RNFE.

(2) Gender of the HHH. We hypothesize that female headed households have a positive effect on participation in unskilled RNFE and AWE. Empirical evidence in the literature (Lanjouw, 1996 in Ecuador) have shown that controlling for wealth level, women tend to undertake labor-intensive, low-skill, low entry barrier.

(3) Number of adults (members of the household between 14 and 60 years old) in the household. The number of adults in the household is also a proxy for the shadow price of own labor (Singh et al 1986). This variable should have a less ambiguous effect on participation in off-farm employment. All else equal, households with higher labor stock have the incentive to shift a portion of their labor stock to off-farm employment to increase the household's income.

(4) Age of the HHH, in itself a proxy for experience. This variable can have ambiguous expectations. On the one hand, as the HHH ages, he/she can be reluctant about letting the household to shift from on to off-farm employment. On the other hand, as age increases, experience increase, and therefore the HHH might have the necessary skills to participate in higher payment off-farm employment.

Farm assets:

In our empirical model we have included the following farm assets:

(1) Total land owned and total land squared: total land is the total area in hectares that the household owns (for all uses, for all types of crops plus pasture plus fallow plus wooded or barren), which includes the land owned and cultivated, land rented out, and lent out. Total land owned squared is included to allow for diminishing returns of the land assets. We would expect a positive effect of land on participation in RNFE, as one can expect that land owned can be used as a collateral for access to credit, that will allow for capital investments needed to engage in RNFE. However the empirical evidence in the literature, have shown that land has a U-curve relationship with the share of off-farm income in total household income (Reardon et al. 2000), where the share is high for small farms, declines in the middle handholding range and then rises at the higher end of landholdings.

(2) Total value of animals owned: this variable is defined as the total value (in USD 100's) of the following animals owned by the household; cattle, goats, sheep, pigs, horses, beehive, small animals, and other animals.. We expect a positive effect of livestock holding in participation in RNFE, since livestock is a proxy for liquidity and wealth, then household with higher levels of livestock holdings are in a more favorable position to diversify into non-farm activities if diversification is costly (i.e. has high entry barriers) (Reardon et al. 2000).

(3) Irrigation: This is variable is defined as a binary variable that captures whether the household has (or doesn't have) irrigation system in the farm. we hypothesize that irrigation should favor participation in non-farm employment since investments in technological change in the farm can free labor to work in the non-farm sector (Estudillo and Otsuka, 1998)

(4) Total value of other agricultural assets: this variable is defined as the total value (in USD) of farm productive assets of the household. Agricultural assets should have a positive effect on participation in RNFE, since capital farm investments are often labor-saving investments, which allow households to allocate labor stock into non-farm employment.

Non-farm assets

Non-farm assets can be subdivided into assets that could affect non-farm production and assets that are needed for consumption. The former are important determinants of participation in off-farm employment, while the latter are included in accord with our theoretical model, where consumption and production decisions are non-separable. We have included the following nonfarm assets in our model:

(1) Household infrastructure: this is proxied by several dummy variables that show if the household have access to the following services; (a) electricity; (b) piped water; and (c) cemented floor. Electricity and piped water are productive assets, and they should have a positive effect on RNFE, since those can be entry barriers to engage in non-farm business investments.

(2) Non-agricultural household assets: this is proxied by two dummy variables that show if the household owns the following household assets: (a) land-line telephone or cellular phone; and (b) vehicles. Telephones are proxies for access to information, and vehicles are productive assets that could be entry barriers for RNFE activities, they both proxy lower transaction costs, and as transaction costs are reduced, there is greater incentive to shift from farm to non-farm activities.

Community assets

Reardon et al (2000) show that one of the main determinants of non-farm employment is the inter-location differences in infrastructure, market and population densities, since more developed infrastructure and denser population means lower transaction costs to market products, and greater availability of inputs at lower costs. We have included the following community characteristics to control for the zone effects:

(1) Urban population share: this variable is defined as the rate of urban population over total population at the municipality level.. The hypothesis normally found in the literature is that quality and quantity of infrastructure is tend to be correlated with urbanization and population densities (Anderson and Leiserson, 1980; Lanjouw and Lanjouw, 1995; Reardon et al., 1994), therefore we expect that as urban population increases within the same municipality, there is more quality and quantity of infrastructure that will mean lower transaction costs for the households in the municipality, which will increase the availability of off-farm employment and business opportunities.

(2) Rural density: this variable is defined as the rate of rural population over rural area of the municipality. The hypothesis for this variable is similar to the one for urban population share, since quality and quantity of infrastructure is often correlated with population densities.

(3) The agricultural commercialization rate: this variable is defined as the average rate of sold crop production over total crop at the municipality level.. We expect that as the agricultural commercialization rate increases; there is higher availability of off farm employment. First, high commercial zones have higher demand for farm wage labor; therefore the effect of the agricultural commercialization rate should have a positive effect on participation in agricultural wage employment. Second, from the production linkages literature we can expect that higher commercial zones will bolster the demand for non-farm employment. We have also included agricultural commercialization rate squared since as the rate increases, farm wages increases, cost of land

increases, and then farms are encourage to invest in labor-saving technologies, hence implying diminishing returns of the commercialization rate

Exogenous transfers

Remittances as shown in our descriptive analysis are the most important transfers that rural households receive, but since remittances can be endogenous in our labor allocation equations, we have included the natural log of remittances received by the household using an instrumental variables approach, where we have used two instruments: (1) a dummy variable if the household has a family member in the US; and (2) a dummy variable if the household has a family member in other municipality in Guatemala.

Access to credit

We do not measure access to credit directly, but we proxy access to credit by including farm assets (land and non-land) and livestock holdings, since these assets are often used as proxies of household's wealth.

Risk

Agricultural risk is normally included in empirical models with measures of weather conditions, we do not have weather information needed to construct these variables and therefore there is no explicit measure of agricultural risk.

Market risk is normally included as indexes of volatility of market. We proxy market risk in our implementation model by including the agricultural commercialization rate at the municipality level, then volatility of market is proxied by thickness of the market, we hypothesize that as the density of the market increases there is lower transaction costs and higher price stability. This approach goes far beyond controlling for location dummies since it controls for both; zone characteristics and transaction costs.

In addition, household's degree of risk aversion is proxied by farm assets and livestock holdings, as economic literature have shown that risk aversion varies inversely with wealth (Newbery and Stiglitz, 1981).

Estimation method for off-farm employment: We estimate the probability of participation in off farm employment activities using the (well-known) IV probit model for the regressions, and we instrument remittances in each equation.

2.2. Technology correlates of off-farm employment participation

Conceptual Model and general implementation model: The conceptual model for the decisions in the farm is the same as the one used in the previous section since the solution of the maximization problem, the vector *q* (equation 4.2) includes the farm input demands and output supply functions. The general implementation model is similar to the one used in the previous section, the difference is that now we have included participation in off-farm employment as an explanatory variable of the farm decisions, therefore our general implementation models for input demands and output supply are as follows:

$$q^S_{outputs} = f(\tilde{q}_{of}, input\ and\ output\ prices, farm\ assets, human\ assets, nonfarm\ assets, \\ community\ assets, exogenous\ transfers, access\ to\ credit, risk)$$

$$q^D_{inputs} = f(\tilde{q}_{of}, input\ and\ output\ prices, farm\ assets, human\ assets, nonfarm\ assets, \\ community\ assets, exogenous\ transfers, access\ to\ credit, risk)$$

Regression model for technology and crop output we have estimated five input demand equations and two crop output equations. All input demands are expressed as input expenditures aggregated over all seasons in 2000. In these models, the regressands for the input equations are:

(1) Expenditure (as imputed use) of own labor.

(2) Expenditure on hired farm labor.

(3) Expenditures on Seeds.

(4) Expenditures on fertilizers.

(5) Expenditures on pesticides.

The output supply variables are expressed as the total production in metric tons aggregated over all seasons in 2000. The regressands for the crop output equations are:

(1) Production of beans and grains.

(2) Production of horticultural crops.

. The regressors are as follows:

Participation in off farm employment

(1) The predicted probabilities of participation in skilled RNFE, unskilled RNFE, and AWE derived from the IV probit model estimation in section 4.A. We expect that participation in RNFE (skilled and unskilled) can have a positive effect on purchased inputs and outputs, but a negative effect on use of own labor. In accord with the RNFE literature, we expect that RNFE can relax the household's credit constraint and allow for self financing of crop inputs that will also increase production of outputs. AWE does not have a clear effect on the use of inputs and production of outputs. On the one hand, it may have the same effect as RNFE, since the earnings from AWE can be used for self financing of crop inputs. On the other hand, the economic literature shows that households that dedicate their household labor stock to AWE, are generally the poorest (asset based) households, who have very limited agricultural production.

Vector of prices:

(1) Agricultural wage rate.

(2) Nonfarm skilled wage rate.

(3) Nonfarm unskilled wage rate.

The hypothesis on the effects of all wages on input use and output produces are ambiguous. On the one hand higher wages might imply higher off-farm income, which can be used for financing in the farm, therefore increasing the use of purchased inputs and increasing the production of crop outputs. On the other hand, higher wages may induce households to shift from farm to off-farm, therefore reducing production and then reducing outputs.

Human capital assets:

(1) Years of education of the HHH. The effect of education on input use and output produced are ambiguous. On the one hand, we will expect that higher levels of education will allow farm households to switch between labor-using to capital-saving technologies. On the other hand, empirical evidence in rural Mexico (Taylor and Yuñez-Naude, 2000) have shown that as schooling levels increase, the returns from schooling shift away from crop production.

(2) Household labor stock. Empirical studies in the literature (Carletto et al. 2007) suggest that hired labor is an imperfect substitute of family labor, then as the number of available adults to work in the own farm increase, the supervision capability of the household increases, resulting in decreasing the overuse of variable inputs.

(3) Age of the HHH. this variable is a proxy for experiences, so we expect that as age of the HHH increases, there is greater production of crop outputs in the farm, and this might be accompanied by lower use of purchased inputs.

Farm capital assets:

(1) Total land owned. This variable have ambiguous expectations. On the one hand, the use of inputs and labor can be affected by economies of scale, and then as land increases, the use of variable inputs can be more efficient. On the other hand as the area of production increases, there is higher

pressure of pests and the managerial capacity of farmers decrease, resulting on overspending in variable inputs and reduction of crop yields.

(2) Irrigation. This variable should have a positive effect on use of purchased inputs and production of outputs, since having irrigation should allow farm households to crop more seasons during the year. However, all else equal, irrigation should have a negative effect on use of labor since irrigation systems can be labor saving technology.

(3) Total value of agricultural assets. this variable should have similar effects than irrigation.

Non-farm assets:

(1) Non-agricultural household assets. This variables do not have a clear effect on decision on the farm. However, those are included in accord to our theoretical model, since consumption and production decisions are made simultaneously and therefore we should have proxies of consumption decisions in the equations that model farm decisions.

(2) Distance to the main road: this is defined as the distance from the household to the main road (paved or unpaved) in the community where the household is located. As farm households are located in areas far from roads and urban areas, they have higher transaction costs that will affect negatively the use of inputs and production of crop outputs.

Community assets:

(1) The agricultural commercialization rate. We will expect that as the agricultural commercialization rate increases, there is higher demand for variables inputs.

Estimation methods for technology correlates: The seven equations of input use and output produced are estimated as a system using Zellner's seemingly unrelated regression (SUR) model to exploit potential correlation across the errors in all system equations. Since we are using three variables not actually observed (the probabilities of participation in off farm employment were derived from a first stage (probit estimation) we use a bootstrapping procedure to obtain the correct standard errors.

2.2. Data

The analysis uses farm household data from the Guatemala Living Standards Measurement Survey (LSMS) carried out in 2000. The sample for the Guatemala 2000 LSMS was drawn using a two-stage stratified sampling procedure using the census segments from the 1998 survey of family income and expenses (ENIGFAM) to draw the primary sampling units (PSUs). The sampling unit was the individual occupied or vacant household.

8,940 households were selected for the LSMS sample and after attrition, the total sample of completed survey interviews was 7,276 households (3,852 rural and 3,424 urban). Rural areas are defined as localities which have agglomeration of 2000 or less inhabitants (http://esa.un.org/wup/source/country.aspx), therefore it represent many small villages and hamlets. In Guatemala, the rural population is scattered all over the countryside, both close and far from urban centers but more concentrated near urban centers, this is supported by the high variations of therural density and the share of urban population at the municipality level

The LSMS sample is representative at national, urban, and rural levels, but given that the objective of our study is to analyze how the household's decision to participate in off farm employment affects production decisions on the farm, we only use the rural portion of LSMS sample. Out of the total of 3,852 rural observations in the LSMS sample, there are 1,417 observations that were excluded from our analysis, the reasons for the exclusion of this subsample are:1) 1,183 rural household observations were excluded from our analysis because they do not crop and information about crop production and farm input use is essential for our analysis,

2) while all study households do cropping, only 76% have livestock. All but 5% have the equivalent of 1 cow or less, and the other 5% have just a few cattle; so cropping families that are large scale ranchers (animals) were also excluded from our sample as these ranchers are very unrepresentative and highly different in structure and behavior from rural farmers, and 3) we have also dropped three observations of rural households that received large amounts of remittances (more than $1,000/month) which are not representative of rural households that receive remittances in Guatemala.

After the exclusion of these three groups of rural household observations (households without cropping, large scale ranchers, and households with large amounts of remittances) we ended up with a total sample of 2442 observations which represent 63% of the rural LSMS sample.

3. Descriptive Results

In this section, we present descriptive statistics on the variables used in the econometrics. We do so by income quartile of the sample and overall in order to provide contextual background that makes several key points important in themselves and also needed for interpretation of the econometric results.

Table 1 shows income sources of sample households, stratified by household income quartiles. The salient points are as follows. In general the results corroborate findings in recent literature on RNFE and migration remittances.

First, in terms of overall income, the average is about 600 dollars per capita, with the top quartile about 2.5 times that, similar levels and spread to other rural areas in Central America in 2000 (such as Nicaragua, see Corral and Reardon, 2001). Moreover, as usual in many developing countries, the rural income is well below the average income (reflected in the GDP/capita in 2000 of 1558 dollars (1995 dollars) http://earthtrends.wri.org/pdf_library/country_profiles/eco_cou_320.pdf), reflecting the well-known sharp rural-urban divide.

Second, the share of own-agriculture (crop and livestock) is only 21% for the overall sample – versus 35% in Nicaragua (Corral and Reardon, 2001) in the same time period. The reasons for this will be manifest below, but note that in general this shows the difference between a more diversified, commercialized, and relatively better off rural area in Guatemala versus its poorer neighbor Nicaragua.

Moreover, in rural Guatemala, total cropping income rises quickly as one goes from lower to upper quartile – but the share of cropping income in total income is an inverted U curve – and thus its complement, the relation of non-cropping income with total income is a U curve. The latter is interesting in the context of comparison with international evidence, in which the Guatemala case figures as an intermediate case. This means that poorer households have alternatives to cropping. Part of these are in spin-off activities from commercialized agriculture, and part is in other nonfarm activities with low capital entry requirements.

Third, on average the share of farm wage-employment income in total income is similar to that of own-agriculture, but less than half of the total share of RNFE. This finding echoes a number of similar findings reviewed in Reardon et al. (2001) showing that contrary to conventional wisdom and much of the rural literature in Latin America (and elsewhere), the farm wage labor market is much less important than the RNFE labor market. Moreover, as in most other studies, the share of farm wage-employment income drops quickly as one ascends the income strata – as farm wage labor is a low-entry requirement "refuge" employment, where farm households lack the means for better paid work, and are often (in other studies) driven by a lack of land to work on the farms of others. But note that the share of households in the quartile (indicated by SHS in the table) that participate in farm wage-labor is roughly half for all quartiles but the poorest, where it is only one-quarter; that the average income share for the poorest is higher than the other quartiles means that there is a subset of the poorest quartile depending mainly on farm wage-labor. Finally, in table 2 we can note that the average farm-labor wage does not differ much across quartiles, hence showing no obvious bargaining power or skill difference, note that this is well below the legal minimum wage to pay farm-workers of 2.85 dollars a day (http://www.tusalario.org/guatemala/Portada/salario-minimo/minimo). Interestingly, however, there is a strong and steep correlation between quartile and months worked as farm wage-laborers; thus, while the richer quartiles depend less on this source, in absolute terms they participate more in this labor market than do the poorest, and earn nearly half (44%) of all farm wage-labor income.

Fourth, confirming other recent empirical evidence in Latin America (Reardon et al., 2001), Africa (Reardon 1997) and Asia (Lanjouw and Lanjouw 2001), the share of RNFE (skilled and unskilled) is substantial, and in rural Guatemala, at 48%, more than twice that of own-agriculture. This flies in the face of conventional wisdom viewing rural households as exclusively or mainly engaged in own-farming.

Moreover, whereas RNFE overall is regressive, it is very sharply regressive in the category of skilled RNFE. The relation in shares and levels is nearly flat for the first three quartiles and then inflects sharply upward only in the last quartile. In short, the richest quartile is very dominant in the skilled RNFE labor market – earning 85% of the total.

The unskilled RNFE is seven times more important for the rural households than is skilled RNFE, and equal to own-farming and farm wage-labor combined, at 42% of income. Despite lower entry barriers (than skilled RNFE), its distribution over quartiles is still sharply regressive.. However, as expected, it is more evenly distributed in terms of dependence (the poorest earn 23% of their income from this source, the richest, 51%). Again, however, it is striking that the richest quartile corners 73% of the unskilled RNFE labor market, and the top half of the income distribution earns a whopping 93% of the unskilled RNFE. Despite the easier entry (in unskilled versus skilled RNFE), one sees that the upper quartiles dominate it, and the situation leaves the poorest half of the rural population to depend on farming directly or in the labor market, and thus on the vicissitudes and risks of that sector.

Finally, while the RNFE average wages received(Table 2) are near the official minimum wage (3.1 dollars/day), they vary sharply over quartiles. The skilled wage is 4.8 per day among the richest quartile (who in any case nearly full dominate this category). But more striking is that the wage for unskilled RNFE smoothly quadruples from the poorest quartile to the richest, implying at least a very different mix in specific activities over the quartiles, and possibly (an untested) presence of greater capital/labor ratio, and relative skill demanding, in the unskilled RNFE of the richer quartiles. That higher wage is compounded by a very steep relation of household time spent in RNFE of both types as one ascends the quartiles.

Fifth, unearned income (transfers) are fully 9% of rural income –This is mainly due to rural households in Central America being linked to the international economy and the urban economy (through remittances) and the government sector (through pensions). There are several surprises to note. (1) Remittances (from migrants in foreign and domestic markets) are fully 7% of income, and 78% of unearned income. But contrary to the conventional wisdom in Central America that "most rural households have someone in the US", in fact, only 10% of rural households have migrant remittances! This is similar to the finding of only 10% in Nicaragua (Corral and Reardon, 2001), and 16% in Mexico (de Janvry and Sadoulet, 2001) where the same myth prevails. Moreover, as found in many studies (e.g. in Burkina Faso, Reardon and Taylor 1996, and de Janvry and Sadoulet (2001) in Mexico, there is a strong correlation between migration remittances (share and level) and quartile; Table 1 shows that the poorest quartile only has 6% of its households receiving remittances, and for the quartile, only derives 5% of income from remittances; those shares are 19 and 9% respectively for the upper quartile. Put another way, the richest quartile captures 50% of remittances – so this source is as concentrated, and in the topmost quartile, hence extremely regressive as is skilled RNFE. Pension distribution tells a roughly similar story.

Table 3 shows descriptive statistics, for the overall sample and by income quartile, concerning demographic characteristics and non-land assets of the households. Several salient points emerge.

First, while richer households are larger than poorer households, and have a slight tendency to be male-headed, surprisingly, there is very little difference in education, either of the head or the average over the household members, over the income strata. All the quartiles have on average very low education, just two years.

Second, surprisingly, there are only very small differences over the quartiles in terms of access to various wealth indicators (durables, electricity, piped water, cement floor, phones (this is 2000, before the era of widespread cell phone use)). However, predictably, there is a very sharp correlation between distance to a bus stop (a proxy for distance to paved highway) and having a vehicle, on the one hand, and income quartile: the richer households face lower transaction costs.

Table 4 shows descriptive statistics, for the overall sample and by income quartile, concerning demographic characteristics and non-land assets of the households. Several salient points emerge.

First, the richest households have more than twice the capital/labor stock ratio than the poorest households, an indication of capital-led intensification increasing with overall income.

Second, a surprisingly high share (29% on average, decreasingly slightly over quartiles) of households are “landless”; but as they are cropping-households (per our sample choice), they are renting-in or borrowing the land. This shows a very active land rental market, similar to that found in Nicaragua for small farmers (Deininger et al., 2003).

Third, land ownership is relatively stable at 4 ha across all quartiles but the poorest (who have 2.2), and cropped land is on average 3.6 ha. However, the irrigation rate is extremely low – only 1% over all quartiles. So these farms are very small by irrigated-equivalents.

Fourth, land use varies very sharply over quartiles; while a steady 92-93% of the households grow grains, the poorest grow much less horticulture than do the upper three quartiles, as expected. The share of households growing horticulture crops is surprisingly high – 51% of the sample – showing that agricultural diversification has proceeded quite far.

Fifth, agricultural commercialization ranges about a third of output for the top 3 quartiles, but is only a quarter for the poorest.

Sixth, whereas the commercialization rate at the household level differs a lot between the poorest quartile and the others, the differences are less sharp when one looks at the commercialization rate of the municipalities in which the households live; table 5 shows that the overall rate of the municipalities is higher for the poorest than the poorest households' rate, showing that there are less commercialized households in higher commercialized zones. There tends to be somewhat of a correlation of income quartile and share of urban population in the zone, and a sharp correlation with rural population density. These facts corroborate the general picture that the richer quartiles face lower transaction costs.

Finally, in table 5 shows that the use of non-family labor inputs (hired labor, fertilizers, seeds, chemicals) are roughly correlated with overall income levels, and vary substantially over households.

The overall picture that emerges from the above has several key points.

First, there tends to be a rough correlation among overall household income, non-labor-led cropping intensification, agricultural diversification (into horticulture), commercialization (both of household and of zone), and lower transaction costs (in zones with higher density, infrastructure, and urban share).

Second, income from RNFE plays a major role in rural incomes – as much as own-cropping and farm wage-labor put together. But RNFE is very unequally distributed over households, mainly regressively, with the richer strata sharply dominant in higher paying skilled RNFE, and the top half of the population dominating the unskilled RNFE. The poorest tend to not only be relegated to mainly farming or farm wage-labor, but when farming, tend to have the lowest levels of intensification/technification, be most wed to grain farming, and have the smallest farms.

4. Econometric Results

4.1. Determinants of RNFE

Table 6 presents the IV probit estimation results for the determinants of participation in the three categories of off-farm employment.

First, the salient and significant determinants of participation in skilled RNFE are as follows.

(1) Participation in skilled RNFE is positively sensitive to own-wage, and negatively sensitive to the unskilled RNFE wage. This is rare empirical evidence of rural households' RNFE labor-supply responsiveness to relative RNFE wages.

(2) Moreover, as expected, skilled RNFE responds positively to access to electricity and telephones.

(3) A very interesting result is that the share of urban population in the municipality, and the rural population density in the municipality, significantly determine skilled RNFE participation. This result is unique in the literature. Prior research showed a relation of infrastructure density and share of RNFE in total employment (Anderson and Leiserson, 1980, and see Ahmed et al. 2007 for a review of this literature), and Fafchamps and Shilpi (2003) show that RNFE tends to be clustered in rural areas near urban areas. But no empirical research has shown the effect of population density and urban share over a large sample of municipalities, on RNFE incidence in general, and skilled

and thus higher paying RNFE incidence in particular. The interpretation is a variant of that used by the cited works: economies of agglomeration and lower transaction costs associated with urban proximity and population density favor production and consumption linkages from agriculture, as well as the growth of manufactures and services for peri-urban areas. Our results show that in addition, access to electricity and telephone increases the probability of participation, as predicted.

(4) Contrary to expectations (based on the working hypothesis that rural households face liquidity constraints for investment in skilled RNFE activities that remittances can relax), there is no significant relationship between the household receiving remittances and participating in skilled RNFE.

Second, the salient determinants of participation in unskilled RNFE are as follows.

(1) Participation in unskilled RNFE responds to infrastructure, in this case electricity.

(2) A very interesting result, and one not shown in any published article to date, is that unskilled RNFE participation is positively correlated with the agricultural commercialization rate of the municipality. This result is an extension, to the RNFE domain, of the findings by David and Otsuka (1993) and Pingali and Rosegrant (1995) of commercialized Green Revolution areas having higher hired agricultural-labor market participation. This suggests that in commercialized agriculture zones, there are both production and consumption linkage spinoff employment, as shown for example in the work on North Arcot, India, by Hazell and Ramasamy (1993).

(3) Moreover, as with skilled RNFE, the results show that the urban share of the municipality and population density of the rural areas favors participation in unskilled RNFE, presumably by favoring via economies of agglomeration the multiplication of small-scale service and manufacture activities intensive in unskilled labor.

(4) Again, as with skilled RNFE, and contrary to expectation, there is no positive statistically significant relationship with (the IV for) migration remittances.

Third, the salient determinants of participation in agricultural wage employment are as follows.

(1) Contrary to expectation, participation in agricultural wage employment is not sensitive to own-wage or relative wage. This inelasticity could be simply because those supplying such labor are doing it for “push factor” reasons, and not with the luxury of changing that supply with variation in the wage.

(2) With respect to human capital, all variables were significant and had the hypothesized signs: (1) the head of household being female negatively affects the probability of agricultural wage employment, presumably because of the opportunity cost of this employment for z-good production in the household; (2) older and more educated household heads tend to have households participating less in this type of employment, presumably because this type of employment is low-paying and an “inferior good” that households in a more advanced point in the lifecycle of wealth accumulation would avoid; (3) households with more abundant labor are more prone to participate in this employment, presumably because the opportunity cost to own-farming in the farming season of sending some of the households own members to other farms, is lower than in smaller households.

(3) With respect to farm capital and other assets and services, several variables were significant. The smaller the farm, less access to electricity and communication (cell phone), and the lower the value of the stock of livestock, the more likely the household undertakes farm wage-labor. Both of these accord with the hypothesis that farm wage-labor is a “refuge” employment for those with the least productive or savings assets.

(4) Participation in farm wage-labor is positively correlated with the commercialization rate of municipalities. This corroborates for Central America a point made concerning Asian agriculture in Pingali and Rosegrant (1995). To explore this point further, we examined several correlations using

the 165 municipality observations, and found that the higher the commercialization rate of the municipality, the (a) higher the share of horticulture in total cropping; (b) the higher the rate of labor hiring in total labor used; (c) and the higher the share of landless (depending partly on farm wage-labor); (d) but there is nearly no correlation between average farm size (cropped) area as well as variation in farm size over farms in the municipality, and the municipality's commercialization rate, so there lacks the distinction we expected between subsistence areas with tiny farms and commercial areas with larger farms or greater inequality of farm size; in fact, small farms dominate on average (with an average of about 2 ha cropped area, but with only less than 5% of the farms with irrigation; as dry farm, this is the same as an average farm in India, and comparable to a 1 ha irrigated farm in Indonesia).

4.2. Determinants of Technology and Crop Choice

Table 7 presents the SUR estimation results of regressions explaining input use and output supply. The inputs modeled are family labor, hired labor, seeds, fertilizers, pesticides. The outputs modeled are beans and grains, and horticultural crops. We organize our discussion of results by determinant in order to highlight our main contribution which is to model the effects on input and output choices of participation in off-farm activity, controlling for the more usual determinants one finds in these equations.

First, more participation in skilled RNFE is associated with sharply less use of family labor (as posited by Pingali and Rosegrant 1995 for the Asian setting), more hired labor, and more supply of horticultural crops. The fascinating image is of skilled RNFE households saving their scarce and relatively highly paid labor for off-farm activity, and intensifying cropping with hired labor, and undertaking the more commercial farming which in Guatemala is mainly horticulture. While this is the first time in the literature that skilled RNFE per se is separated out to test this relationship (of RNFE with commercialization, intensification, and crop diversification), the result is reminiscent of the relation between RNFE and cash cropping found in Burkina Faso by Reardon et al. (1992). These results are suggestive of households using proceeds of one activity to own-liquidity finance startup and investment in the other activity.

Focusing in particular on the distinction we are emphasizing within RNFE between skilled and unskilled, the above result is also consistent with a working assumption that the skills formed in skilled RNFE may be facilitating agricultural diversification in horticulture. This result contradicts some recent work that posits a strong trade-off between RNFE and agricultural diversification; we surmise that this competitive relationship would exist mainly where there is a constraint in the farm wage-labor market, or lack of capital-intensification of agriculture, or both, so that off-farm labor must, at least in the cropping season, come at the price of time spent on the farm, especially in labor-intensive activity such as horticulture.

Second, participation in unskilled RNFE is associated with lower use of hired farm labor, suggesting that the farm and unskilled RNFE labor are not competing for family labor use at the same time, or individuals are specialized in the two types of labor within a family. Interestingly, unskilled RNFE participation increases sharply non-labor variable input intensification (with use of seeds, fertilizers, and pesticides). This suggests that even the relatively meager wages of unskilled RNFE may be relaxing a credit constraint needed to buy these external inputs. Third, participation in farm wage-labor is significantly correlated with greater use of family labor and less use of hired labor; these results align with the descriptives which show these households to be larger and poorer, and thus have relatively low opportunity cost of time.. The lower use of external inputs correlated with the households' participation in farm wage-labor, plus the high own-labor use on-farm, paint a picture of labor-led intensification of farming, in contrast with the capital-led intensification one sees among the households with the extra liquidity arising from RNFE activity.

Fourth, technology and product choice are somewhat sensitive to relative prices and wages. (1) The results show that a higher skilled RNFE wage is associated with lower use of hired labor; these results are contrary to our expectations. Note that this is effect of RNFE wage already controlling for participation, so it could be that there is a tighter agricultural labor market in areas where the skilled RNFE wage is higher, such as near cities. (2) However, the unskilled RNFE result is according to our expectations, that a higher RNFE wage induces less use of own-farm own-labor and more use of hired labor. This latter result is presumably dependent on the households' ability to sell RNF labor and buy grain, which in turn suggests that in the areas where RNF demand is higher (and the wage is thus higher), grain output markets are not missing. Our result is an extension of the combination of RNFE and cash cropping of the point made by Binswanger and McIntire (1987) that missing or failed food markets undermine the incentive (by increasing uncompensated risk) of households to undertake cash cropping. (3) Interestingly, a higher farm wage induces less use of own-labor on-farm. This may suggest a pool of surplus labor on-farm.

Fifth, there are several striking effects of human and farm assets on technology and crop output choices. (1) As can be predicted, and coincident with the above farm wage effect, we find that lower effective wage for labor (from more adult laborers in the household), the greater the tendency to labor on-farm. (2) Moreover, there is an effect, similar to that of skilled RNFE, of education and farm assets on using less own-labor for farming and more hired labor (explicable by the opportunity cost of labor). (3) The correlation between irrigation and horticulture is typical in the literature.

Sixth, the impacts of transaction costs – proxied by distance from the road and having a vehicle – are important, and reinforce and coincide with the effects of skilled RNFE and education, with the additional effect of strongly reinforcing capital-led intensification.

Finally, and information rare in the literature, are the results concerning the effect of the commercialization rate of the municipality on farm technology and crop output mix. On the one hand, the effect is strongly positive and significant on all inputs and on both grains and horticulture. On the other hand, the relative effect on horticulture is greater, a point made above in our discussion of the descriptive correlates of the commercialization rate.

5. Conclusions

This study used a rich primary data set on rural cropping-households in Guatemala in 2000 to address two questions: (1) What determines participation in RNFE? (2) How does participation in RNFE condition technology choice and crop choice among cropping households? These questions are among those at the heart of the development issues facing rural areas in Central America, where policymakers – and farmers – are seeking to combine agricultural technology change and modernization, with commercialization, income diversification, and crop diversification into high-value crops like horticulture – all to raise small farmers' incomes. The study contributed to the literature in several ways in addressing these questions.

First, the descriptive results provided evidence of a correlation among overall household income, non-labor-led cropping intensification, agricultural diversification (into horticulture), RNFE, commercialization (both of household and of zone), and lower transaction costs (in zones with higher density, infrastructure, and urban share). The converse is that the poorest tend to have the lowest levels of RNFE, the least intensification/technification of farming, the least crop diversification into high-value crops (and thus to be most wed to grain farming), and to have the smallest farms. They are least linked to the dynamic market forces of urbanization, and linked to the vicissitudes of rainfed grain farming.

Second, the descriptive results provided evidence that income from RNFE plays a major role in rural incomes – as much as own-cropping and farm wage-labor put together. But RNFE is very unequally distributed over households, mainly regressively, with the richer strata sharply dominant in higher paying skilled RNFE, and the top half of the population dominating the unskilled RNFE. The poorest tend to not only be relegated to mainly farming or farm wage-labor. If then RNFE is shown to be positively correlated in the regressions with intensification and crop diversification, then the sharply unequal access to RNFE can be said to correlate with diminished capacity of the poor to modernize their farming. We turn to that next.

Third, the econometrics showed, for the first time in the literature, the impact of the urbanization rate of the zone and the rural population density, as proxies for the overall transaction costs and economies of agglomeration, on RNFE, both skilled and unskilled. In addition, for the first time in the literature, we showed the positive impact of the agricultural commercialization rate of the zone on unskilled RNFE per se. This is important because these results taken together suggest that investments in cash cropping (of grains but more especially of horticulture), combined with investments in infrastructure, generate opportunities for income diversification that are relatively low entry barrier, the unskilled RNFE.

Fourth, while the findings here repeat the point made before in the literature that the poorest and smallest farmers tend to be the most dependent on farm wage-employment, we showed that the higher the commercialization rate of the zone, correlated with the more labor-intensive horticulture, the greater the opportunity for this work for the poorest.

Fifth, the greater the participation in skilled RNFE, the more reliance on hired labor – and thus creation of jobs for the poorest. Education and rural density produced similar effects. Greater participation in skilled RNFE also generated greater participation in horticulture, potentially interpretable as a skill transference effect.

Sixth, the greater the participation in unskilled RNFE (an income category for rural Guatemalans that is equal to the combined total income from own-cropping and farm wage-labor), the greater the tendency to intensify agriculture with external inputs. This effect was further magnified by the zone being a more commercial zone.

In sum, the results are positive and exciting in the sense that we demonstrate the presence of a "virtuous circle" of diversification of income and agriculture, commercialization, rur-urbanization, and income increases. The flip side of that result, however, is the concern that RNFE is relatively concentrated. Policies and programs that broaden the ability of the poor to have access to RNFE will have positive repercussions on farming and incomes.

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Table 1. Annual net income sources by household income quartiles for rural cropping-households in Guatemala in 2000

Quartile of total household income →	First		Second		Third		Fourth		Overall Sample
Number of observations	611		611		611		610		2443
1 On-farm income									
1.1 Crop income	16 (9%)	a	195 (27%)	b	326 (22%)	c	379 (10%)	c	229 (15%)
Share of households within the subsample (SHS)	100%		100%		100%		100%		100%
1.2 Livestock income	37 (22%)	a	87 (12%)	b	99 (7%)	b	104 (3%)	b	82 (6%)
SHS	70%		74%		75%		76%		74%
2 Off-farm income									
2.1 Agricultural wage employment	53 (31%)	a	222 (31%)	b	399 (27%)	c	556 (15%)	d	307 (21%)
SHS	27%		50%		56%		54%		47%
2.2 Skilled RNFE (self + wage) income	4 (2%)	a	17 (2%)	a	33 (2%)	a	296 (8%)	b	88 (6%)
SHS	2%		4%		6%		14%		7%
2.3 Unskilled RNFE (self + wage) income	39 (23%)	a	139 (20%)	a	508 (35%)	b	1840 (51%)	c	631 (42%)
SHS	24%		40%		58%		81%		51%
3 Not earned income									
3.1 Remittances	9 (5%)	a	23 (3%)	a	50 (3%)	a	333 (9%)	b	104 (7%)
SHS	6%		7%		9%		19%		10%
3.2 Other private transfers	6 (4%)	a	12 (2%)	a	10 (1%)	a	51 (1%)	b	20 (1%)
SHS	7%		9%		9%		10%		9%
3.3 Social assistance	4 (2%)	a	6 (1%)	a,b	10 (1%)	b	9 (0%)	b	7 (0%)
SHS	4%		6%		7%		8%		6%
3.4 Pensions	1 (1%)	a	11 (2%)	a	17 (1%)	a	47 (1%)	b	19 (1%)
SHS	0%		3%		3%		4%		3%
4 Total household income	169 (100%)	a	712 (100%)	b	1452 (100%)	c	3613 (100%)	d	1486 (100%)
5 Total income per capita	79		326		608		1493		627

a, b, c, d. show the differences among quartiles using Tukey-Kramer test at 10% significance level.

Table 2. Average daily wage (USD) and time worked by household income quartiles for rural cropping-households in Guatemala in 2000

Quartile of total household income →	First		Second		Third		Fourth		Overall Sample
Number of observations	611		611		611		610		2443
Agricultural wage	2.3	b	2.3	b	2.4	b	2.1	a	2.3
Time worked in agricultural wage (months)	1.5	a	5.7	b	6.7	c	8.5	d	5.6
Nonfarm skilled wage	0.7	a	1.2	b	2.0	c	4.8	d	3.2
Time worked in nonfarm skilled wage (months)	0.1	a	0.2	a	0.3	a	1.6	b	0.5
Nonfarm unskilled wage	0.9	a	1.6	b	2.5	c	3.7	d	2.6
Time worked in nonfarm unskilled wage (months)	0.8	a	2.0	b	5.3	c	12.0	d	5.0

a, b, c, d. show the differences among quartiles using Tukey-Kramer test at 10% significance level.

Table 3. Household Demographics, Education, and Non-agricultural assets of rural cropping- households in Guatemala: by household income quartiles in 2000.

		First		Second		Third		Fourth		Overall Sample
	Quartile of total household income →									
	Number of observations	611		611		611		610		2443
1	*Demographics and education*									
1.1	Age of head of household (HHH) (years)	42	a	43	a	43	a,b	45	b	44
1.2	Number of people in the household (HH) (unweighted)	4.0	a	4.3	a	4.5	b	4.8	b	4.4
1.3	Number of adults in HH (age between 14 and 60 years)	2.4	a	2.6	a	2.8	b	3.0	b	2.7
1.4	Female headed HH (percentage of HH)	12%	b	9%	a	9%	a	12%	b	10%
1.5	Average years of education in HH (taken over all members of the HH)	1.9	a	1.9	a,b	2.1	b	2.1	b	2.0
1.6	Years of education of head of HH	1.9	a,b	1.8	a,b	2.1	b	1.7	a	1.9
2	*Non-land assets and services*									
2.1	Total value of durables (USD)	231	a,b	155	a	241	b	347	c	243
2.2	Distance from HH to public bus stop (Kms)	5.5	a	5.4	a	3.1	a	3.4	a	4.3
2.3	Percentage of HH with electricity	44%	a	40%	a	44%	a	51%	b	45%
2.4	Percentage of HH with piped water	55%	a	50%	a	53%	a	56%	a	53%
2.5	Percentage of HH with cemented floor	27%	a,b	23%	a	31%	b,c	33%	c	28%
2.6	Percentage of HH with phone service	2%	a	1%	a	2%	a	3%	a	2%
2.7	Percentage of HH with vehicles	26%	a,b	22%	a	28%	b	35%	c	28%

a, b, c, d. show the differences among quartiles using Tukey-Kramer test at 10% significance level.

Table 4. Farming characteristics of rural cropping-households in Guatemala by household income quartile in 2000.

	Quartile of total household income →	First		Second		Third		Fourth		Overall Sample
	Number of observations	611		611		611		610		2443
1	*Farm characteristics*									
1.1	Total value of non-land agricultural assets (USD)	80	a	85	a	159	a,b	189	b	129
1.2	Household is landless (percentage of HH)	29%	a,b	31%	b	31%	b	24%	a	29%
1.3	Household rents in land (percentage of HH)	33%	b	35%	b	35%	b	29%	a	33%
1.4	Household borrows land (percentage of HH)	9%	a	13%	a	12%	a	11%	a	11%
1.5	Total land owned (hectares)	2.2	a	3.8	b	3.9	b	4.3	b	3.6
1.6	Percentage of HH with irrigation	1%	a	0%	a	1%	a	1%	a	1%
1.7	Total harvested (horticulture + beans & grains) area (Ha)	3.4	a	3.4	a	3.4	a	3.3	a	3.4
2	*Farm output produced*									
2.1	Total value of animals owned (USD)	99	a	127	b	134	b	128	b	122
	SHS	(77%)		(77%)		(82%)		(81%)		(79%)
2.2	Total production of beans and grains (MT)	1.2	a	1.6	a	1.7	a	1.6	a	1.5
	SHS	(93%)		(92%)		(92%)		(91%)		(92%)
2.3	Total production of horticultural crops (MT)	0.5	a	0.9	b	1.2	b,c	1.6	c	1.0
	SHS	(39%)		(52%)		(54%)		(58%)		(51%)
2.4	Agricultural commercialization rate at the HH	24%	a	32%	a	52%	a	63%	a	43%
	SHS	(51%)		(67%)		(70%)		(66%)		(64%)
2.5	Market surplus rate for beans and grains	19%	a	40%	a	31%	a	53%	a	36%
	SHS	(37%)		(50%)		(53%)		(48%)		(47%)
2.6	Market surplus rate for horticultural crops	51%	a	23%	a	41%	a	32%	a	37%
	SHS	(24%)		(36%)		(39%)		(40%)		(35%)
2.7	Yields of beans and grains (MT/Ha)	1.3	a	1.4	a	1.4	a	1.6	a	1.4
2.8	Yields of horticultural crops (MT/Ha)	2.2	a	3.4	a,b	3.1	a,b	3.9	b	3.2

a, b, c, d. show the differences among quartiles using Tukey-Kramer test at 10% significance level.

Table 5. Annual farm input use and municipality characteristics of rural cropping-households in Guatemala by household income quartile in 2000.

		First		Second		Third		Fourth		Overall Sample
	Quartile of total household income →									
	Number of observations	611		611		611		610		2443
1	*Farm annual input use*									
1.1	Imputed family labor expenditure (USD)	359	a	511	b	555	b,c	576	c	500
	Share of households within the subsample (SHS)	(75%)		(90%)		(88%)		(86%)		(85%)
1.2	Hired labor expenditure (USD)	36	a,b	29	a	40	a,b	43	b	37
	SHS	(43%)		(36%)		(42%)		(45%)		(41%)
1.3	Fertilizers expenditures (USD)	48	a,b	42	a	47	a,b	51	b	47
	SHS	(82%)		(78%)		(82%)		(84%)		(82%)
1.4	Pesticides expenditures (USD)	11	a	11	a	17	b	19	b	15
	SHS	(41%)		(41%)		(50%)		(46%)		(45%)
1.5	Seed expenditures (USD)	6	a	7	a	8	a,b	12	b	8
	SHS	(23%)		(23%)		(25%)		(25%)		(24%)
2	*Municipality characteristics*									
2.1	Agricultural commercialization rate	29%	a	33%	b	35%	b	34%	b	33%
2.2	Share of urban population	29%	a	28%	a,b	31%	b,c	32%	c	30%
2.3	Rural population density	129.7	b	115.0	a	129.2	b	137.2	b	127.8

a, b, c, d. show the differences among quartiles using Tukey-Kramer test at 10% significance level.

Table 6. IV probit results of determinants of participation in different types of off-farm employment by cropping households in rural Guatemala.

Type of off farm employment participation	Skilled nonfarm employment	Unskilled nonfarm employment	Agricultural wage employment
1. Prices			
1.1 Ln (agricultural wage rate (USD), by month at municipality level)	-0.025	0.235***	-0.051
	(0.103)	(0.066)	(0.068)
1.2 Ln (nonfarm skilled wage rate (USD), by month at municipality level)	0.364***	0.041	-0.025
	(0.082)	(0.058)	(0.059)
1.3 Ln (nonfarm unskilled wage rate (USD), by month at municipality level)	-0.287***	-0.044	0.123**
	(0.060)	(0.047)	(0.048)
2. Human capital assets			
2.1 Head of household (HHH) is female (yes=1, no=0)	-0.053	0.003	-0.242***
	(0.136)	(0.090)	(0.094)
2.2 Age of the HHH (years)	-0.000	-0.000	-0.004**
	(0.003)	(0.002)	(0.002)
2.3 Years of education of HHH	-0.019	0.013	-0.113***
	(0.025)	(0.016)	(0.018)
2.4 Household labor (number of adults in HH)	0.003	0.007	0.179***
	(0.028)	(0.019)	(0.020)
3. Farm capital			
3.1 Total land owned (Ha)	0.010	-0.003	-0.035***
	(0.007)	(0.005)	(0.005)
3.2 Total land squared	-0.000	0.000	0.000***
	(0.000)	(0.000)	(0.000)
3.3 Total value of livestock (USD 100's)	-0.007	0.005	-0.036**
	(0.024)	(0.015)	(0.016)
3.4 HH has irrigation in the farm (yes =1, no = 0)	0.313	-0.092	0.023
	(0.416)	(0.287)	(0.321)
3.5 Total value of agricultural assets (USD)	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
4. Non agricultural assets and access to services			
4.1 HH has electricity (yes = 1, no = 0)	0.206**	0.180***	-0.238***
	(0.094)	(0.060)	(0.061)
4.2 HH has piped water (yes = 1, no = 0)	-0.023	-0.005	-0.068
	(0.089)	(0.057)	(0.058)
4.3 HH has cement floor (yes =1, no = 0)	0.019	-0.074	-0.162**
	(0.095)	(0.063)	(0.065)
4.4 HH has a telephone or cellphone (yes = 1, no = 0)	0.515**	-0.043	-1.001***
	(0.233)	(0.199)	(0.285)
4.5 HH has a vehicle or motorcycle (yes = 1, no =	-0.146	-0.019	-0.088

	0)	(0.103)	(0.064)	(0.066)
5. Meso characteristics				
5.1	Agricultural commercialization rate (unit) by municipality	-0.786	0.622*	1.145**
		(0.680)	(0.389)	(0.475)
5.2	Agricultural commercialization rate squared	0.572	0.360	-1.706***
		(0.939)	(0.606)	(0.647)
5.3	Share of urban population at the Municipality level (unit)	0.306*	0.880***	-0.069
		(0.191)	(0.139)	(0.141)
5.3	Rural population density at the Municipality level (people/kms2)	0.001*	0.002***	-0.000
		(0.000)	(0.000)	(0.000)
6. Instrumented variable				
6.1	Household recieves remittances (yes =1, no = 0)	0.003	0.005	-0.014**
		(0.008)	(0.005)	(0.006)
	Constant	-1.884***	-1.308***	-0.164
		(0.550)	(0.359)	(0.367)
	Observations	2443	2443	2443
	Wald chi2 (22)	60.92	167.8	275.8
	Prob > chi2	0.000	0.000	0.000

Coefficients with asterisks (*,**,***) imply statistical significance at (10,5,1)% level.

Table 7. SUR estimation results[a] of input use by cropping households in rural Guatemala in 2000

	Input demands					Output Supply	
	Family Labor	Hired Labor	Seeds	Fertilizers	Pesticides	Beans & Grains	Horticultural Crops
1. Participation in off-farm employment							
1.1 Skilled non-farm	-1,822.228***	539.987***	59.602	77.552	-8.960	1.753	11.705*
	(690.435)	(153.460)	(42.927)	(78.894)	(40.482)	(7.168)	(7.316)
1.2 Unskilled non-farm	-124.915	-105.147***	44.210***	88.214***	18.973*	-1.114	2.499
	(151.179)	(32.203)	(10.338)	(18.440)	(11.145)	(1.474)	(2.556)
1.3 Agricultural wage	292.862***	-67.068***	-2.970	-40.848***	-11.563*	-0.216	-0.866
	(88.010)	(18.466)	(5.321)	(11.137)	(6.105)	(0.897)	(0.860)
2. Prices							
2.1 Ln (nonfarm skilled wage rate (USD), by month at municipality level)	62.279	-33.231***	2.024	3.701	0.519	-0.287	0.796
	(44.027)	(9.834)	(3.009)	(4.912)	(2.771)	(0.404)	(0.829)
2.2 Ln (nonfarm unskilled wage rate (USD), by month at municipality level)	-76.462**	27.184***	-0.952	-1.903	2.376	0.200	-0.791
	(34.804)	(8.230)	(2.325)	(3.955)	(2.195)	(0.342)	(0.678)
2.3 Ln (agricultural wage rate (USD), by month at municipality level)	-59.747**	-2.134	1.129	-11.191***	-1.507	-0.058	-0.219
	(28.279)	(5.915)	(2.208)	(3.363)	(1.964)	(0.200)	(0.378)
3. Human capital assets							
3.1 Household labor (number of adults in HH)	125.128***	2.727	0.492	6.047***	1.219**	0.119**	0.031
	(9.580)	(1.814)	(0.565)	(0.978)	(0.533)	(0.053)	(0.075)
3.2 Age of the HHH (years)	-0.345	0.080	-0.014	-0.035	-0.033	0.006	0.002
	(0.525)	(0.141)	(0.032)	(0.065)	(0.046)	(0.006)	(0.004)
3.3 Years of education of HHH	-9.547**	2.385***	0.640*	-0.310	0.126	0.016	0.013
	(3.911)	(0.907)	(0.380)	(0.500)	(0.327)	(0.029)	(0.042)
4. Farm assets							
4.1 Total land owned (Ha)	1.859	0.329	0.028	-0.100	0.173*	0.049***	0.037*
	(1.287)	(0.313)	(0.079)	(0.202)	(0.097)	(0.012)	(0.022)
4.2 HH has irrigation in the farm (yes =1, no = 0)	-160.538*	-9.020	-1.589	10.386	0.671	2.770	5.831*
	(93.651)	(36.588)	(4.777)	(11.777)	(7.707)	(2.096)	(3.151)

4.3 Total value of agricultural assets (USD)	-0.005	0.013***	0.001	0.002	0.000	0.000	0.000
	(0.025)	(0.005)	(0.003)	(0.006)	(0.002)	(0.001)	(0.001)
5. Non agricultural assets and access to services							
5.1 HH has a telephone or cellphone (yes = 1, no = 0)	75.097	-67.119***	4.267	-22.538**	-4.709	-0.098	1.812
	(97.129)	(23.171)	(8.377)	(11.169)	(8.494)	(1.023)	(2.301)
5.2 HH has a vehicle or motorcycle (yes = 1, no = 0)	-70.784***	19.527***	5.727***	4.397	8.127***	0.246	0.394
	(26.848)	(5.994)	(2.013)	(2.977)	(2.134)	(0.209)	(0.259)
5.3 Distance from household to main road (km)	-0.020	0.168*	-0.021***	-0.032*	-0.003	0.001	-0.001
	(0.248)	(0.093)	(0.004)	(0.017)	(0.017)	(0.002)	(0.001)
6. Meso characteristics							
6.1 Agricultural commercialization rate (unit) by municipality	167.351***	57.619***	37.976***	22.102***	38.346***	1.540***	2.790***
	(52.152)	(11.126)	(5.397)	(7.145)	(5.213)	(0.431)	(0.585)
Constant	499.303***	87.252***	-34.751***	42.643**	-12.913	1.553*	0.147
	(125.972)	(28.695)	(10.043)	(16.601)	(10.945)	(0.842)	(1.023)
Observations	2423	2423	2423	2423	2423	2423	2423
R squared (16)	0.246	0.090	0.092	0.075	0.091	0.052	0.158
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000

a. The standard errors reported are bootstrapped standard errors, to account for the estimation uncertainty introduced by using the predicted probabilities of participation in off-farm employment.

Coefficients with asterisks (*,**,***) imply statistical significance at (10,5,1)% level.