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Rural Nonfarm Employment and Farm Technology in Guatemala

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Abstract. This paper first analyzes the determinants of Guatemalan farmer participation in off-farm employment (in different activities, the lion's share of which is in local rural nonfarm employment (RNFE), as skilled RNFE and unskilled RNFE, and in agricultural wage employment (AWE)). The paper then analyzes how that participation in off-farm employment is correlated with farming technology and crop choice, in particular in terms of diversification into horticulture (versus traditional grain and bean farming). The paper uses a two stage regression model applied to rural data in the LSMS dataset collected in Guatemala in 2000. The key results are as follows. First, RNFE has a major share in farm household incomes, but is very unequally distributed over households; in particular larger farmers and farmers with higher farm assets (controlling for land) have more RNFE. Secondly, meso variables including urbanization rate of the district, rural population density, and the agricultural commercialization rate in a rural area are correlated with households having more RNFE. This suggests the presence of production and consumption linkages intersectorally. Third, households undertaking more RNFE tend to diversify more into horticultural crops, and use more fertilizer, seeds and pesticides. By contrast, households who do more AWE (and tend to be poorer and less educated with smaller farms) tend to hire less labor, and use fewer external inputs. These results overall suggest a virtuous triangle of income inter-sectoral diversification, agricultural diversification into higher value crops, and modernization of agricultural technology. This process appears to be spurred by overall development of agricultural markets and rur-urbanization. The concern is that this combination is uneven distributed, with the asset-poor participating least. This suggests policy interventions to help the poor have greater access to RNFE would spur diversification which helps incomes and manages risk, and technology modernization which spurs farm productivity.

Keywords. Guatemala, nonfarm employment, horticulture, technology

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1. Introduction

Pingali and Rosegrant (1995) posited the correlation of agricultural commercialization, agricultural diversification, and technological intensification via the increased use of external non-labor inputs and hired farm labor (agricultural wage employment), which Lele and Stone (1989) call "capital-led intensification". Reardon et al. (1994) further posited the correlation of the latter with rural nonfarm employment (RNFE). A 2009 issue of Agricultural Economics was devoted to exploring the links above links, in particular see Davis et al. (2009), Pfeiffer et al. (2009) for Mexico, Kilic et al. (2009) for Albania, Stampini and Davis (2009) for Vietnam, Oseni and Winters (2009) for Nigeria and Huang et al. (2009) for China. These papers tended to find off-farm employment is associated with capital-led intensification; Huang et al. (2009) was the only one to test the relation of RNFE and crop diversification (into fruit farming), and actually found a negative relation of substitution.

In this paper we extend the work from the above papers by focusing on the three way links among RNFE, capital-led intensification, and agricultural diversification into horticulture in Guatemala. We address the following three gaps in the above papers. (1) The above papers, and existing literature in general, does not systematically test the differential determinants of, and impacts on technology and crop composition of, different categories of off-farm employment – to wit, the three we note (skilled and unskilled RNFE and AWE). Skill levels, and sectors in which off-farm activity occurs, tend to be lumped together by the extant papers. We expect the different kinds of employment to differ in their determinants and impacts due to skill and other capital requirements to entry, and to complementarity or substitutability in terms of timing and thus labor use. (2) No paper tests the relation of all the three-way linkages we note; papers tend to focus on one or two of the links. (3) The papers do not address certain meso-level determinants we posit to be important, and to link to the debate on “rur-urbanization” and “territorial development” in Latin America on one hand (Schejtman and Berdegue (2003), and the production linkages perspective; we proxy these with urban share in the districts, the marketed surplus rate in the districts, and rural density of population.

This paper focuses on three research questions. (1) What are the differential determinants of farmers’ participation in skilled rural nonfarm employment (RNFE), unskilled RNFE, and agricultural wage employment (AWE) in rural Guatemala? (2) What effects do those three off-farm employment activities have on farm technology? (3) What effects do the off-farm employment activities have on crop composition, in particular diversification into horticulture?

We expect farm size and non-land assets to determine entry into off-farm employment, with a strong positive correlation with skilled RNFE, a moderate one for unskilled RNFE, and a negative correlation with AWE. These hypotheses are based on the entry requirements in terms of skill and other forms of capital.

We expect that income diversification will have an impact on technology use through the opportunity cost of labor and the wealth effect in the presence of presumed constraints on access to credit – but the effect is a priori ambiguous and requires empirical testing. We will test the direct effect, but not test the reason for the effect, which would require testing for the presence of a credit constraint that own-liquidity would relax.

Moreover, we expect that especially skilled RNFE but also unskilled RNFE will be associated with farmers undertaking horticulture, the most important agricultural diversification activity away from or in addition to low-remunerated staples (maize and beans). This is because liquidity from RNFE helps to meet input expenditure needs for horticulture before grain sales cash is available; horticulture is more intensive in external inputs than grain farming.

We address these three questions with data from the Living Standards Measurement Survey (LSMS) for 2000 in Guatemala.

The paper 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 5 concludes.

2. Behavioral and Econometric Models

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 supplied.

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's (1995) model with adaptations from Lopez (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:

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

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; 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);); $\bar{p}_i$ 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 assets that affect consumption decisions. z^q and z^h include nonfarm productive assets (because the maximization problem involves both farm and nonfarm activities) and consumption assets (as this is a non-separable household model, consumption and production decisions are decided jointly). For the labor allocation decision to work on 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):

$$q = q(p^*, z^q) \tag{4.2}$$

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 on farm (q_f), off farm (q_{of}), and in 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), transfers (S) and access to credit (K), then the equation 4.2 can be rewritten as follows:

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

Sadoulet and de Janvry (1995) show 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 then is an extension of equation 4.3:

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

Note that only "risk" does not map directly from the conceptual model (equation 4.3) to the implementation model. However, nonfarm employment is typically modeled as a function of risk as it is an instrument of risk management.

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 regressors are derived from the conceptual and implementation models noted above.

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 (have or not): 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.

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 used the share of households receiving remittances at the municipality level as an instrument.

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 IV probit model for the regressions, and we instrument remittances in each equation.

2.2. Modeling RNFE's Impact on Farm Technology

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:

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

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

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 cropped land. 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 (consumption 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 marketed surplus rate of the municipality. We will expect that as the agricultural commercialization rate increases, there is higher demand for variables inputs.

Estimation methods for technology correlates: Note that we call these regressions "technology correlates" because with a cross section data set, we cannot strongly posit causality, but just correlation. 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). We only use the rural portion of the data. After the exclusion of 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. Table 1 shows the income sources of sample households, stratified by household total-income quartiles. The salient points are as follows.

First, the average overall household income per capita is 600 US dollars. This can be compared with Guatemalan GDP/capita of 1558 dollars (in 1995 dollars) in 2000 (www.earthtrends.wri.org), showing thus the urban-rural income divide. There is sharp inequality; the Gini is 52% and the ratio of the richest to poorest quartiles' incomes is 21 to 1 – with the sharpest divide between the first two quartiles (4 to 1) and less difference over the others (with the other quartiles separated by 2 to 1 ratios).

Second, incomes are very diversified outside own-farming: the share of own-agriculture income (from crops and livestock) in total income is only 21%. This is similar to the 22% found by Ruben and van den Berg (2001) for Honduras, but below that in Nicaragua (42%) found by Corral and Reardon (2001). There is a sharp inverted-U in the share of own-cropping income as one goes from the poorest to the richest quartile, but a sharp descent in the share of livestock income. But crop income among the richest quartile is 23 times that of the poorest quartile, but only twice that of the 2nd quartile. Thus, as with overall income, there is a step function with the first step, the poorest, very low, and then the other steps well above the poorest but not far from each other. Livestock income also rises over the quartiles but only by a factor of 3.

Third, the corollary of the inverted-U shape of quartile income with own-agricultural income is a U shape of the share of off-farm income over quartiles. But the absolute level of off-farm income (total income less own-crop and livestock income) climbs quickly over quartiles, 30 times; off-farm income (with a gini of .63) is thus more concentrated than overall income (gini of .52), as is farm income (with a gini of .72), showing diversification in off-farm as partially compensating farm income inequality. Just the upper 25% of the rural population has 67% of the off-farm income earned in rural areas; the top half has 88%. These patterns (shares, levels, and concentration) are common in findings in surveys in Latin America and Asia, where poorer households enter low-paying off-farm jobs such as farm wage labor and low capital-entry-barrier nonfarm jobs, and the richer rural households dominate the higher-paying (and often more capital-intensive) nonfarm activities (Lanjouw and Lanjouw, 2001; Reardon et al. 2001).

Fourth, the share of farm wage-employment income (the lowest per day paid of the off-farm employment types) in total income is similar to that of own-farming, but less than half of the total share of RNFE. This finding echoes a number of similar findings elsewhere in Latin America (Reardon et al., 2001). Moreover, as in most other studies, this share drops as household income rises. This makes sense as farm wage labor is a low-entry requirement job. Despite the latter, however, the share of households doing this work rises from a quarter to half as one moves from the lowest to the second quartile and then stays steady as a share over other quartiles; moreover, while the upper two quartiles depend less on this activity, they earn 78% of the total earned in farm wage labor. Even this supposedly "refuge" off-farm employment is highly concentrated (gini of 75%).

Fifth, the overall share of RNFE in total income is 48%, similar to a Latin America-wide estimate from a review of studies provided by Haggblade et al. (2007). We decomposed it into skilled and non-skilled activity (self-employment and wage-employment), using specific activity categorizations as provided in the LSMS data set. We examine each.

On the one hand, skilled RNFE income is highly concentrated (with a gini of 97%). Its share is low (2% of income) for the first three quartiles and then inflects sharply upward (but only to 8% of income and 14% of households) in the highest quartile. The richest quartile is very dominant in the skilled RNFE labor market – earning 85% of the total.

On the other hand, unskilled RNFE is 42% of overall income, and is the most common income source of any income source. It is also however quite concentrated: its gini coefficient is 0.77, and its share in income rises from 20-23% for the first two quartiles to 35% for the third and 51% for the richest quartile. This pattern is common in Latin America and Africa (Haggblade et al. 2007; and Reardon et al. 2001). Despite the low skill requirement seeming to represent a low entry barrier to the poorest, the table shows that the richest quartile earns 77% of unskilled RNFE, and the top half of the income strata earn 93% of low-skilled RNFE. This may suggest barriers and requirements other than skill, such as capital investments, play a part in concentrating this income source. This 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 much public attention in sending areas focuses on migration as a source of income for rural households, only 10% of the households receive remittances, and it is only 7% of incomes, far less important than local RNFE. But this is a common research finding elsewhere in Latin America as well as Asia and Africa, explained by the capital entry requirements of migration (Haggblade et al. 2010; de Janvry and Sadoulet, 2001). Moreover, remittances are highly concentrated: the richest quartile earns 80% of the remittances. Pension distribution tells a roughly similar story.

Table 2 shows characteristics regarding demographics, education, and non-agricultural assets of the sample. Upper quartile households are slightly larger; but surprisingly, the average education barely differs over the quartiles – and is quite low, at several years. Consumer durables holdings, access to electricity and piped water increase with income, but far less steeply than does income; only about half the sample has access to the two latter. As this is 2000 (before the cell phone trend of the 2000s), access to phone service is slight. 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. However, only a quarter of households in the first three quartiles and only a third in the highest quartile have a car/truck or motorcycle.

Table 3 shows farm characteristics. Several points stand out.

First, the richest two quartiles have more than twice the non-land assets (such as farm machinery) of the poorest two quartiles. Two technology characterizations emerge. As household labor stocks are similar across quartiles, this means capital/labor ratios rise with household income. Moreover, as cropped land is similar over quartiles, this also means the capital/land ratio rises with 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.

Third, land ownership is relatively even at 4 ha across all quartiles but the poorest (who have 2.2), and cropped land is on average 3.4 ha. Note that nearly all the cropped land is merely rainfed and thus particularly exposed to production risk: the irrigation rate is extremely low – only 1% over all quartiles. So these farms are very small by irrigated-equivalent hectares. Moreover, livestock holdings vary little over quartiles, and 80% of the farms have livestock; the average holdings are just a pig and a few chickens.

Fourth, land use varies over quartiles, with more crop diversification (as horticulture) as income rises. While a steady 92-93% of the households grow the staples (beans and grains), there is sharp variation in horticulture: 39% of the poorest and 58% of the richest undertake it, and the average area rises from 0.5 ha to 1.6 ha over the income quartiles. The share of households growing horticulture crops is surprisingly high – 51% of the sample – belying a conventional image of small farm agriculture in Guatemala being maize-bean apart from pockets of commercial horticulture and some garden plots.

Fifth, marketed surplus rates for grain/beans display the "step function" that we saw in other assets; while almost all the poorest quartile grow staples, only 37% sell, with the marketed surplus rate of only 19%; they are thus mainly subsistence farmers; the share of farms selling in the upper quartile is 48% and the rate, 53%. The average for the sample is a rate of 36%, with only 47% of households selling, so in the staples food economy, farms are still semi-subsistence. By contrast, for those doing horticulture (row 2.6), the market surplus rate is double that of grains - around 68%, and varying little over strata. Thus horticulture is mainly "cash cropping." The last rows show that grain/bean yields differ little over strata (and are quite low), but horticulture yields rise in the familiar step function from lowest quartile, to the two middle quartiles, to double among the highest quartile.

Table 4 shows farm input use and district characteristics by household income quartile.

First, 93% of farm labor is family labor, with only 7% hired; these shares are similar across quartiles. But differential labor use over quartiles leads to the hired labor market being concentrated (the gini is .82). The labor/land ratio rises 60% over the quartiles; this may be partly explained by the higher share of labor-using horticulture in total cropping as one ascends income quartiles. While 82% of farms use fertilizer, the expenditure averages only 50 USD per farm (with a gini of 55%), or only about 70 kg/ha. By contrast, only 45% of the farms use pesticides, at 15 USD per farm (with a gini of .80), with a sharp correlation with household income; this is probably correlated with horticulture.

Second, the average marketed surplus rate is 33%, indicating a general situation of semi-subsistence. Surprisingly, this does not differ much when districts are stratified by household income quartile. The share of urban population in these mainly rural districts is about 30%, and population density in rural areas is about 128 persons/square km (similar to the country's average, but much more concentrated than most of the rest of Central America and Mexico, but much less than much of Asia). These district demographic measures do not differ much by household strata.

In sum, the descriptive tables yield two sets of images of the households of the sample.

On the one hand, regarding farm technology and crop composition, there is a somewhat flat distribution of cropped land at about 3.5 ha, and small holdings of livestock, but there is substantial variation (correlated with household income) in the share of horticulture, and the intensity of use of pesticides, farm capital, and labor. While the overall situation is one of semi-subsistence, there is substantial correlation of household income and crop marketed surplus rates.

However, there is little correlation of household income and district market surplus rate, rural population density, and urban share in the district.

On the other hand, 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.

Table 5 foreshadows descriptively and heuristically some key results that will be econometrically demonstrated below. The table's columns shows four combinations of households (roughly quarters of the sample households) ranged over pairs of low and high technology (defined by intensity of variable input use, apart from labor, per hectare) and low and high RNFE (defined by share of RNFE in total household income). Several points stand out.

First, there is surprisingly little variation in the share of horticulture in total cropped area over the four groups. This suggests that horticulture is undertaken with substitution over households between capital and labor.

Second, the table shows that there is a correlation (at the municipality level) of cropped area with low technology and low RNFE, suggesting an "extensive" system (land using, labor using), versus the extreme opposite, with cropped area some half of the first group's cropped area, for the group with high technology (capital intensive) and high RNFE (land saving, capital using technology). Interestingly, there is little difference over the four groups in terms of animal holdings; in Guatemalan rural areas outside of pockets of ranching, livestock husbandry does not appear as a major substitute for nonfarm activity and intensive cropping.

Third, the table shows that a dip in the crop marketed surplus rate among households with low farming technology and a high share of RNFE in total income; this suggests a group of households that have substituted off-farm activity for cropping income. The table shows that there is a clear correlation on the one hand between the urbanization rate of a municipality (as well as the rural density) and technology level of the farms, and controlling for technology level, a correlation with intensity of engagement in RNFE. Both these suggest that with great urban proximity and rural density, both associated with denser infrastructure, the labor market and the crop market are more developed.

Fourth, there is a striking correlation between incidence of the fourth group (high technology, high RNFE) with the richer regions, and the first group (low technology, low RNFE) with the poorer regions. This is as expected (although we did not expect the sharpness of the correlation) for the reasons of effective demand, perhaps access to capital, and transaction costs.

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. 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.

Moreover, an 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, and the propensity of RNFE to develop near urban areas. However, no 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 that 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 increase the incidence of skilled RNFE. However, contrary to expectation, neither farm size nor education has significant effect on skilled RNFE.

Second, the salient determinants of participation in unskilled RNFE are as follows. Participation in unskilled RNFE responds to the agricultural wage. This would point to farm wage labor and unskilled RNFE as being complements; this relation could be in reality indirect, as opportunities for unskilled nonfarm activity may abound in situations where agriculture is dynamic and inter-sectoral linkages occur, and at the same time increase the demand for hired farm labor.

In addition, a household's having access to electricity is correlated with unskilled RNFE, probably via facilitating cottage industry.

Moreover, an interesting result, and one not shown in any published article to date, is that unskilled RNFE participation is positively correlated with the marketed surplus rate of the municipality. This result is an extension, to the RNFE domain, of the findings by Pingali and Rosegrant (1995) of commercialized Green Revolution areas having higher hired agricultural-labor market participation. This could again suggest, like the result in the above paragraph, the presence of intersectoral production and consumption linkages leading to nonfarm employment. In addition, 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.

Third, the salient determinants of participation in agricultural wage employment are as follows. Consistent with the result in the unskilled RNFE regression, we find here that farm wage labor is positively influenced by the unskilled-RNFE wage, presumably with a similar interpretation.

Moreover, 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. 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. In addition, the results show that 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.

Furthermore, the results show that the smaller the farm, less access to electricity and communication (cell phone), the lower the value of the stock of livestock, and the household not receiving remittances, 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.

Finally, participation in farm wage-labor is positively correlated with the marketed surplus 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. Nonfarm Employment effects on Technology and Crop Choice

Table 7 presents the SUR estimation results of regressions explaining input use (family labor, hired labor, seeds, fertilizer, pesticide) and output supply (of beans, grains, and horticultural crops). We organize our discussion of results by determinant.

First, more participation in <u>skilled RNFE</u> is associated with sharply less use of family labor, more hired farm labor, and more supply of horticultural crops. This suggests that skilled RNFE households save their scarce and relatively highly paid labor for off-farm activity, and intensify cropping with hired labor, and undertaking commercial horticulture. This result contributes to the literature by showing the empirical relation of skilled RNFE with commercialization, farm employment-creating intensification, and crop diversification. This result contradicts the hypothesis that there is a 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.

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 Moreover, unskilled RNFE has a positive effect on horticulture (as found for example in China by Huang et al. 2009); this could be related to facilitating buying inputs at the start of the horticultural season, combined with possible credit constraints.

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 above 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. Their participation in horticulture is also lower; they are more staple grains oriented.

Fourth, technology and product choice are somewhat sensitive to relative prices and wages. 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. However, a higher unskilled 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), farmers access grain output markets. Interestingly, a higher farm wage induces less use of own-labor on-farm, which 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. Farms with larger cropped areas are shown to have great use of both labor and external inputs, and to have a greater tendency to horticulture. These results are at odds with a vision of medium farms being more grain oriented and using extensive technology. Rather, smaller farms tend to be more labor using and grain oriented, and medium farms using more intensive technology and crop diversification. This suggests that there are constraints to capital access for smaller farms.

Moreover, we find that lower shadow wage for labor (from more adult laborers in the household), the greater the tendency to labor on-farm. 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). Finally as expected, irrigation and horticulture are correlated.

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 market surplus rate of the municipality on farm technology and crop output mix. The effect is strongly positive and significant on all inputs and on both grains and horticulture. The relative effect on horticulture is greater, a point made above in our discussion of the descriptive correlates of the marketed surplus rate. This also supports empirically the hypothesis of the correlation of commercialization and agricultural diversification and intensification made by Pingali and Rosegrant (1995).

5. Conclusions

This paper first analyzes the determinants of Guatemalan farmer participation in off-farm employment (in different activities, the lion's share of which is in local rural nonfarm employment (RNFE), as skilled RNFE and unskilled RNFE, and in agricultural wage employment (AWE)). The paper then analyzes how that participation in off-farm employment is correlated with farming technology and crop choice, in particular in terms of diversification into horticulture (versus traditional grain and bean farming). The paper uses a two stage regression model applied to rural data in the LSMS dataset collected in Guatemala in 2000. The key results are as follows. First, RNFE has a major share in farm household incomes, but is very unequally distributed over households; in particular larger farmers and farmers with higher farm assets (controlling for land) have more RNFE. Secondly, meso variables including urbanization rate of the district, rural population density, and the agricultural commercialization rate in a rural area are correlated with households having more RNFE. This suggests the presence of production and consumption linkages intersectorally. Third, households undertaking more RNFE tend to diversify more into horticultural crops, and use more fertilizer, seeds and pesticides. By contrast, households who do more AWE (and tend to be poorer and less educated with smaller farms) tend to hire less labor, and use fewer external inputs. These results overall suggest a virtuous triangle of income inter-sectoral diversification, agricultural diversification into higher value crops, and modernization of agricultural technology. This process appears to be spurred by overall development of agricultural markets and rur-urbanization. The concern is that this combination is uneven distributed, with the asset-poor participating least. This suggests policy interventions to help the poor have greater access to RNFE would spur diversification which helps incomes and manages risk, and technology modernization which spurs farm productivity.

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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 HH 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%)
% of HHs	100%		100%		100%		100%		100%
1.2 Livestock income	37 (22%)	a	87 (12%)	b	99 (7%)	b	104 (3%)	b	82 (6%)
% of HHs	70%		74%		75%		76%		74%
2 Off-farm income									
2.1 Ag. wage employment	53 (31%)	a	222 (31%)	b	399 (27%)	c	556 (15%)	d	307 (21%)
% of HHs	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%)
% of HHs	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%)
% of HHs	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%)
% of HHs	6%		7%		9%		19%		10%
3.2 Other private transfers	6 (4%)	a	12 (2%)	a	10 (1%)	a	51 (1%)	b	20 (1%)
% of HHs	7%		9%		9%		10%		9%
3.3 Social assistance	4 (2%)	a	6 (1%)	a,b	10 (1%)	b	9 (0%)	b	7 (0%)
% of HHs	4%		6%		7%		8%		6%
3.4 Pensions	1 (1%)	a	11 (2%)	a	17 (1%)	a	47 (1%)	b	19 (1%)
% of HHs	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. 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 (% of HHs)	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	% of HHs with electricity	44%	a	40%	a	44%	a	51%	b	45%
2.4	% of HHs with piped water	55%	a	50%	a	53%	a	56%	a	53%
2.5	% of HHs with cemented floor	27%	a,b	23%	a	31%	b,c	33%	c	28%
2.6	% of HHs with phone service	2%	a	1%	a	2%	a	3%	a	2%
2.7	% of HHs with car or motorcycle	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 3. Farm 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 characteristics*									
1.1	Total value of non-land agricultural assets (USD)	80	a	85	a	159	a,b	189	b	129
1.2	HH is owned-land-less (% of HHs)	29%	a,b	31%	b	31%	b	24%	a	29%
1.3	Household rents in land (% of HHs)	33%	b	35%	b	35%	b	29%	a	33%
1.4	Household borrows land (% of HHs)	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	% of HHs with irrigation	1%	a	0%	a	1%	a	1%	a	1%
1.7	Total cropped land (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
	% of HHs	(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
	% of HHs	(93%)		(92%)		(92%)		(91%)		(92%)
2.3	Total output of horticultural crops (MT)	0.5	a	0.9	b	1.2	b,c	1.6	c	1.0
	% of HHs	(39%)		(52%)		(54%)		(58%)		(51%)
2.4	Marketed surplus rate of the HH	24%	a	32%	a	52%	a	63%	a	43%
	% of HHs	(51%)		(67%)		(70%)		(66%)		(64%)
2.5	Market surplus rate for beans and grains	19%	a	40%	a	31%	a	53%	a	36%
	% of HHs	(37%)		(50%)		(53%)		(48%)		(47%)
2.6	Market surplus rate for horticultural crops	51%	a	23%	a	41%	a	32%	a	37%
2.7	Market surplus rate for horticultural crops (non-zeroed out)	70%		65%		65%		68%		67%
	% of HHs	(24%)		(36%)		(39%)		(40%)		(35%)
2.8	Yields of beans and grains (MT/Ha)	1.3	a	1.4	a	1.4	a	1.6	a	1.4
2.9	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 4. Farm input use and municipality characteristics 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 hh within the subsample (% of HHs)	(75%)		(90%)		(88%)		(86%)		(85%)
1.2	Hired labor expenditure (USD)	36	a,b	29	a	40	a,b	43	b	37
	% of HHs	(43%)		(36%)		(42%)		(45%)		(41%)
1.3	Fertilizers expenditures (USD)	48	a,b	42	a	47	a,b	51	b	47
	% of HHs	(82%)		(78%)		(82%)		(84%)		(82%)
1.4	Pesticides expenditures (USD)	11	a	11	a	17	b	19	b	15
	% of HHs	(41%)		(41%)		(50%)		(46%)		(45%)
1.5	Seed (purchased) expenditures (USD)	6	a	7	a	8	a,b	12	b	8
	% of HHs	(23%)		(23%)		(25%)		(25%)		(24%)
2	*District characteristics*									
2.1	Marketed surplus rate (sales/output)	29%	a	33%	b	35%	b	34%	b	33%
2.2	Share of urban population in rural district	29%	a	28%	a,b	31%	b,c	32%	c	30%
2.3	Rural population density (persons/sq. km)	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 5. Characteristics of households with different technology-RNFE combinations by cropping households in rural Guatemala in 2000

	Technology / RNFE Combinations →	Low Tech / Low RNFE	Low Tech / High RNFE	High Tech / Low RNFE	High Tech / High RNFE	Overall Sample
	Number of observations	641	571	571	640	2423
1	Share of skilled RNFE over total RNFE income	9%	8%	4%	10%	9%
2	Share of horticultural area over total crop area in the farm	25%	24%	22%	24%	24%
3	Average crop area (ha) at the municipality level	4.4 [d]	3.7 [c]	3.0 [b]	2.4 [a]	3.4
4	Total value of animals (USD)	120	129	130	111	122
5	Market surplus rate (product sold / total production)	33% [b]	24% [a]	35% [b]	36% [b]	32%
6	Share of urban population over total population at the municipality level	22% [a]	28% [b]	31% [b]	38% [c]	30%
7	Rural density at the municipality level (persons/km2)	92.5 [a]	129.1 [b]	131.1 [b]	158.9 [c]	127.8
	Distribution of households by region:					
	Richer regions					
1	Metropolitan	13%	30%	5%	53%	100%
2	Central	6%	7%	32%	55%	100%
3	Southwest	18%	29%	22%	30%	100%
	Middle regions					
4	Northeast	24%	13%	41%	22%	100%
5	Northwest	23%	32%	22%	22%	100%
	Poorer regions					
6	Southeast	25%	19%	32%	24%	100%
7	North	50%	29%	13%	9%	100%
8	Peten	64%	15%	16%	4%	100%

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 RNFE	Unskilled RNFE	Agricultural wage employment
1. Prices				
1.1	Ln (agricultural wage rate (USD), by month at municipality level)	-0.032	0.234***	-0.048
		(0.103)	(0.066)	(0.068)
1.2	Ln (nonfarm skilled wage rate (USD), by month at municipality level)	0.357***	0.040	-0.023
		(0.082)	(0.058)	(0.059)
1.3	Ln (nonfarm unskilled wage rate (USD), by month at municipality level)	-0.278***	-0.042	0.119**
		(0.061)	(0.047)	(0.049)
2. Human capital assets				
2.1	Head of household (HHH) is female (yes=1, no=0)	-0.132	-0.014	-0.210*
		(0.156)	(0.105)	(0.109)
2.2	Age of the HHH (years)	-0.001	-0.000	-0.004**
		(0.003)	(0.002)	(0.002)
2.3	Years of education of HHH	-0.020	0.013	-0.113***
		(0.025)	(0.016)	(0.018)
2.4	Household labor (number of adults in HH)	0.008	0.008	0.177***
		(0.029)	(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)	-0.009	0.005	-0.035**
		(0.024)	(0.016)	(0.016)
3.4	HH has irrigation in the farm (yes =1, no = 0)	0.317	-0.093	0.024
		(0.413)	(0.288)	(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)	0.194**	0.178***	-0.235***
		(0.094)	(0.060)	(0.062)
4.2	HH has piped water (yes = 1, no = 0)	-0.022	-0.006	-0.067
		(0.089)	(0.057)	(0.058)
4.3	HH has cement floor (yes =1, no = 0)	0.014	-0.075	-0.160**
		(0.095)	(0.063)	(0.065)
4.4	HH has a telephone or cellphone (yes = 1, no = 0)	0.463*	-0.053	-0.981***
		(0.238)	(0.201)	(0.287)
4.5	HH has a vehicle or motorcycle (yes = 1, no = 0)	-0.149	-0.020	-0.086
		(0.102)	(0.064)	(0.066)
5. Meso characteristics				
5.1	Agricultural commercialization rate (unit) by municipality	-0.734	0.612*	1.119**
		(0.681)	(0.372)	(0.477)
5.2	Agricultural commercialization rate squared	0.555	0.357	-1.691***
		(0.938)	(0.606)	(0.647)
5.3	Share of urban population at the Municipality level (unit)	0.341*	0.886***	-0.081
		(0.206)	(0.140)	(0.143)
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 receives remittances (yes =1, no = 0)	0.024	0.009	-0.023
		(0.022)	(0.015)	(0.016)
	Constant	-1.675***	-1.263***	-0.249

	(0.590)	(0.386)	(0.393)
Observations	2,443	2,443	2,443
Wald chi2 (22)	62.76	168.0	275.1
Prob > chi2	0.000	0.000	0.000

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

Table 7. SUR estimation results 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	-1,863.759***	459.523***	-59.640	-114.862	-27.919	-4.730	15.004*
	(631.614)	(141.708)	(43.118)	(77.083)	(40.372)	(6.790)	(8.243)
1.2 Unskilled non-farm	-112.985	-57.124*	44.021***	112.400***	29.561***	0.381	4.287*
	(131.782)	(29.854)	(10.185)	(18.568)	(11.196)	(1.606)	(2.320)
1.3 Agricultural wage	245.935***	-60.258***	-3.798	-30.163***	-12.809**	-1.067	-1.296*
	(75.705)	(17.951)	(4.787)	(9.628)	(6.244)	(0.964)	(0.755)
2. Prices							
2.1 Ln (nonfarm skilled wage rate (USD), by	66.992	-27.998***	2.059	5.828	1.865	-0.049	1.038
month at municipality level)	(40.998)	(9.023)	(2.990)	(4.973)	(2.596)	(0.395)	(0.790)
2.2 Ln (nonfarm unskilled wage rate (USD), by	-78.489**	22.576***	-0.949	-4.092	1.310	0.038	-0.975
month at municipality level)	(31.768)	(7.433)	(2.278)	(3.925)	(2.161)	(0.331)	(0.625)
2.3 Ln (agricultural wage rate (USD), by month at	-63.122**	-6.602	1.109	-13.103***	-2.620	-0.247	-0.417
municipality level)	(27.641)	(5.835)	(2.214)	(3.384)	(2.028)	(0.195)	(0.394)
3. Human capital assets							
3.1 Household labor (number of adults in HH)	125.983***	0.930	0.521	4.948***	0.897	0.091*	-0.018
	(9.824)	(1.680)	(0.584)	(0.958)	(0.613)	(0.048)	(0.065)
3.2 Age of the HHH (years)	-0.529	0.025	-0.017	-0.038	-0.055	0.000	-0.002
	(0.509)	(0.131)	(0.035)	(0.065)	(0.044)	(0.006)	(0.004)
3.3 Years of education of HHH	-10.978***	2.019**	0.619*	-0.294	-0.030	-0.024	-0.019
	(3.858)	(0.901)	(0.373)	(0.498)	(0.337)	(0.033)	(0.047)
4. Farm assets							
4.1 Total cropped area (Ha)	6.171**	4.213***	0.068	1.357***	1.218***	0.243***	0.229***
	(2.961)	(0.819)	(0.216)	(0.441)	(0.280)	(0.047)	(0.048)
4.2 HH has irrigation in the farm (yes =1, no = 0)	-161.078*	-9.321	-1.596	10.303	0.578	2.750	5.813*
	(89.513)	(35.948)	(5.239)	(11.884)	(7.842)	(2.057)	(3.366)
4.3 Total value of agricultural assets (USD)	-0.006	0.012***	0.001	0.001	0.000	0.000	0.000
	(0.023)	(0.004)	(0.003)	(0.005)	(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 =	64.172	-59.517***	4.026	-16.798	-3.757	-0.142	1.915
0)	(92.283)	(22.552)	(7.969)	(10.653)	(8.414)	(0.974)	(2.090)
5.2 HH has a vehicle or motorcycle (yes = 1, no =	-71.977***	19.394***	5.709***	4.503	8.032***	0.216	0.372
0)	(24.716)	(5.652)	(1.806)	(2.857)	(2.094)	(0.189)	(0.262)
5.3 Distance from household to main road (km)	-0.027	0.165*	-0.022***	-0.032*	-0.004	0.001	-0.001
	(0.248)	(0.096)	(0.004)	(0.018)	(0.017)	(0.002)	(0.001)

Constant	518.094***	76.286***	-34.353***	33.910**	-14.115	1.682**	0.041
	(123.230)	(28.826)	(9.857)	(15.965)	(11.426)	(0.834)	(1.134)
Observations	2,423	2,423	2,423	2,423	2,423	2,423	2,423
Share of observations with value=0	15%	59%	76%	18%	55%	7%	49%
R squared (16)	0.246	0.106	0.092	0.081	0.100	0.067	0.192
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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