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ABSTRACT

In this study we analyze the degree of output diversification (anything produced in the farm that is not a subsistence crop, i.e., corn or beans) among 520 hillside farmers in El Salvador. Half of those farmers have participated in the Environmental Program for El Salvador (PAES) implemented between 1998 and 2005. This study is an ex-post evaluation of PAES for which there was no baseline and no randomized control group. Therefore, quasi-experimental techniques were applied to select the treatment and comparison groups after the intervention occurred. Matching techniques were employed to construct a comparison group that resembles the treatment group based on observed characteristics while statistical controls were applied to measure differences on diversification for the treatment group at two points in time (2002 and 2005) and between the treatment and comparison groups at a given point in time (2005), allowing for before-after and with-without comparisons.

Count regression models are used to econometrically estimate diversification, while Probit models evaluate factors associated with disadoption of a diversified cropping system over the 2002-2005 period. Overall, more diversified farm plans are positively associated with farm size, schooling, participation in communal organizations, and with the frequency of extension visits, which captures the PAES intervention. Also, farmers involved with PAES have significantly increased the number of agricultural activities in their farms between 2002 and 2005. The Probit model estimated to examine disadoption indicates that schooling, frequency of extension visits, erosion perception and participation in communal organizations are significant contributors to reducing the probability of disadoption of diversification. In turn, disadoption is significantly associated with farm size and land tenure.

INTRODUCTION

El Salvador is the smallest country in Central America with 21,476 km^2, and it is also one of the most densely populated in the region with 292.5 inhabitants per km^2. El Salvador has also one of the lowest social indicators scores in Latin America, and still faces social conflicts as a consequence of 12 years of civil war (World Bank, 2006; Pelupessy, 1997). These problems are more severe in the rural areas, mainly among poor people, who are least able to cope and are caught in a seamless web of deteriorating conditions (UNDP *et al*., 2002). In fact, up to 25% of the Salvadorian population lives on less than a dollar per day and 65% of the poor live in rural areas (ODI, 2003).

Peasant farmers in El Salvador typically grow subsistence crops -mainly corn and beans- in sloping and marginal uplands. The development path has usually involved the migration of poor or landless farmers to public or open-access lands, who then clear forest areas, and cultivate staple crops for a few years, before moving on to clear new plots. As migration increases and the pool of available land declines, farmers use land more intensively. Those unable to purchase agrochemicals face declines in soil fertility and productivity, and farming becomes unsustainable (Neill and Lee, 2001). For many resource-poor farmers, soil degradation exacerbates the continuous struggle for food security. Production increases of the two main staple foods, corn and beans have historically been below that of population growth (Arellanes and Lee, 2003).

To respond to this deteriorating situation, the Salvadorian government with the support of international organizations has undertaken a series of public investments focusing on poverty reduction in rural areas. Among these investments, the Environmental Program for El Salvador (PAES) has been developed with the goal of improving household income through improved soil productivity, the adoption of conservation technologies and product diversification (Bravo-Ureta *et al*., 2003; Bravo-Ureta *et al*., 2006a)

Although systematic extension programs have promoted crop diversification for years, studies analyzing the adoption of diversified cropping patterns are rare. Thus, the objective of this study is to analyze the factors associated with output diversification among hillside small-scale farmers in El Salvador. Furthermore, recent literature on technology adoption in less-developed areas has shown the presence of an adoption/disadoption process. Specifically, it has been found that successful cases of adoption of a new technology are often followed by disadoption (Abdulai and Huffman, 2005; Neill and Lee, 2001). Thus, this study also evaluates the factors associated with the disadoption of diversified cropping systems using Probit regressions.

The rest of this paper is organized as follows. The next section gives an overview of the literature, followed by a discussion of the methodological framework and a description of the data used. The empirical results are presented and analyzed in the subsequent section, and the paper ends with some concluding remarks.

I. REVIEW OF THE LITERATURE: DIVERSIFICATION *VERSUS* SPECIALIZATION

Fifty-four years have passed since Earl Heady noted that "the topic of diversification as a means of handling uncertainty is an old one in agricultural economics" (Heady, 1952, p. 483). Since the early work by Heady (1952) and Markowitz (1959), attention has focused mainly on mean-variance portfolio approaches (e.g., Stovall, 1966; Johnson 1967). Indeed, an important goal of diversification in agriculture is to reduce the risk of the overall return by selecting a mixture of activities whose net returns have a low or negative correlation. Thus, the aim should be to find the risk-efficient combination of farming activities, not the one that merely minimizes variance (Culas, 2003). Usually, farm-planning models solved by quadratic risk programs and based on the portfolio selection framework, have been used to find such combination of farming activities (Hazell, 1971; Chen and Baker, 1974).

Crop diversification strategies have been incorporated in several development programs worldwide to improve household income in less-developed areas (Papademetriou and Dent, 2001). The rational for diversification strategies is based on the following grounds: i) business risk reduction by lessening price fluctuations; ii) production stabilization, by reducing potential pest and diseases; iii) food security, by offering farmers and their societies access to sufficient, nutritious and safe food; and iv) environmental protection, since some specific crop mix can also be used as soil conservation strategies (Caviglia-Harris and Sills, 2005; Kurosaki, 2003; Papademetriou and Dent, 2001; Yao, 1997).

Recently, the issue of diversification has gained renewed interest, not least due to the liberalization of agricultural policies and the globalization of agricultural markets. Market interventions in the past have caused domestic prices to vary considerably less than international prices. Now, as domestic prices start following international signals more closely, farmers are forced to consider the implications of larger fluctuations in commodity prices (Weiss and Briglauer, 2000).

Various factors, beyond risk considerations, are important in the decision to specialize or diversify farm production. The most extreme form of specialization is monoculture and most of the literature on this subject relates to the developing world, although monoculture is common in the developed world. Specialization on large farms is often attributed to economies of scale but Chaplin (2000) has identified a more comprehensive set of reasons that might explain varying levels of specialization and diversification. First, available resources (i.e., soil type, local climate, water availability, etc.) affect the opportunities for cropping and livestock rearing. Also, farmers have varying levels of knowledge and expertise about specific production activities and farm plans outside this knowledge base are riskier. This implies that areas with a history of monoculture will tend to remain specialized. Second, the extent of diversification in domestic and world markets will influence the production mix. A poorly diversified market will propagate monoculture. In addition, government intervention, such as subsidies, influences a producer's output mix in favor of those commodities that enjoy preferential treatment. Third, market access restrictions reduce the range of commodities produced, increasing the propensity for monoculture. Fourth, the prevailing infrastructure in rural areas affects the availability of inputs and market access. Thus, poor infrastructure may limit the production mix and increase the tendency towards monoculture. Fifth, historical factors such as colonization, which created plantations and left an infrastructure and resources biased towards monoculture, increase the propensity to specialization.

Several concerns have been raised over possible adverse effects of the transformation of agriculture through income diversification, including household welfare, regional income distribution, market risks and resource sustainability. Von Braun (1995) argues that shifts from low input subsistence production to crops relying on purchased inputs to supply external markets have tended to benefit the poor by directly generating employment and increased labor productivity. However, von Braun cautions that while diversification by itself rarely has adverse consequences on household welfare, diversification combined with failures of institutions, policies, or markets can be damaging.

In principle, a switch from monoculture to a diversified farm production plan can reduce both production and price risk (Pingali and Rosegrant, 1995). In practice, however, production diversification usually does not reduce price risk significantly because commodity prices exhibit similar reaction patterns to aggregate, worldwide and macroeconomic shocks, and thus tend to be positively correlated (Quiroz and Valdés, 1995). On the supply side, diversification-led improvements in infrastructure and market integration increase product substitution, thereby increasing price correlations. Therefore, "the more each unit of production is diversified, the more positive the correlation between prices and the lower the gains to diversification" (Quiroz and Valdés, 1995, p. 251). Nevertheless, Chaplin (2000) posits that this argument is only applicable when diversification occurs within the primary production of food and fiber. If diversification combines non-agricultural with agricultural activities, then there is little or no price correlation between the activities and thus risk reduction through diversification can be obtained. This is particularly so in the case of diversification by holding off-farm employment which stabilizes the variability in agricultural income (Barlett, 1991; Kimhi and Bollman, 1999).

During the late 1960s and early 1970s, much was written to document the benefits of diversification; more recently this trend has reversed. This is partly due to the fact that diversification may have both value-enhancing and value-reducing effects so the net effect is ambiguous (Chaplin, 2000). Despite the frequent observation that diversification plays an important role in agriculture, there are few studies that explicitly relate income with farm diversification. Most of the econometric studies available are confined to the U.S. situation and focus on the relationship between diversification and farm size (Weiss and Briglauer, 2000). White and Irwin (1972) compare diversification across farm size clusters using U.S. census data and conclude that larger farms are more specialized. In contrast, Pope and Prescott (1980) found a strong and positive relationship between diversification and size among Californian crop farms. Sun *et al*., (1995) distinguish between different 'stages of diversification', which are likely to influence the relation between size and diversification.

Changes in land use can have substantial consequences for farmers' welfare as well as the environment. For instance, conversion of a forest or pasture into irrigated cropland may increase farmers' income, but may also increase soil erosion, reduce plant bio-diversity, or lead to environmental pollution. Land use decisions are generally viewed as a function of both macro- and micro-level processes (Bergeron and Pender, 1999). The effects of macro-level factors, such as agricultural policies, markets, trade, aggregate population growth, and technological change, on land use decisions have been relatively well studied (Geist and Lambin, 2001; Capistrano and Kiker, 1995; Turner *et al*, 1995). However, the effects of micro-level factors, such as social and economic conditions of the household and the community, have received little attention in the literature (Bergeron and Pender, 1999).

II. METHODOLOGICAL FRAMEWORK

In this section the strategy followed to analyze the farm-level impacts associated with PAES is discussed. The evaluation of impacts relies on the construction of a counterfactual situation to examine what would have happened to a group of beneficiaries had they not participated on a given project. The counterfactual outcome is never actually observed as people cannot simultaneously participate and not participate in a project. To generate counterfactual data it is necessary to establish a control or comparison group (those who do not participate or receive benefits) to compare it with the group under intervention. If there is data for a control group then "with and without" project comparisons are possible. Ideally, data for impact evaluation would be collected from the same set of households at least twice, before and after the intervention. Beneficiaries can also be compared before and after the intervention if baseline and follow-up data are available. Even if only post-intervention data are available, it is still possible to conduct a sound evaluation by choosing an appropriate evaluation design (Adam, 2006; Prennushi *et al*., 2000)[1].

A variety of econometric approaches have been used to model technology adoption. One such approach is to group technologies into packages and to assume that farms make a single decision about whether or not to adopt the entire package (Rahm and Huffman, 1984). A second approach is to assume that farmers make independent decisions about each technology (Fletcher and Terza, 1986). Both approaches rely on probit or logit models and both have drawbacks. While the package approach does not shed light on differences in decision-making across individual technologies, the independent-decisions approach ignores jointness in farmers' decisions to adopt such technologies (Blackman and Kildergaard, 2003). Moreover, the use of binomial models requires artificially lumping adoption levels into two categories (1=full adoption, 0=no adoption) which, according to Ramírez and Shultz (2000), induces measurement errors.

To mitigate these problems, crop diversification in this study is examined using count regression models. Recent applications of this approach to model technology adoption are found in Mbaga-Semgalawe and Fomer (2000), and Ramírez and Shultz (2000), while Van Dusen and Taylor (2003) employ it to model genetic crop diversity and Faria and Fenn (2003) to analyze industrial technology adoption. The dependent variable is the number of products (excluding maize and beans) in the farm plan implemented during the agricultural year for which the data are available. In this framework,

[1] For a more detailed discussion of the strategy used see Bravo-Ureta *et al*., (2006b).

diversification is the realization of nonnegative integer-valued random variables, i.e., farms can have zero, one, two, or *n* products (Cameron and Trivedi, 1998).

Two commonly used count data models are the Poisson and the Negative Binomial models (Cameron and Trivedi, 1998). These models can be linked to a theoretical household model through a random-utility type framework involving a series of discrete decisions of whether or not to diversify (Van Dusen and Taylor, 2003; Hellerstein and Mendelsohn, 1993). The usual way to deal with the discrete nature of a dependent variable is to consider the Poisson regression model where the number of products, *y*, is generated by the Poisson process

$$(1) \qquad Prob(Y = y) = \frac{e^{-\mu}\mu^{y}}{y!}, \quad y = 0,1,2,...$$

where μ is the conditional mean and variance of the Poisson distribution. The equality of the first two conditional moments (i.e., the mean and the variance) is a distinguishing property of Poisson models. The parameter μ depends on a set of explanatory variables ***X***, and the most common formulation for μ is the log-linear model, $\ln\mu=\beta'\boldsymbol{X}$, where β is a 1 by *k* vector of parameters and ***X*** is a *k* by 1 vector of independent variables (Greene, 1997). It can be shown that the expected number of products is given by (Ramírez and Shultz, 2000; Greene, 1997):

$$(2) \qquad E(y_i) = Var(y_i) = \mu_i = e^{\beta' X_i}, \quad i=1,\dots,n$$

where *n* is the number of observations.

The Poisson model requires that the mean and variance be equal to each other. Therefore, if the variance is higher (overdispersion) or lower (underdispersion) than the mean, then the Negative Binomial is the recommended alternative, wherein the variance is specified to be a function of the mean, such as

$$(3) \qquad \omega_i = \mu_i + \alpha\mu_i$$

for some specified function $\omega(\cdot)$ and where α is the *dispersion parameter* to be estimated. The Poisson model is a special case of the Negative Binomial when $\alpha = 0$ (Cameron and Trivedi, 1998). Failure of the Poisson assumption of equidispersion has similar qualitative consequences as the failure of the assumption of homoskedasticity in the linear regression model. Simple comparisons of sample means and variances can produce an indication of the magnitude of over- or under dispersion of the dependent count variable.

The recommended practice is to estimate both the Poisson and the Negative Binomial model, and to perform a Wald test using the reported *t* statistic for the estimated α in the Negative Binomial model (Bierens, 2005). An additional test proposed by Cameron and Trivedi (1998) is based on the assumption that the Poisson model consistently estimates the conditional mean and that the following expression

$$\frac{(y_i - \hat{\mu}_i)^2 - y_i}{\hat{\mu}_i} = \alpha\hat{\mu}_i + \mu_i \quad (4)$$

has mean zero, where y_i is the dependent variable and $\hat{\mu}_i = \exp(x_i \hat{\beta})$ is the predicted value from the Poisson model and μ_i is an error term. The test is performed by estimating equation (4) as an auxiliary OLS regression without intercept. The reported *t* statistic for α is asymptotically normal under the null hypothesis of no dispersion.

The Poisson and the Negative Binomial models are non-linear regressions. Thus, the estimated coefficients do not have the same interpretation as in the case of linear models; i.e., a coefficient does not measure the change in the conditional mean resulting from a unit change in a specific regressor. Instead, the impact of a change in a regressor is a function of the values of the regressors across observations. According to Cameron and Trivedi (1998), one may directly interpret the coefficient of a Poisson or Negative Binomial regression as a semielasticity. This can be seen by taking the derivative of equation (2) with respect to any explanatory variable x_j, which yields:

$$\frac{\delta E(y_j)}{\delta x_j} = \beta_j \exp(\mathbf{x'\beta}) = \beta_j E(y_j) \quad (5)$$

since $E(y_j) = \exp(\mathbf{x'\beta})$, according to equation (2). Rearranging equation (5) results in:

$$\beta_j = \frac{\delta E(y_j)}{\delta x_j}\frac{1}{E(y_j)} \quad (6)$$

where β_j is a semielasticity that can be interpreted as a percentage change in the conditional mean when the explanatory variable x_j changes by one unit. In the case of *dummy* variables, the semielasticities are measured by taking the difference between the value of β_j when the *dummy* variable equals 1 and when its value equals 0 holding all other variables at their mean values (STATA, 2003).

Very few studies have focused on the factors associated with farmers' decision to abandon or disadopt new production activities. Thus, in addition to count data models, a disadoption model is also developed in this study. In this case, the disadoption indicator is calculated as a binary variable which equals one if the number of agricultural activities included in the farm plan is smaller in 2005 than in 2002, and zero otherwise (Neil and Lee, 2001). Consistent with the literature, the output diversification and disadoption models will be expressed as a function of different sets of variables including household and farm characteristics and project specific attributes, such as extension and training activities, and years of participation. The disadoption models are estimated using probit regressions.

III. DATA

The data used in this study consist of detailed information obtained from surveys applied to representative samples of small scale farm households in El Salvador. The data set covers a wide range of variables including attributes of the households, land tenure status, inputs used and outputs produced, prices paid and received, technology adoption, soil conservation practices implemented, non-farm sources of income, and access to services such as formal education, credit, training, extension, and technical assistance. First, a sample of households participating in PAES was surveyed in 2002. These data were collected and analyzed by Bravo-Ureta *et al*., (2003), as part of a Technical Cooperation between the Office of International Affairs (OIA) at the University of Connecticut (UConn) and the Inter-American Development Bank (IDB). For the purpose of the current study, a sub-sample of the 2002 survey was re-surveyed in 2005, this time along with a control group of non-participating families. For a detailed discussion of the fieldwork and data set see Bravo-Ureta *et al*., (2006b).

The farmers in this sample reported a total of 24 different production items (corn, beans, eggs, poultry, sorghum, coffee, citrus, milk, hogs, mango, avocado, banana, bovines, sugarcane, white cocoa, tomato, cucumber, cabbage, watermelon, rice, yucca, pineapple, chili, and papaya). The number (count) of crops, beyond corn and beans, is used to construct the variable diversification.

An alternative measure of diversification is the entropy index (*EN*), which weighs the value shares of a farm's activity by the log of the inverse of the respective shares (Culas, 2003), and can be expressed as:

$$(7) \qquad \text{EN} = \sum_{i}^{n} P_i \log \frac{1}{P_i}$$

where P_i is the share of crop i on total farm income. This index takes the value of zero when the farm is completely specialized, whereas the maximum diversification is given by EN=log(n) (Weiss and Briglauer, 2000). The entropy models are estimated by OLS and the results are compared with those from the count models.

Table 1 displays variable definitions as well as their means. This table also includes the statistics for the tests of mean differences for the different groups included in the analysis. The data are disaggregated by survey year (2002 and 2005) and groups under analysis (i.e., PAES beneficiaries, neighbors and non-neighbors). The tests of means reveal that the PAES beneficiaries have increased significantly the number of crops in their farm plans between 2002 and 2005. Moreover, the data clearly show that beneficiaries have significantly higher rates of adoption than neighbors and non-neighbors in 2005.

IV. EMPIRICAL RESULTS

A. Farm Diversification

Table 2 and 3 show the estimates of farm diversification among PAES beneficiaries in 2002 and 2005 and among beneficiaries and the control group in 2005, respectively. Results using count (Negative Binomial) and entropy (OLS) are shown for comparison. Overall, both techniques yield very similar patterns. The following analysis is based on the count model since it is easier to interpret.

As indicated in Section 3, the Cameron and Trivedi (1998) test (equation 4) was used to evaluate whether the data were over- or under-dispersed in order to select the appropriate count model (Poisson vs. Negative binomial). The result of this test in all estimated models indicates that the dispersion coefficient α is significantly different from zero. Therefore, the null hypothesis of equidispersion is rejected, implying that the Poisson model is more appropriate in this situation than the Negative Binomial model.

Two Wald tests are used to check for structural differences among the estimated models (Link *et al.*, 2001; Bai and Peron, 1998). The calculated χ^2-tests reject both null hypotheses indicating that beneficiaries between 2002 and 2005, and beneficiaries and control group in 2005 do not have the same parameters at the 1% level of significance. Thus, treating the data as separate subsamples (i.e., Models 2002 and 2005 in Table 2 and Models Beneficiaries and Control in Table 3) is more suitable than assuming that the model parameters are the same across groups (Model Pooled in both tables).

Overall, the farm diversification models perform fairly well and consistently across models. The likelihood ratio test reveals that jointly all slope coefficients are statistically different from zero at the 1% level in all models. Individually, approximately 40% of all parameters are statistically different from zero and their signs are generally consistent with expectations.

Variables that can be associated with human capital tend to have a significant and positive association with diversification (frequency of extension visits, social organizations and education). Land ownership is also positively related with diversification in more than half of the estimated models. Farm size presents a positive but decreasing link with output diversification since its first degree parameter is positive and larger than the quadratic parameter which is negative. The interaction of the binary variables for non-neighbor and participation in social organizations is also positive and mostly significant, suggesting social and communal organizations are a good channel for spreading new technologies for those who are not PAES participants.

Another important result is that PAES beneficiaries increased output diversification significantly between 2002 and 2005, as revealed by the positive coefficients for the dummy for Year in the 'beneficiaries pooled' models presented in Table 2. This result is consistent with the tests of means for 2002-2005 reported in Table 1.

In line with Weiss and Briglauer (2000), and Pope and Prescott (1980), all the diversification models include off-farm income as an explanatory variable. Since smaller farms are more likely to have off-farm earnings the effect of farm size is expected to be biased upwards when off-farm employment is ignored (Weiss and Briglauer, 2000). In our case, off-farm income presents a positive but non significant correlation with diversification.

Table 4 presents semielasticities calculated, as indicated in Section 3, at the mean of the data for the dominant models based on the results obtained from the Wald tests. For example, the elasticity of 0.0946 for land in the first column of Table 4 indicates that a 10.0% increase in cultivated land would lead to a 0.946% increment in the number of agricultural activities in the farm plan. Overall, the variables affecting output diversification the most are labor, off-farm income and the number of years associated with PAES. In addition, the elasticity analysis suggests that for the control group farm size and land tenure play key roles in output diversification.

B. Disadoption

Table 5 presents the Probit estimates of the disadoption model for PAES beneficiaries. As defined earlier, in the Probit model the dependent variable is equal to one if in 2005 the farm has decreased the number of agricultural outputs with respect to 2002. Therefore, a positive (negative) coefficient indicates that the corresponding variable is positively (negatively) associated with the probability of disadoption (adoption). The null hypothesis that all coefficients are simultaneously zero is rejected at the 5% significance level while the percentage of correctly predicted responses is equal to 79.1%.

The results indicate that education, frequency of extension visits, erosion and social participation have a significant negative impact on the probability of disadopting a more diversified farm plan. These results suggest that human capital is essential in defining the level of output diversification in the farm. In turn, farm size and land tenure exhibit a significant positive association with the probability of disadoption.

Table 5 also displays marginal effects (ME), which measure the change in the probability of adoption due to a one unit change of a specific explanatory variable. Marginal effects (M.E.) for the continuous variables in the Probit models are equal to:

$$\text{M.E.} = \phi(\delta Z)\delta \qquad (8)$$

where ϕ is the probability density function, Z is the vector of exogenous variables and δ are the estimated parameters (Madalla, 1983). The marginal effects are measured at the mean value of the regressors. Marginal effects for the *dummy* variables are measured by taking the difference between the value of the prediction when the dummy variable equals 1 and when it equals 0 again holding other variables at their mean values (STATA, 2003).

The largest marginal effect is found for participation in social organizations, followed by education and erosion perception. Other things being equal, the participation in a social organization is associated with an 11.2% increase in the probability of adopting an additional agricultural activity in the farm, while an additional year of education and a high level of perception of erosion problems in the farm increase the same probability by 5.5% and 8.1%, respectively. The significant effect associated with an extra year of schooling is in line with the robustness of the empirical evidence on the returns to education at the micro-economic level (Besley and Burgess, 2003; Krueger and Lindhal, 2001; Lau *et al*., 1990; Glewwe, 1996). In addition, the significance of erosion perception can be explained by the fact that PAES promoted the adoption of a number of crops as a way to control erosion problems in the area.

V. CONCLUDING REMARKS

This study analyzes the degree of output diversification among 520 hillside farmers in El Salvador, of which 260 have participated in the Environmental Program for El Salvador (PAES) implemented between 1998 and 2005. Count regression models are used to examine the variables associated with the adoption of additional outputs, while a Probit model is the basis for evaluating factors related to the disadoption of more diversified cropping systems.

The empirical analysis was divided into two independent procedures. First, we evaluate factors affecting farm-plan diversification among PAES beneficiaries between 2002 and 2005 and among beneficiaries and a control group in 2005. For this purpose, the diversification model was estimated using two separate samples (PAES beneficiaries 2002 and 2005, and beneficiaries-control group 2005). We then analyzed the factors associated with disadoption of output diversification in 2005 relative to 2002. In doing so, a Probit model was estimated using the 2002 and 2005 data for the PAES beneficiaries.

In general, the results indicate that the adoption of a diversified farm plan is positively associated with frequency of extension visits, participation in social organizations, education and land tenure. In addition, farm land presents a positive but decreasing impact on the adoption of diversified farm plans. The results also suggest that for farmers not associated with PAES, social institutions are a good way to spread new technologies. More importantly, PAES beneficiaries increased significantly the number of agricultural activities in their farms between 2002 and 2005. The results also confirm that the project intervention, captured by the frequency of extension visits, is positively associated with adoption.

The Probit model estimated to examine disadoption indicates that education, frequency of extension visits, erosion perception and social participation have a positive and significant association with lower rates of disadoption of diversified farm plans. In turn, higher rates of disadoption are significantly associated with farm size and land tenure.

In sum, to implement a crop diversification strategy as an element for rural development (i.e., poverty alleviation, income generation and natural resource conservation) it is necessary to design extension mechanisms which pay particular attention to the development of human capital. This goal can be reached by facilitating the access to formal education especially to the younger generations, by implementing agricultural extension programs designed to train farmers in improved production technologies, soil conservation practices and commercialization, and by enhancing social networks.

REFERENCES

Abdulai, A. and W. Huffman. “The Diffusion of New Agricultural Technologies: The Case of Crossbred-Cow Technology in Tanzania”. *American Journal of Agricultural Economics* 87 (2005): 645-659.

Adam, S. “Evaluating Social Fund Impact: A Toolkit for Task Teams and Social Fund Managers”. Social Protection Discussion Paper No. 0611, World Bank, October 2006.

Arellanes, P. and D.R. Lee. “The Determinants of Adoption of Sustainable Agriculture Technologies: Evidence From The Hillsides Of Honduras”. Proceedings of the 25th International Conference of Agricultural Economists, Durban, South Africa. August, 2003.

Bai, J, and P. Peron. “Estimating and Testing Linear Models with Multiple Structural Changes.” Econometrica 66(1998): 47-78.

Barlett, P.F. “Motivations of Part-time Farmers.” In: Hallberg, M.C., J.L. Findeis and D.A. Lass eds. “Multiple Job-Holding Among Farm Families.” Ames: Iowa State University Press, 1991.

Bergeron, G. and J. Pender. “Determinants of Land Use Change: Evidence From a Community Study in Honduras”. IFPR, EPTD Discussion Paper No. 46, July 1999.

Besley, T. and Robin Burgess. “Halving Global Poverty,” Journal of Economic Perspectives, 17(2003), 3-22.

Bierens, H. J. Introduction to the Mathematical and Statistical Foundations of Econometrics. Cambridge: Cambridge University Press, 2005.

Blackman, A. and A. Kildergaard. “Clean Technological Change in Developing-Country Industrial Clusters: Mexican Leather Tanning.” Discussion Paper 03-12, Resources for the Future, 2003.

Bravo-Ureta, B. E., H. Cocchi and D. Solís. “Adoption of Soil Conservation Technologies in El Salvador: A Cross-Section and Over-Time Analysis.” OVE/IADB/UConn, 2006b.

Bravo-Ureta, B., D. Solís, H. Cocchi and R. Quiroga. "The Impact of Soil Conservation and Output Diversification on Farm Income in Central American Hillside Farming". Agricultural Economics. (2006a): 267-276.

Bravo-Ureta, B.E., H. Cocchi, D. Solís and T. E. Rivas. "Análisis del Impacto Económico de Tres Proyectos de Manejo de Recursos Naturales en América Central." Technical Cooperation 01-08-01-1-RS University of Connecticut – Inter-American Development Bank, August, 2003.

Cameron, A.C. and P.K. Trivedi. Regression Analisis of Count Data. Cambridge University Press. Cambridge, 1998.

Capistrano, A. and C. Kiker. "Macro-scale Influences on Tropical Depletion". Ecological Economics 14(1995): 21-29.

Caviglia-Harris, J. and E. Sills. "Land Use and Income Diversification: Comparing Traditional and Colonist Population in the Brazilian Amazon". Agricultural Economics (2005): 221-237.

Chaplin, H. "Agricultural Diversification: A Review of Methodological Approaches and Empirical Evidence." Idara Working Paper 2/2, Wye, 2000.

Chen, J. and C. Baker. "Marginal Risk Constraint Linear Programme for Activity Analysis". American Journal of Agricultural Economics 56(1974): 622-627.

Culas, R."Farm Diversification and Environmental Management: Panel Data Evidence from Norwegian Agriculture". Paper presented at the Australasian Meeting of the Econometric Society. Sydney, Australia, July 2003.

Faria, B. A. and A. Fenn, P. "A Count Data Model of Technology Adoption". Journal of Technology Transfer 28 (2003): 63-86.

Fletcher, S.M., and J.V. Terza. "Analyzing farmers' Selection of Available Marketing Alternatives using the Multivariate Probit Model." Canadian Journal of Agricultural Economics 34(1986): 243–51.

Geist, H. and E. Lambin. What Drives Tropical Deforestation?. Report Series No. 4, Land Use and Land Cover Change Project (LUCC). Louvain-la-Neueve, 2001.

Glewwe, P. “The Relevance of Standard Estimates of Rates of Return to Schooling for Education Policy: A Critical Assessment”. Journal of Development Economics 51 2 (1996): 267-290.

Greene, W. Econometric Analysis. Prentice Hall. New Jersey, 1997.

Hazell P. “A Linear Alternative To Quadratic And Semivariance Programming For Farm Planning Under Uncertainty”. American Journal of Agricultural Economics 53 (1971) 53-62.

Heady, E. “Diversification in Resource Allocation and Minimization of Income Variability”. Journal of Farm Economics 34(1952): 482-496.

Hellerstein, D. and R. Mendelsohn. ‘A Theoretical Foundation for Count Data Models, with an Application to a Travel Cost Model.” American Journal of Agricultural Economics 75 (1993): 604-611.

Johnson, S. “Re-examination of the Farm Diversification Problem”. Journal of Farm Economics 49(1967): 610-621.

Kimhi, A. and R. Bollman. “Family Farm Dynamics in Canada and Israel: The Case of Farm Exists”. Journal of Agricultural Economics 21(1999):69-79.

Krueger, Alan B. and Mikael Lindhal, “Education for Growth: Why and For Whom?” Journal of Economic Literature XXXIX (4) (2001): 1101-1136.

Kurosaki, T. “Specialization and Diversification in Agricultural Transformation: The Case of West Punjab, 19903-92”. American Journal of Agricultural Economics 85(2003): 372-386.

Lau, L., D. Jamison and F. Louat. “Education and Productivity in Developing Countries: An Aggregate Production Function Approach”. World Bank, Washington, D.C., 1990.

Link, A.,D. Paton and D. Siegel. “An Econometric Analysis of Trends in Research Joint Venture Activity. Leverhulme Center for Research on Globalization and Economic Policy, Research Paper 2001/19, 2001.

Markowitz H. “Portfolio Selection: Efficient Diversification of Investments”. Cowles Foundation Monograph 16, Yale University, 1959.

Mbaga-Semgalawe, Z. and H. Fomer. Household Adoption Behaviour of Improved Soil Conservation: The Case of the North Pare and West Usambara Mountains Of Tanzania". Land Use Policy 17(2000): 321-336.

Neill, S. and D. Lee. "Explaining the Adoption and Disadoption of Sustainable Agriculture: The Case of Cover Crops in Northern Honduras". Economic Development and Cultural Change 49 (2001): 793-820.

ODI. "Options for Rural Poverty Reduction in Central America". Overseas Development Institute Briefing Paper. odi.org.uk/publications/briefing/bp_jan03.pdf. January 2003.

Papademetriou, M. and F. Dent. Crops Diversification in the Asia-Pacific Region. FAO, Rome, 2001.

Pelupessy, W. The Limits of Economic Reform in El Salvador. St. Martin's Press. 1997.

Pingali, P. and M. Rosegrant. "Agricultural Commercialization and Diversification: Process and Policies". Food Policy 20(1995): 171-185.

Pope, R. and R. Prescott. "Diversification in Relation to Farm Size and other Socioeconomic Characteristics". American Journal of Agricultural Economics 62 (1980): 554-559.

Prennushi, G., G. Rubio and K. Subbarao. "Monitoring and Evaluation" in Sourcebook for Poverty Reduction Strategies, edited by Jeni Klugman. Washington, D.C.: World Bank, 2000.

Quiroz, J. and A. Valdés. "Agricultural Diversification and Policy Reform". Food Policy 20(1995):245-255.

Rahm, M.R. and Huffman, W.E. "The Adoption of Reduced Tillage: The Role of Human Capital and other Variables." American Journal of Agricultural Economics 66(1984): 405-413.

Ramírez, O.A. and S. Shultz. "Poisson Count Models to Explain the Adoption of Agricultural and Natural Resource Management Technologies by Small Farmers in Central America." Journal of Agricultural and Applied Economics 32(2000): 21-33.

STATA, 2003, Reference Manual, STATA Corp.

Stovall, J. “Income Variation and Selection of Enterprises”. Journal of Farm Economics 48(1966): 1575-1579.

Sun, T., Jinkins, J., and H. El-Osta. “Multinomial Logit Analysis of Farm Diversification for Midwestern Farms.” Paper presented at the Annual Conference of the American Agricultural Economics Association in Indianapolis, 1995.

Turner, B., D. Skole, S. Sanderson, G. Fischer, L. Fresco, and R. Leemans. Land-Use and Land-Cover Change: Science/Research Plan. IGBP Report No. 35 and HDP Report No. 7, International Geosphere-Biosphere Programme and Human Dimensions of Global Environmental Change Programme, Stockholm, Sweden, 1995.

UNDP-European Commission (EC)-World Bank. “Linking Poverty Reduction and Environmental Management. Policy Challenges and Opportunities.” 2002.

van Dusen, M. E. and J. E. Taylor. “Missing Markets and Crop Diversity: Evidence from Mexico.” Center on Rural Economies of the Americas and Pacific Rim Working Papers, University of California Davis. Available at iga.ucdavis.edu/working.html. February 2003.

von Braun, J. “Agricultural Commercialization: Impacts On Income And Nutrition And Implications For Policy”. Food Policy 20(1995): 187-202.

Weiss, C. R. and W. Briglauer. “Determinants and Dynamics of Farm Diversification”. Working Paper EWP 0002, Department of Food Economics and Consumption Studies, University of Kiel. July, 2000.

White, T. and G. Irwin. “Farm Size And Specialization”, in Ball, G, and E. Heady (eds.): Size, Structure And Future Of Farms. Ames, Iowa State University Press, 1972.

World Bank. El Salvador. The World Bank Group, www.worldbank.org, 2006.

Yao, S. “Comparative Advantage and Crop Diversification: A Policy Analysis For Thai Agriculture”. Journal of Agricultural Economics 48(1997): 211-222.

TABLES

Table 1: Variable Definitions, Means, and Test of Means

Variable Definitions	2002	2005		2005			2005		
	Beneficiaries	Beneficiaries	Test	Neighbors	Non-Neighbors	Test	Adopters	Disadopters	Test
Farm									
Diversification (count)	1.1	3.1	***	2.3	2.8	***	3.4	1.1	***
Land (Manzana=0.7 Has.)	4.8	4.0		2.1	2.3	***	3.8	4.8	
Tenure, 1 if owns > 50% total land (%)	81.3	82.0		75.0	83.6		90.1	68.7	***
Slope, 1 if >15% (%)	50.8	66.4	***	66.4	53.9		65.2	65.6	
Household									
Family size (#)	5.3	5.4		4.5	5.1	***	5.5	4.6	
Off-farm income, 1 if earns (%)	53.85	31.0	***	37.0	36.0		33.0	32.0	
Age Household Head (HH) (Years)	48.3	51.8	***	50.1	51.2		52.4	48.2	***
Gender HH, 1 if male (%)	84.4	84.4		88.3	89.1		85.5	75.5	***
Education HH (Years)	2.8	2.6		2.9	3.7	***	2.6	2.2	
Social organizations, 1 if participates (%)	52.7	50.8		15.6	21.9	***	52.2	34.3	***
Labor ($)	204.0	73.9		92.2	74.6		85.3	56.1	***
Erosion Perception, 1 if perceives (%)	86.9	32.3		46.2	43.8		34.6	15.6	***
Project									
Years with PAES (Years)	2.7	3.6	***				3.5	3.4	
Frequency visits (# per year)	29.5	14.6	***	2.8	4.2	***	15.5	3.1	***
Local									
Access to Markets		0.06		0.12	-0.25	***	-0.25	0.19	***
Local Infrastructure		0.03		-0.01	-0.04		0.47	0.05	***
Number of Observations	260	260		130	130		228	32	

Table 2: Negative Binomial (Count) and OLS (Entropy) Estimates of Farm Diversification: Beneficiaries 2002-2005

	Negative Binomial (Count)						**OLS (Entropy)**					
	Pooled		**2002**		**2005**		**Pooled**		**2002**		**2005**	
	Coef.	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Constant	-0.4355**	0.188	0.5769*	0.341	0.4010*	0.239	0.8278***	0.088	0.1835***	0.011	0.6578***	0.151
Land	0.0174*	0.010	0.0196	0.022	0.0237*	0.012	0.0219***	0.006	0.0274***	0.009	-0.0069	0.011
Land*Land	-0.0002***	0.000	-0.0003*	0.000	-0.0002***	0.000	0.0001	0.000	0.0001	0.000	0.0000	0.000
Labor	0.0003***	0.000	0.0005***	0.000	0.0003***	0.000	0.0002***	0.000	0.0001***	0.000	0.0002***	0.000
Off-farm income	0.0000	0.000	0.0003***	0.000	0.0001	0.000	0.0000	0.000	0.0000	0.000	0.0000	0.000
Age	0.0004	0.002	-0.0027	0.005	0.0020	0.003	-0.0006	0.001	-0.0430	0.042	0.0019	0.002
Gender	0.0113	0.088	-0.2611	0.169	0.1067	0.103	0.0305	0.044	0.0012	0.001	-0.0005	0.010
Education	0.0156**	0.007	0.0207	0.024	0.0015	0.015	0.0131***	0.004	0.0169**	0.007	0.1619**	0.066
Slope	-0.1202*	0.072	-0.2297	0.148	-0.0418	0.095	-0.0400	0.036	-0.0873**	0.047	0.0423	0.063
Slope*Land	-0.0077	0.013	0.0091	0.011	0.0070	0.013	-0.0093	0.006	0.0154	0.050	0.0006	0.012
Social organization	0.1056	0.067	-0.0728	0.133	0.1020	0.080	0.0835**	0.033	0.0028*	0.002	0.0941*	0.052
Frequency visits	0.0055***	0.002	0.0002	0.003	0.0089***	0.002	0.0020**	0.001	0.1012*	0.057	0.0036**	0.002
Tenure	0.1146	0.087	-0.0723	0.170	0.1705*	0.102	-0.0037	0.040	-0.0478	0.053	0.0399	0.062
Years with PAES	0.0125	0.034	0.0899	0.080	0.0214	0.038	0.0038	0.018	0.0056	0.025	0.0070	0.025
PAES1	-0.2807***	0.068	-0.2395*	0.136	-0.2745***	0.078	-0.1279***	0.033	-0.1119***	0.042	-0.1429***	0.050
YEAR (2005)	1.2137***	0.103	--		--		0.2012***	0.047				
Log-Likelihood	***-852.84***		***-334.81***		***-501.54***		--		--		--	
X^2	***278.59****		***59.00****		***77.44****		--		--		--	
R^2	--		--		--		***0.354***		***0.241***		***0.273***	
F	--		--		--		***6.09****		***3.01****		***3.64****	
N	***520***		***260***		***260***		***520***		***260***		***260***	

*p < 10%; **p <5%;***p<1%

Table 3: Negative Binomial and OLS Estimates of Farm Diversification: Beneficiaries and Control Group 2005

	Negative Binomial (Count)						**OLS (Entropy)**					
	Pooled		**Beneficiaries**		**Control**		**Pooled**		**Beneficiaries**		**Control**	
	Coef.	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Constant	0.3838**	0.163	0.3074	0.210	0.4708*	0.264	0.7255***	0.098	0.5533***	0.133	0.4926***	0.046
Land	0.0224*	0.014	0.0286*	0.016	0.1032**	0.043	0.0189*	0.011	-0.0114	0.014	0.0047	0.028
Land*Land	-0.0002**	0.000	-0.0002**	0.000	-0.0074***	0.002	0.0000	0.000	0.0000	0.000	-0.0021**	0.001
Labor	0.0003***	0.000	0.0002***	0.000	0.0002**	0.000	0.0002***	0.000	0.0002***	0.000	0.0002**	0.000
Off-farm income	0.0000	0.000	0.0001*	0.000	0.0001	0.000	0.0000	0.000	0.0000	0.000	0.0001	0.000
Age	0.0014	0.002	0.0023	0.003	-0.0006	0.004	-0.0004	0.001	0.0016	0.002	0.0026	0.009
Gender	0.0436	0.081	0.0718	0.103	-0.0992	0.133	0.0581	0.049	0.0023	0.010	-0.0564	0.074
Education	0.0015	0.011	0.0029	0.015	0.0732*	0.042	0.0023	0.006	0.1291*	0.067	0.0035*	0.002
Slope	-0.0277	0.069	0.0220	0.095	-0.2180*	0.131	0.0127	0.044	0.0542	0.063	0.0336	0.064
Slope*Land	0.0018	0.013	-0.0030	0.015	-0.0036	0.016	0.0114	0.011	0.0005	0.012	0.0035	0.002
Social organization	0.1172*	0.071	0.0900	0.080	0.0229	0.115	0.0750*	0.045	0.0862*	0.043	0.1238*	0.074
Frequency visits	0.0080***	0.002	0.0085*	0.002	0.0063*	0.003	0.0034***	0.001	0.0029*	0.002	0.0649**	0.027
Tenure	0.2556***	0.074	0.2269	0.101	0.2990***	0.111	0.0692*	0.041	0.0793	0.061	0.0268	0.057
Access to Markets	0.0089	0.016	-0.0022	0.019	0.0233	0.037	0.0121	0.012	0.0020	0.014	-0.0048	0.023
Local Infrastructure	0.1035***	0.034	0.0737*	0.044	0.1337**	0.056	0.0231**	0.012	0.0253*	0.014	0.0250	0.028
Neighbor	-0.0824	0.075	--		--		-0.0752*	0.045			--	
No-neighbor	-0.0404	0.085	--		-0.0024	0.086	-0.0129	0.051			0.0722	0.046
No-neigh * Orga.	0.2517*	0.146	--		0.2632*	0.151	-0.0771	0.091	--		0.2797*	0.162
Log-Likelihood	***-974.36***		***-506.62***		***-458.24***		--		--		--	
X^2	***134.35***		***76.11**** ***		***70.36***		--		--		--	
R^2	--		--		--		***0.373***		***0.256***		***0.239***	
F	--		--		--		***4.00**** ***		***3.14**** ***		***2.64**** ***	
N	***520***		***260***		***260***		***520***		***260***		***260***	

*p < 10%; **p <5%;***p<1%

Table 4: Semielasticities of Farm Diversification

	2002-2005		2005	
	Beneficiaries	Beneficiaries	Beneficiaries	Control
Land	0.0946	0.0935	0.1127	0.2247
Labor	0.3098	0.1521	0.1384	0.1322
Off-farm income	0.1527	0.0232	0.0246	0.0321
Age	-0.1314	0.1047	0.1203	-0.0294
Gender	-0.2189	0.0899	0.0605	-0.0881
Education	0.0575	0.0038	0.0076	0.0972
Slope	-0.1166	-0.0277	-0.0146	-0.1300
Social organizations	-0.0386	0.0510	0.0450	0.0042
Frequency visits	0.0060	0.1288	0.1232	0.0217
Tenure	-0.0467	0.1247	0.1658	0.2163
Years with PAES	0.1566	0.0753	--	--

Table 5: Probit Estimation of Disadoption of Output Diversification: PAES Beneficiaries 2002-2005

	Coefficient	S.E.	M.E.[a]
Constant	0.2816	0.699	--
Land	0.0819*	0.043	0.012
Land*Land	-0.0001	0.000	--
Labor	0.0001	0.000	0.000
Off-farm income	0.0000	0.000	0.000
Age	-0.0703	0.056	-0.011
Gender	-0.3653	0.265	-0.003
Education	-0.0224***	0.01	-0.055
Slope	0.1529	0.306	0.022
Slope*Land	-0.0532	0.046	--
Social organizations	-0.5767*	0.306	-0.112
Frequency visits	-0.0155*	0.009	-0.002
Erosion	-0.6239**	0.284	-0.081
Tenure	0.8482*	0.458	0.027
Access to Markets	-0.0067	0.147	--
Local Infrastructure	0.1350	0.245	--
Years with PAES	-0.0625	0.121	-0.009
PAES1	0.1194	0.275	--
Likelihood Ratio Test	***54.31****		
% of Right Predictions	***0.791***		
N	***260***		

[a] Dependent variable equals one if the number of agricultural activities in 2005 diminished with respect to 2002.
[b] The marginal effect for the dummies variables is computed as Pr[y| x=1]-Pr[y| x=1].
*p < 10%; **p <5%;***p<1%.

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