

The Impact of Off-Farm Work on the Land Clearing and Land Use Decisions of Colonist Settlers in the Northern Ecuadorian Amazon

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Abstract

The issue of tropical deforestation has garnered a great deal of attention over the last twenty years, much of which has focused on the ways in which rapid deforestation may be curtailed. The immediate agents of tropical deforestation in the developing world are primarily migrant colonist farmers. One approach for confronting deforestation suggested in the literature has been off-farm employment (OFE), since it takes household labor away from the farm, reducing pressures on the land while also increasing farm household incomes. Nevertheless, research on the impact of OFE on land use and deforestation at the household level continues to be sparse. This paper investigates the factors affecting the OFE and land clearing/use choices of migrant settler households in the Northern Ecuadorian Amazon (NEA) rainforest, an area of extraordinary biodiversity that has been undergoing rapid deforestation since the discovery of oil in 1967. Land clearing/use and household labor allocation are interrelated but have not been examined together in previous empirical studies. The research uses detailed data from a probability sample of over 700 farm households to assess the impact of OFE on land clearing and land use. Because participation in OFE is a choice variable, the estimation strategy utilizes an instrumental variables framework with community level fixed effects. The results show that households who take part in more OFE do not deforest significantly less than other households, nor do they allocate their land to different uses than households who choose not to participate. Thus policies to promote more OFE, such as the expansion of road networks, increases in educational opportunities, and improved access to electricity, will not solve the problem of deforestation.

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1. Introduction

Over the past few decades, there has been a great deal of attention given to tropical deforestation, for a number of reasons. First and foremost in the minds of much of the developed world is the impact of forest loss, particularly of tropical rainforests, on global warming. This is because tropical rainforests act as the “lungs” of the planet, absorbing carbon dioxide from the atmosphere and replacing it with oxygen. A second major reason is that the loss of tropical forests leads to the extinction of certain species of plants and animals. In addition, the clearing of the rainforests has been cited by some as a large source of greenhouse gas emissions, second only to energy consumption (Mitchell, Secoy, & Mardas, 2007). In total, the worldwide economic value of nature’s services has been estimated to be between \$18 trillion and \$61 trillion annually (Balmford et al., 2002). While this does not precisely quantify the costs of deforestation, it does provide a basis for the assertion that deforestation, and the resultant loss of nature has a real economic cost.

While deforestation is a worldwide issue, much of the concern has centered on the Amazonian region of South America, an area which has been undergoing rapid deforestation over the past four decades. The Amazon has been singled out by many because of its high biodiversity and the number of plants and animals endemic (unique) to the region. My study area is in the Northern Ecuadorian Amazon (NEA), also known as the Oriente, which is part of Western Amazonia. Western Amazonia has been described as “...surely the richest biotic zone on Earth” and an area that “...deserves to rank as a kind of global epicentre of biodiversity” (Myers, 1986).

There are many tools that may help to reduce the rate of deforestation in the Amazon. However, as the people living in this region are very poor, by world standards, it is important to devise a method which sustains the rainforests without negatively impacting the wellbeing of area residents. Because of this, one of the tools that has received the most attention is off-farm employment (OFE). It has been suggested that providing people living in areas like the NEA with off-farm employment opportunities may serve to both reduce the rate of forest loss and increase household income levels.

Economic analysis shows that income levels would clearly benefit from additional employment opportunities as those who accept those jobs would do so because they generate higher income than they could achieve working on the farm. Thus, any households who choose to participate in OFE do so because it improves their welfare relative to relying on the farm as their sole source of income.

It is less clear that off-farm employment would reduce the rate of forest loss. If the household's ability to obtain off-farm employment resulted in either a reduction in land clearing or a reallocation of land towards more sustainable uses then off-farm employment opportunities could help reduce deforestation. This has been the traditional view of the impact of off-farm employment and one that has enjoyed support in the limited literature on the subject.

If households reduced their agricultural extensification, or further land clearing for agriculture, as a result of the outside source of income, the provision of such income would have beneficial effects for both the household and the environment. However, it is not clear *a priori* that this will in fact be the case and that non-farm income will reduce the pressure on the rainforest. This is because in the presence of incomplete or missing credit markets, the additional income from participation in OFE may allow households to invest further in their farms to more fully exploit their potential. In this case, OFE would result in either more intensive use of already cleared land or extensification to new land. In the latter case, off-farm work may result in even more rapid deforestation than would exist otherwise. Therefore, the relationship between OFE and land-clearing is an empirical issue, which will be examined herein.

2. Background

2.1 Literature

The idea that an increase in off-farm work opportunities or income result in less deforestation has been supported by a number of studies. In a review of earlier economic studies of deforestation based on much more limited data sets, Angelsen & Kaimowitz (1999) find that increases in off-farm wages and employment tend to result in reduced deforestation as agricultural and forestry activities become relatively more costly. Godoy

et al. (1997), in a study of forest clearing in Honduras based on a small sample, found that the share of income coming from off-farm sources has a negative impact on the area of forest cleared by the household. Caviglia-Harris & Sills (2005) found that increased cash income resulted in decreased deforestation among agricultural colonists in the Brazilian Amazon. However, all of these studies fail to control for possible endogeneity with respect to the off-farm work decision and/or off-farm income. The failure to recognize the simultaneous determination of off-farm employment and land use or land clearing decisions has likely led to biased findings in these studies.

The presence of endogeneity in the determination of the impact of off-farm employment on land use and land clearing may result in two types of bias, both of which are a result of unobservable household and area characteristics. If, for example, households who choose to engage in off-farm employment do so because they are more “industrious” than non-participating households, then these more industrious households may also engage in more farming, and hence more land clearing. In this case, the failure to account for the endogeneity of the off-farm work choice would create an upward bias on the impact of off-farm employment on deforestation. If, on the other hand, households who engage in off-farm employment make this choice because they prefer market work to farm work, then the results of the analysis would be biased downwards. Regardless of whether the off farm work choice is a result of motivation or work preferences, it is important to address its impact before drawing conclusions with respect to the impact of market work on farm level deforestation.

2.2 Farm Level Land Use and Regional Deforestation

Deforestation, in general, is seen as a regional, national or worldwide phenomenon. However, the forest clearing decisions which combine to generate the overall level of deforestation are mostly made by low level actors, in particular farm households and firms. While many have advocated off-farm employment as a means of reducing deforestation, it is unclear how household level analysis in an area such as the NEA generalizes to an understanding of regional deforestation. This area in particular is complicated due to the fact that the majority of off-farm workers are actually engaged in

farm work as agricultural day laborers or other types of agricultural workers. Because of this, it is necessary, before proceeding further, to analyze how the results of this type of analysis may inform the body of knowledge with respect to regional deforestation levels.

While this research is not designed to evaluate the impact of off-farm employment on the overall level of deforestation, it does shed light on the issue. The question is often raised as to whether or not off-farm employment has any impact whatsoever on deforestation as off-farm agricultural workers would contribute similar forest pressure on the farm they are employed on as they would if engaged on their own farm. It matters little in the overall picture if you save a hectare of forest on a household's farm, only to have that worker clear that same hectare on the farm where they are hired.

However, the question of whether or not market work affects farm level land use decisions is not inconsequential. In order to understand why household level impacts matter, let's begin by making the rather dubious assumption that there is no deforestation occurring as a result of off-farm employment. In this case, an increase in off-farm employment would lead to a decrease in deforestation, provided that this same employment reduced deforestation at the level of the family farm. If, however, we cannot assume that market work would never involve deforestation, then the situation is somewhat changed. Now, if off-farm employment decreases household level deforestation, then the overall level of deforestation may fall, but only if the decrease in household level deforestation exceeded the increase in market employment related deforestation. If off-farm employment failed to reduce household level deforestation, however, then it is certain, given the deforestation impacts of OFE, that there is no decrease in overall deforestation as a result of OFE. The decrease in household level deforestation, therefore is a necessary but not sufficient condition for the conclusion that market work decreases regional deforestation.

The question that this research attempts to address is whether or not market work in fact results in decreases in household level deforestation. This is a non-trivial question both in terms of its own merit and the overall deforestation question, as described above. There is a serious question regarding the direction of the impact of off-farm work on farm-level deforestation, especially in areas such as the NEA. This is because

households engaging in off-farm employment gain an income stream that may be used either for present consumption or to increase farm production through the hiring of labor and the use of other purchased agricultural inputs. If households are simply using off-farm income as a replacement for farm income, then off-farm employment is likely to result in a decrease in farm-level deforestation as agricultural production is reduced. If, however, they choose to invest off-farm earnings in the family farm, then market employment may actually result in increases in farm level deforestation.

2.3 *The Northern Ecuadorian Amazon (NEA)*

The NEA was a relatively pristine area sparsely inhabited by native groups until the 1970's, when the discovery of oil in the region in 1967 precipitated the building of roads to provide access for oil companies to lay pipelines to extract and transport the oil to the Pacific Coast for export. These roads also provided access for agricultural migrants from more heavily populated areas of Ecuador where they had little or no land to move to the area in search of land. These migrants settled along the oil roads beginning in the 1970's, causing the population of the Amazon to surge and resulting in major encroachments on the rainforest in the region (Pichón, 1993, 1997a; Bilsborrow et al. 2004).

Since the 1970's, the deforestation rate in the NEA has been rapid, even by Latin American regional standards. Ecuador as a whole is losing its forest cover more rapidly than any other country in the Amazon Basin, with most of the loss occurring in the NEA. Between 1986 and 1996, the northern Ecuadorian Amazon was deforested at the rate of 2.49% per year, while the rate between 1996 and 2002 was 1.78% per year (Mena, Bilsborrow, & McClain, 2006). This resulted in the loss of an average of 11,850 hectares of forest per year for the period 1986-2002. Deforestation rates were much higher in some localities, with *parroquia* (parish) level rates reaching 7.63% (Mena, Bilsborrow, & McClain, 2006). By comparison, Brazil had a deforestation rate of 0.5% for the period 1990-2000, while the national deforestation rate for Ecuador was 1.5% for the same time period (Food and Agriculture Organization of the United Nations, 2007).

While the presence of oil provided the basis for the massive population growth, as with many areas of the world, it has not improved the economic status of the area

residents to any great extent. This combination has resulted in a large and rapidly growing number of area residents who are extremely poor. Thus the problems in the NEA are substantially more complex than deforestation alone. The combination of deforestation, rapid population growth, extreme poverty and international interests (in oil) has created a complex situation that must be clearly understood in any attempt to create or expand policies to protect the rainforests that house many species unique to this region or deal with human poverty.

3. Theoretical Framework

I will use a utility maximization framework derived from Huffman (1991) and Becker (1993). The Huffman model is particularly useful in this context as it allows for households to choose to work on-farm full time, to spend time on both on-farm and off-farm employment, or to work off-farm full time.

I expand the Huffman model in three ways, by including Becker's model of home production (Becker, 1965), by allowing for more than two household members, and through segmentation of the household farm into different crop categories. The Becker model of home production considers market goods and home time to be inputs to the household production process, instead of allowing them to generate direct utility for the household. Thus the household generates utility through the consumption of home produced goods. For example, a meal is a home produced good created using food inputs (which may be purchased or produced on the farm), and other purchased inputs (such as fuel for cooking the food, and capital inputs like a stove, kitchen pots, and knives), as well as time. Other examples of these home-produced goods include healthy children, a clean house and many others which are difficult to quantify.

3.1 *Utility*

The household is assumed to maximize a monotonic, twice continuously differentiable, strictly concave joint utility function subject to the usual constraints: a budget constraint, a time constraint, and a production function for the farm. The household is assumed to

have an endowment of time (\mathbf{T}) and human capital (\mathbf{H}). Time can be spend in three possible ways: household production (\mathbf{T}_h), market work (\mathbf{T}_m) and farm work (\mathbf{T}_f), and human capital can be divided into capital applicable to home production, market work, and farm production which will be indicated by the subscripts h , m and f respectively.

The household purchases \mathbf{X} in the marketplace, but only gains utility from these consumption goods through their usefulness as inputs into the production of utility generating home produced commodities (\mathbf{Z}_i).

$$U(\mathbf{Z}_1, \dots, \mathbf{Z}_n; \mathbf{C}_h) \quad (2)$$

where

$$\mathbf{Z}_i = z_i(\mathbf{X}_i, \mathbf{T}_{hi}; \mathbf{H}_h) \quad (3)$$

and \mathbf{X}_i is the vector of consumption goods used in the production of commodity i , \mathbf{T}_{hi} is the vector of household members' time used in producing i , and \mathbf{H}_h is a vector of fixed human capital variables which affect the efficiency of household production. The goods and time spent on the production of all commodities sum to \mathbf{X} and \mathbf{T}_h .

3.2 Constraints

The purchase of consumption goods is financed through the production of agricultural goods and wages from time spent in market work (\mathbf{T}_m). Agricultural goods are produced according to the household's agricultural production function,

$$Q = q(\mathbf{T}_f, l_a, l_p, l_c, \mathbf{N}; \mathbf{H}_f, \mathbf{C}_f) \quad (4)$$

where (\mathbf{T}_f) is the vector of household time spent in farm work, l_a , l_p and l_c are the hectares of land devoted to the production of annual crops, perennial crops, and cattle or other livestock (i.e., pasture), respectively; and \mathbf{N} is a vector of purchased inputs. Output also depends on exogenous variables \mathbf{H}_f and \mathbf{C}_f , which represent household human capital applicable to farming, (e.g. past farming experience, physical strength etc.) and farm characteristics (e.g. farm size, soil quality etc.) respectively.

Any agricultural production can be sold for the exogenously determined price \mathbf{P}_a so that farm profit Π is given by

$$\Pi = \mathbf{P}_a \cdot q(\mathbf{T}_f, l_a, l_p, l_c, \mathbf{N}; \mathbf{H}_f, \mathbf{C}_f) - \mathbf{P}_n \mathbf{N} \quad (5)$$

where \mathbf{P}_n is paid for purchased inputs. The household has the following budget constraint:

$$\mathbf{P}_x \mathbf{X} = \mathbf{W} \cdot \mathbf{T}_m + \Pi + Y_n \quad (6)$$

where \mathbf{W} is a vector of market or shadow wages for all household members, and Y_n is the household's non-labor income.

The wage of individual i is determined by:

$$\mathbf{W}_i = W(\mathbf{H}_m, \mathbf{C}_m, \mathbf{J}_m) \quad (7)$$

where \mathbf{H}_m is an individual's marketable human capital, \mathbf{C}_m is a vector of local labor market characteristics, and \mathbf{J}_m is job characteristics. Increases in human capital, whether through schooling, vocational training, experience or specific skills, will shift the individual's wage schedule to the right.

Time is constrained such that the time each individual spends in each activity must be non-negative and the sum of the time spent in all activities must equal the total time available:

$$\mathbf{T} = \mathbf{T}_f + \mathbf{T}_m + \sum_i \mathbf{T}_{hi}, \quad \mathbf{T}_f, \mathbf{T}_m \geq 0 \quad (8)$$

where \mathbf{T}_{hi} is the time spent in household production of good Z_i .

The sum of the land areas in each productive use (l_a, l_p, l_c) and the land in forest l_f must equal L , the total farm area, so that:

$$l_a + l_p + l_c + l_f = L, \quad l_a, l_p, l_c, l_f \geq 0. \quad (9)$$

Substituting farm profit into the budget constraint, we get the full budget constraint:

$$\mathbf{P}_x \mathbf{X} = \mathbf{W} \mathbf{T}_m + \mathbf{P}_a \cdot q(\mathbf{T}_f, l_a, l_p, l_c, \mathbf{N}; \mathbf{H}_f, \mathbf{C}_f) - \mathbf{P}_n \mathbf{N} + Y_n. \quad (10)$$

Substituting the time constraint in for \mathbf{T}_m and rearranging, we find:

$$\mathbf{P}_x \mathbf{X} + \mathbf{W} \sum_{i=1}^n \mathbf{T}_{hi} = \mathbf{W}(\mathbf{T} - \mathbf{T}_f) + \mathbf{P}_a \cdot q(\mathbf{T}_f, l_a, l_p, l_c, \mathbf{N}; \mathbf{H}_f, \mathbf{C}_f) - \mathbf{P}_n \mathbf{N} + Y_n \quad (11)$$

where the left hand side is the total opportunity cost of consumption of home produced commodities and the right hand side is the households "full" or potential income.

4. Empirical Model

In solving this system of equations, one important question to ask is whether farm choices are independent of the household utility maximization problem. If the farm producing unit is independent of the household consumption unit, then decision-makers will choose land uses and other inputs so as to maximize farm profits, irrespective of household characteristics. This would allow household utility maximization and farm profit maximization to be separated from each other and solved independently. Separability of household and farm choices requires that there be complete competitive labor and goods markets (Benjamin, 1992), which is not likely to be a reasonable assumption in a developing country area. If the farm is not separable from the household, then it is acting as an extension of the household, and farm and household choices must be solved for jointly. This is likely to be the case in areas where agriculture is largely for family subsistence rather than a market driven activity or in areas where household members have a preference for working on their own farm.

If the household's problem is separable from the farm's problem, then household composition would impact labor allocation but have no impact on land use decisions. However, if there are not complete markets, the nature of the household's problem changes. If labor markets are incomplete, then the household may not be able to hire the quantity of labor it would wish to use on the farm, or it may be unable to find employment off-farm for household members whose labor is more efficient in non-agricultural uses. If agricultural markets are incomplete, then the household may not be able to buy agricultural goods that it wishes to consume or may not be able to sell the non-subsistence goods which it grows. In either of these cases, the incompleteness of markets creates a situation where household composition becomes important in the farm profit maximization problem. For example, if households are constrained with respect to the hiring of labor then the number of adults in the household and their skill sets is important in determining the household's use of land. Likewise, if agricultural markets are incomplete then the farm must provide for the needs of the household. Thus a large household would need a greater area in food crops than would a small household. In any case, incompleteness of markets is a sufficient condition for the household's land use to

depend on all exogenous household and farm characteristics, making off-farm work and land use decisions endogenous. Thus the household will decide simultaneously how to use its land and how to allocate its labor, which will both depend on exogenous characteristics, such as farm size and household characteristics. The safer, more general assumption is to assume that markets are incomplete.

Assuming that the household utility maximization and farm profit maximization are not separable, the household's demand and supply equations are as follows:

$$l_a^* = D_{l_a}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \quad (12)$$

$$l_p^* = D_{l_p}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \quad (13)$$

$$l_c^* = D_{l_c}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \quad (14)$$

$$\mathbf{T}_m^* = S_{\mathbf{T}_m}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}). \quad (15)$$

The two major decisions this paper is concerned with are the choice of time spent working off-farm and farm land use. These decisions are assumed to take place in two stages. In the first stage, the household realizes the state of its farm, including the area of the farm that has been cleared of forest and the area currently in perennial crops annual crops and pasture, and market conditions for OFE. Because reallocation of land is time consuming and expensive, the household may be assumed to take the current land allocation as given in the short run. With this information, the household maximizes its utility by choosing consumption goods (\mathbf{X}), farm inputs (\mathbf{N}), and the allocation of household member's time to farm, off-farm and household uses (\mathbf{T}_f , \mathbf{T}_m and \mathbf{T}_h). In the second stage, the household makes longer term decisions about the farm which are based on the realized incomes generated from the farm, OFE, and non-labor income, as well as household time available.

Beginning with the off-farm work decision as shown in equation (15), we know that a rational individual will choose to participate in off-farm work only if, at some level of participation, the wage they receive is greater than the value of their time in home production or farm production. If an individual is participating in farm production, the value of this "reservation wage" is the marginal revenue product of their farm labor. If they are not participating in farm work, then their reservation wage is the marginal value

of their home production time, which is very difficult to determine. Analytically, the equation for this relationship can be determined by setting \mathbf{T}_m^* in equation (15) to zero and solving for $\mathbf{W}=\mathbf{W}^R$ (Huffman, 1991). This yields:

$$W_j^R = R_j(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \quad (16)$$

where j refers to the j^{th} family member.

Defining D_j equal to 1 if an individual participates in off-farm work ($W_j^R < W$) and equal to 0 if they do not participate ($W_j^R \geq W$), then the probability of any individual participating in off farm work is determined by:

$$\Pr(D_j = 1) = \Pr(W_j^R < W) = f(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{H}_m, \mathbf{C}_m, \mathbf{J}_m, \mathbf{T}). \quad (17)$$

Thus the probability of an individual participating in off-farm work depends on all the exogenous variables which determine the reservation wage as well as the exogenous variables that determine the off farm wage in equation (7). In this equation, variables which raise the off-farm wage rate will increase the likelihood of off-farm work, while those which increase the reservation wage will decrease the probability. Variables which increase both the reservation wage and market wage have an *a priori* uncertain net effect (Huffman, 1991). For example, an increase in human capital applicable to market work only would increase the wage rate and make it more likely for an individual to work off-farm, while increases in farm related human capital (e.g., previous years of farm work) would increase the opportunity cost of off-farm work, making it less likely.

The household's choice of land area allocated to any particular use depends on the same household, farm and community characteristics as the off-farm work choice:

$$l_{ij} = \alpha_0 + \alpha_1 w_{ij} + \alpha_2 X_{ij} + \alpha_3 X_j + \mu_j + \varepsilon_i \quad (18)$$

where l_{ij} is land use of interest (forest, annual crops, perennial crops, or pasture) for household i living in community j . X_i are household and farm characteristics, X_j are community characteristics which affect the household's ability to sell agricultural outputs. Unobserved community characteristics are accounted for in μ_j , a community fixed effect. And w_{ij} is the quantity of off-farm work of household members. The actual demand by the household for land in each use is represented by the unobservable variable l_{ij}^* that corresponds to the observed variable l_{ij} , such that:

$$l_{ij} = \begin{cases} l_{ij}^* & \text{if } l_{ij}^* > 0 \\ 0 & \text{if } l_{ij}^* \leq 0 \end{cases} \quad (19)$$

While the fact that the dependent variable in this analysis is truncated at zero suggests that Tobit estimation would be a reasonable technique, the sensitivity of Tobit to the violation of the assumption that $\varepsilon_i \sim N(0, \sigma^2)$, makes it unsuitable for this data. OLS is much less sensitive to the violation of the distributional assumptions regarding the error term, however, a necessary condition for this model to be unbiased is $E[\varepsilon_i | X_i, X_j, w_{ij}] = 0$. If there are unobservable characteristics of the farm, household, or community that influence the household's land clearing and land use choices and are also correlated with the decision to participate in off-farm work, estimation of equation (18) using Ordinary Least Squares will be biased. For example, if larger households tend to clear more land and are also more likely to send household members to work off-farm, then the effect of OFE on land clearing will be underestimated.

This possible endogeneity problem can be addressed through the use of various econometric techniques including fixed effects, two stage instrumental variables. The first of these techniques, fixed effects, utilizes multiple observations within a community or geographical area to account for the unobserved factors in the community which may be affecting both decisions. The second estimation method, two stage instrumental variables (IV), relies on the presence of a valid exclusion restriction to correct for the endogeneity of the independent variable. Thus, it is necessary to identify a set of variables that are both uncorrelated with ε_i and correlated with the endogenous right hand side variable. Thus the quantity of off-farm work done by a household is estimated in the first stage as:

$$w_{ij} = \beta_0 + \beta_1 X_i + \beta_2 X_j + \beta_3 Z_j + \mu_j + \zeta_i \quad (20)$$

where the instruments, Z_j , are community characteristics which affect the area job market but do not affect the household's land use decision. While the second stage determines the impact of off-farm work on land use as:

$$l_{ij} = \alpha_0 + \alpha_1 X_i + \alpha_2 X_j + \alpha_3 \mu_j + \alpha_4 \hat{w}_{ij} + \varepsilon_i \quad (21)$$

5. Data

The data I am using in this paper come from a NASA funded study designed and carried out by faculty at the Carolina Population Center. The study area lies in the provinces of Sucumbios, Orellana and Napo in the Northern Ecuadorian Amazon. A broad spectrum of data was collected, via household and community surveys, in 1990 and 1999, mainly to investigate land use and land cover change in the Ecuadorian Amazon and their relationships to demographic, geographic and biophysical factors. This area was chosen partly because of its very high biodiversity and rapid rates of population growth and deforestation.

The sample of households in the survey was chosen in 1990 to be a scientifically representative sample of about 6% of the settler households in the study region (Bilsborrow, 1990; Pichón, 1993). Interviewers returned to these same farms in 1999, and administered surveys to any households found on the original property.

The Amazonian region as a whole had a population of 384,582 in 1990 (INEC, 1992), which had swelled to around 550,000 by the time the data was collected in 1999 (INEC, 2001), an increase of 43% or nearly double the national rate of population growth (Bilsborrow et al. 2004). During the same time period, the number of farms in the survey area rose from 418 to 767, due to subdivision of properties. This led to an increase in the sample population from 2695 to 4334, an increase of 61%

The households within the sample are, for the most part, exceptionally poor. In 1999, their average annual *household* income was about \$1300, with a per capita income of about \$250, less than the \$1 dollar a day level used by the World Bank to classify households in extreme poverty. By comparison, Ecuador as a whole is much wealthier with a per capita GDP of \$1529 in 1999 (United Nations Development Programme & Moyo Wicks Freymann Memorial Fund, 2001), including urban populations and oil income.

The NEA differs from other, previously studied Amazonian regions, particularly in Brazil, in two main ways. First, the households in this region are, for the most part, small scale farmers who engage in three main agricultural activities. The most prevalent is the growing of perennial cash crops, such as coffee and cacao, which 88% of the

households take part in. Many households (55%) also grow annual crops such as maize, rice and plantains, which are mainly for household consumption, while 42% of households have at least some cattle. This is in stark contrast to areas such as the Brazilian Amazon, where the predominant activity is large scale cattle ranching. Another major difference between the NEA and other areas in the Amazon Basin is the nature of the households who have migrated to the area. In the NEA, there was little government involvement in the migration process, with settlers moving to the region mainly as families. This differs also from the Brazilian Amazon where migration to the region was initially largely orchestrated by the government, and restricted to young couples with previous agricultural experience.

Off-farm Employment has become increasingly important to farm families of this region. In 1990, only 35% of households participated in off-farm work at any level, and only 5% of households had members working off-farm thirteen months or more in total during the previous 12 months (Pichón, 1993). By 1999, 59% of households had income from off-farm work by household members. Of these, 28%, or nearly 17% of the entire sample had at least thirteen months of off-farm work by household members.

Most off-farm work in this region is done by men, who make up nearly 88% of off-farm workers. Men most commonly take jobs in agricultural fields such as agricultural day laborers, chainsaw operators or plantation work, which together comprise over 65% of the off-farm jobs held by men. The remainder of the men are employed in the non-agricultural sector (15%), are self-employed (15%), or classify their job as “other” (5%). Women are distributed among the various jobs, with 16% in agriculture, 32% in non-agricultural work, 38% self-employed, and the remaining 13% categorized as “other”.

6. Main Results

6.1 *Summary Statistics*

Table 1 provides summary statistics for the estimation sample of 639 households. In general, most households own or operate large farms, although 32 percent of these

households have less than 10 hectares¹. The average household owns, rents, or borrows 34.25 hectares. Approximately 30% of all households own or operate more than one plot of land and 3% of households own land not included in the sample. Detailed land use information was collected for all household plots within the survey area. Households with complete data for analysis had an average of 27.6 hectares within the survey area. For the typical interviewed household, 54% of their sample area property remained in forest in 1999, with the remaining 46% distributed among the major land uses: 5% in annual or food crops, 14% in perennial or cash crops, 20% in pasture, and 7% fallow.

Column (4) of Table 1 reports the differences in means for the summary statistics by participation in off-farm employment. Compared to households who do not participate, households who engage in some off-farm work have somewhat smaller farms, less area in forest, perennials and pasture, more annuals, and less total cleared area. Households themselves are larger and contain more children. The head of household is also younger and somewhat better educated.

It is clear from the statistics that households who choose to work off-farm have different characteristics than those who choose not to. This suggests that it may be necessary to account for the endogeneity of OFE by farm households if these differences are due to underlying unobservable characteristics such as the level of motivation or ability within the household.

6.2 Deforestation

The household demand for area in forest in Table 2 indicates that OFE increases the percentage of the household farm remaining in forest. An additional 100 days of off-farm work performed by household members in a given year results in 0.38 hectares (0.94 acres) more of the family farm remaining in forest.

The introduction of household demographic variables, shown in column (3), increases the magnitude of the OFE impact without lowering its statistical significance. This result is also of particular interest as the joint significance of the household demographic variables indicates that the household utility maximization and farm profit

¹ 1ha=2.47 acres.

maximization problems are not separable. The lack of separability indicates that it is necessary to take household characteristics into account in the regression analysis. The absence of these demographic variables in the first regression likely biases the coefficient on off-farm work downwards. This downward bias is expected because in the absence of complete markets, larger households will be more likely to deforest more of their land for subsistence crops. At the same time, larger households, especially those that are land constrained, are more likely to send members to work off-farm. Addition of *parroquia* (parish) level fixed effects to the full regression (3), causes a slight decrease in the magnitude of the impact of OFE, which indicates that there are unobservable area characteristics such as the availability of off-farm work opportunities or the quality of roads in the area, which affect both the demand for forest and the household's off-farm work choice.

The OLS analysis is somewhat informative; however, because households choose both the level of off-farm employment and the area of land remaining in forest, it is likely that unobserved household level characteristics are affecting both these choices, resulting in endogeneity of the off-farm work variable. Failure to account for this endogeneity will result in biased estimates for the impact of off-farm work on forest retention. To correct for the endogenous nature of time spent in off-farm employment, 2SLS analysis was performed, instrumenting for OFE in the first stage. The excluded instruments for the first stage analysis are the average number of off-farm days per prime age adult for the *parroquia*, excluding the own household's participation in off-farm employment, and whether or not the household has access to electricity. The first of these instruments is a measure of the competitive nature of the local job market. Greater off-farm employment participation by surrounding households indicates a greater level of competition for jobs in the area and in the full estimation is negatively associated with participation in off-farm employment. The second instrument, access to electricity, is a significant predictor of off-farm employment, especially that of women. Access to electricity is not a choice variable in this region of the world. Electrical lines are run for the benefit of government and large corporations, most often oil companies. If households live under the lines, they are also provided with service, if they do not, then no electricity will be made available. Access to electricity is unrelated to land use, as there is no use of electricity in farming,

but it is a significant predictor of off-farm employment participation, especially for women. This occurs for two reasons. First, electricity shortens the amount of time necessary for household tasks such as cooking, freeing up women's time for other types of employment. Second, electricity is an important input to the running of a *tienda*, a small shop by the road, which is one of the most popular off-farm occupations of women. Both of these variables are useful as instruments as they impact land use on the farm only through their affect on the labor allocation choice of the household.

Table 3 shows the results of the instrumental variables analysis with *canton*² level fixed effects. Column (1) shows the first and second stages for the parsimonious analysis, while column (2) shows the full model specification. Within each of these columns, the first stage shows the impact of the independent variables on household engagement in off-farm work, measured by the number of days of off-farm work done by household members, while the second stage shows the impact of off-farm employment and the other independent variables on the hectares of forest retained by the household. The results indicate that off-farm employment does not have a significant effect on forest retention when taking into account the endogeneity of the off-farm work choice. This result is a strong confirmation of the previously hypothesized endogeneity bias. In addition, this result has important policy implications. A reduction in household level deforestation as a result of off-farm employment is a necessary, but not sufficient, condition for off-farm employment to have a positive impact on regional deforestation. This is because regional deforestation is an aggregate of household level and commercial deforestation, and off-farm employment may result in forest clearing on a commercial level. Thus, the failure of off-farm employment to impact household level deforestation indicates that it cannot be a mechanism for reducing the deforestation problem in this region.

Beyond this, the overall results are remarkably consistent with *a priori* expectations for both off-farm employment and the area of retained forest. The first stage shows that households with access to electricity spend, on average, 41 more days per year in OFE, while those who live in areas with more intense competition for market

² A *canton* is an administrative unit that is smaller than a Province but larger than a *parroquia* (parish). It is typically composed of between 4 and 8 *parroquias*.

employment, as represented by the average number of days of off-farm employment for the area, choose to work off-farm slightly less. Farm size does not impact participation in market work, but has a significant impact on the area remaining in forest. Decreased access to markets, as represented by walking distance from the road, results in decreased participation in market work. Larger households and those that are composed more predominantly of prime age men and women and elderly men, as compared to the excluded group of children, also choose to engage in greater levels of off-farm employment. Finally, household level education, as measured by the years of education for the head of household, is positively associated with greater quantities of off-farm employment.

With respect to the area retained in forest, those with larger farms choose to retain a greater forest area. The results indicate that each additional hectare of farm size results in a marginal increase of 0.65 hectares of retained forest. The fact that larger farms retain more forest area is an indication that farming operations may be constrained by the availability of labor, a result that differs substantially from many developing areas where populations are dense and families more likely to be land constrained. Access is also important for the sale of farm products, thus farms further from town and those lacking vehicular access retain more area in forest. This result makes sense as households whose farms are less accessible have more difficulty in transporting agricultural goods to market for sale, making their plots less profitable and reducing the rate at which they are cleared for agricultural use. As would be expected, the length of time that a farm has been in use increases the percentage of land that has been cleared for agricultural use. Finally, the education level of the household head has a significant impact on forest retention, with each additional year of education yielding a 0.38 hectare reduction in forest. This result is consistent with the theory that education serves to increase the consumptional aspirations of households and indicates that education alone cannot be used to reduce the deforestation problem.

6.3 *Land Use*

Apart from the deforestation problem, land use is a major determinant of the environmental impact of cleared land. There are three major land uses in the NEA:

annuals, which are mostly food crops for own-household consumption; perennials, principally coffee and cacao, which are usually for market sale; and pasture. Pasture is used for raising cattle, which are always for market consumption, although they may provide milk products for household consumption prior to their market sale. Of the three major land uses in this region, pasture is clearly the most environmentally devastating because it represents the largest deviation from the natural state of the land and introduces additional animals that must be supported by the land. In addition, cattle grazing results in greater soil compacting as animals' hooves trample the ground. This increases the likelihood that there will be waste or other contaminant runoff into the local water supply.

Table 4 shows the impact of off-farm work and other independent variables on the area of land devoted to annuals. While the OLS results, presented in columns (1) and (2), indicate that off-farm employment is a significant factor in the area dedicated to the production of annuals, the instrumental variables analysis in column (3) shows that off-farm employment is not an important determination of land in annuals when taking the endogeneity into account. Beyond off-farm employment, households who have larger farms dedicate more area to annuals, as do those closer to population centers and with vehicular access.

Although the area in annuals is only very mildly related to farm size, with only 3% of each additional acre dedicated to annuals, it is strongly related to household size, with a 10% increase in household size generating a one tenth of a hectare increase in the area in annuals. This result is consistent with the idea that annuals are often subsistence food crops, leading larger households to cultivate a greater area than smaller households.

The analysis of the area dedicated to perennials is shown in Table 5. Columns (1) and (2) show OLS results with and without *canton* level fixed effects, and column (3) shows the second stage instrumental variables results. The OLS analysis indicates that the quantity of off-farm employment may play a role in the area dedicated to annuals. The instrumental variables results, however, again do not show this same impact. The larger the farm, the more the area is dedicated to perennials, with 3% of each additional hectare used for perennials. Vehicular access proves important for perennial area, with households who have access maintaining 0.9-1.0 additional hectares in perennials. This

constitutes a large impact on the area in perennials as the average household in the sample has less than four hectares in these cash crops.

Household size and composition have an impact under OLS, but lose their significance when IV is used, indicating that the impact of these variables is indirect, operating through labor allocation decisions of the household. Finally, duration of residence proves to be a significant and positive factor in the area in perennials under all specifications, a result that is highly intuitive given the nature of these crops. Because perennials take time to establish, households new to the area are likely to plant only small areas of them, reserving other areas for crops that can produce near term income. However, as time passes, the household is likely to dedicate more and more area to these crops, as they provide greater cash income than do annuals.

The final land use in this region that must be considered is pasture. Pasture is generally used to graze cattle; however, households also occasionally graze other animals such as horses, African goats and pigs. As noted previously, pasture is generally considered to be the most environmentally devastating of the three major land uses in this region. The results of the analysis of the impact of off-farm employment on pasture are shown in Table 6. As with annuals and perennials, columns (1) and (2) present the OLS results with and without canton level fixed effects, while column (3) shows the second stage instrumental variables results. The results indicate that there is little evidence for the hypothesis that off-farm employment impacts the area in pasture, as the IV results fail to show any significance for that variable. Farm size is a major indicator of area in pasture. This is an expected result as large land areas facilitate the ability to engage in ranching and many small farms do not have the necessary land to graze even a few cows. OLS indicates that households farther from the road and those farther from population centers devote less land to pasture, although this result is not robust to the IV specification. As with perennials, duration is a significant factor in the determination of pasture area. This is likely to be due to the fact that livestock, while more profitable than many crops, involves large fixed costs at startup. Because of this, livestock acquisition is often done in a piecemeal fashion, and households who have been on their farms longer have had a greater length of time to accumulate savings from cash crops and off-farm employment to buy cattle and clear land for pasture. The fraction of the household

composed of prime age females is a positive contributing factor for the area in pasture under both OLS specifications, but this effect disappears under an instrumental variables framework. The same can be said of the education level of the head of the household. The loss of significance for these variables under IV estimates can be explained by their impact on the off-farm work decision, as can be seen in the first stage results, shown in Table 3.

7. Conclusion

The overall results of the analysis of off-farm employment and land use presented herein indicate that there exist substantial endogeneity biases with respect to off-farm employment. These biases, when not accounted for, result in an improper understanding of the impact of off-farm employment on deforestation and land use. OLS results indicate that off-farm employment is associated with retention of additional forest and corresponding decreases in the area allotted to annuals, perennials, and pasture. These results are not substantiated by the use of an instrumental variables framework. Instrumental variables estimates indicate that off-farm employment is not significant with respect to any of these dependent variables, a result which runs counter to the established literature.

Despite the existence of policy instruments that may encourage off-farm employment³, the results here indicate that off-farm employment does not reduce the conversion of forest into farm land when the endogeneity of off-farm work is taken into account. This eliminates the possibility of simultaneously encouraging employment and stemming deforestation through the use of a single instrument.

This work shows no detrimental impact of off-farm employment on forest retention, making it tempting to suggest it as an environmentally neutral method of welfare improvement. However, there are other important effects of off-farm employment that must be considered before reaching this conclusion. It is possible that off-farm employment has no impact on household level deforestation; however the

³ I address this issue in a separate chapter of my dissertation, where I determine the factors that affect the decision to participate in off-farm employment. The citation for this paper is available in the reference section, and copies of the work are available upon request.

broader environmental impacts of off-farm employment should be considered. In the NEA, about two-thirds of off-farm employment is agricultural, meaning that off-farm employment may only spread deforestation to those other farms that hire labor to the extent they put more and more land into productive use.

In addition, areas with higher levels of employment and/or wages are likely to attract additional settlers, leading to increased subdivision of properties in the area. This is important because preliminary evidence indicates that subdivided properties preserve a smaller land share in forest⁴. This means that increasing migration into an area of high employment may lead to additional deforestation as more properties are subdivided.

While this work offers no panacea for the problems that plague many developing areas, the results here indicate that off-farm employment is not the win-win solution that has been presented as in the past. While increases in off-farm job opportunities are likely lead to increases household welfare in this desperately poor part of the world, they will not also serve to stem the recent tide of deforestation in the region. The degree to which off-farm employment may encourage forest loss is a subject for further research. It is necessary to assess both the impact of higher employment rates and wages on migration into the area before the total impact of increased off-farm employment can be fully determined. This paper is an important first step, however, and provides important information that should be considered by policy makers prior any attempt to reduce deforestation and poverty in this area.

⁴ In my dissertation I find that the number of subdivisions between the initial survey in 1990 and the follow up in 1999 is directly related to the percent of the farm remaining in forest. The citation for this paper is available in the reference section, and copies of the work are available upon request.

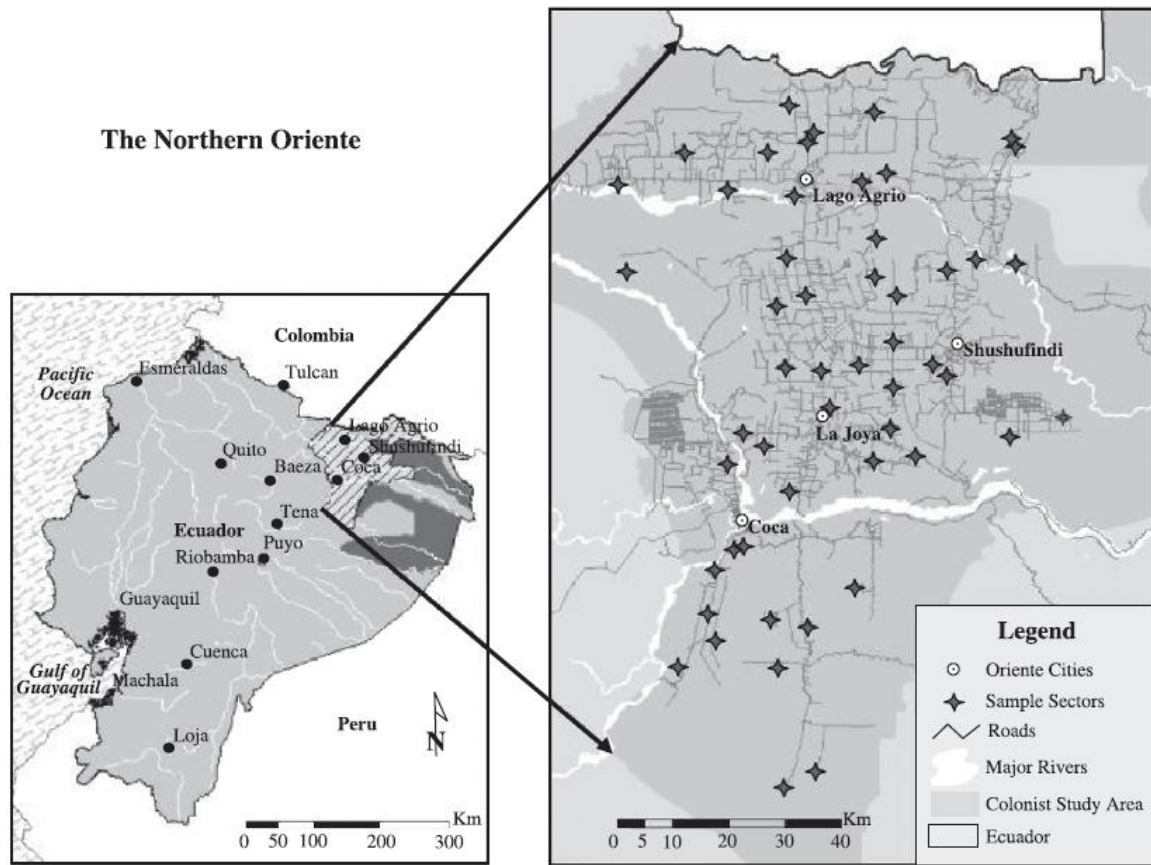


Figure 1: The Study Area in the Northern Ecuadorian Amazon

Table 1 Household Level Summary Statistics

<i>Variable</i>	<i>All</i> (1)	<i>OFE</i> (2)	<i>No OFE</i> (3)	<i>Difference</i> (4)
Farm Characteristics				
Total Land Holdings (hectares)	34.25 (34.01)	30.55 (34.90)	39.56 (32.00)	-9.01*** (2.71)
Area of Surveyed Properties	27.60 (23.00)	24.77 (23.25)	31.67 (22.05)	-6.90*** (1.83)
Total Area in Forest	13.41 (16.50)	13.73 (17.45)	16.57 (17.12)	-2.84** (1.39)
Percent of Farm in Forest	0.40 (0.32)	0.38 (0.32)	0.42 (0.30)	-0.04 (0.03)
Total Cleared Area ⁵	12.71 (12.16)	11.02 (11.26)	15.11 (12.92)	-4.09*** (0.96)
Area in Annuals	1.30 (2.47)	1.30 (2.90)	1.29 (1.68)	0.02 (0.20)
Percent of Farm in Annuals	0.09 (0.17)	0.10 (0.19)	0.07 (0.12)	0.04*** (0.01)
Area in Perennials	3.80 (3.70)	3.16 (3.31)	4.72 (4.03)	-1.56*** (0.29)
Percent of Farm in Perennials	0.24 (0.26)	0.25 (0.28)	0.23 (0.23)	0.02 (0.02)
Area in Pasture	5.63 (8.75)	4.68 (7.96)	6.99 (9.63)	-2.31*** (0.70)
Percent of Farm in Pasture	0.18 (0.22)	0.17 (0.22)	0.21 (0.21)	-0.04** (0.02)
Area in Fallow	1.97 (3.76)	1.87 (3.92)	2.11 (3.52)	-0.24 (0.30)
Percent of Farm left Fallow	0.09 (0.16)	0.09 (0.17)	0.08 (0.14)	0.01 (0.01)
Soil is Black	0.59 (0.49)	0.60 (0.49)	0.57 (0.50)	0.02 (0.04)
Has Coffee	0.86 (0.35)	0.82 (0.39)	0.92 (0.27)	-0.10*** (0.03)
Has Cattle	0.46 (0.50)	0.42 (0.49)	0.56 (0.50)	-0.14*** (0.04)
Farm Accessibility				
Distance to Major Population Center (km)	19.38 (13.44)	18.68 (13.57)	20.37 (13.20)	-1.69 (1.08)
Distance to Farm by Foot	1.17 (1.85)	1.08 (1.72)	1.31 (2.01)	-0.24 (0.15)
Farm Always has Vehicular Access	0.48 (0.50)	0.49 (0.50)	0.46 (0.50)	0.02 (0.04)
Vehicular Access Depends on Rains	0.17 (0.37)	0.16 (0.37)	0.18 (0.38)	-0.02 (0.03)

⁵ Area of surveyed properties not in forest or swamp

<i>Variable</i>	<i>All</i> (1)	<i>OFE</i> (2)	<i>No OFE</i> (3)	<i>Difference</i> (4)
Use of Inputs				
Use Hired Labor	0.45 (0.50)	0.44 (0.50)	0.46 (0.50)	-0.02 (0.04)
Days of Labor Hired for Households Using Hired Labor	70.89 (88.95)	65.17 (89.38)	78.78 (88.10)	-13.60 (10.61)
Use Fertilizer, Pesticide or Herbicide	0.37 (0.48)	0.34 (0.48)	0.41 (0.49)	-0.06 (0.04)
Household Composition				
Number of Household Members	5.83 (3.04)	6.17 (3.16)	5.36 (2.79)	0.81*** (0.24)
Fraction Males Aged 15-59	0.32 (0.20)	0.32 (0.18)	0.32 (0.23)	0.00 (0.02)
Fraction Females Aged 15-59	0.22 (0.13)	0.23 (0.12)	0.21 (0.14)	0.02** (0.01)
Fraction Males 60 and Older	0.04 (0.13)	0.02 (0.07)	0.07 (0.17)	-0.04*** (0.01)
Fraction Females 60 and Older	0.03 (0.09)	0.02 (0.07)	0.04 (0.11)	-0.03*** (0.01)
Fraction Children Under 15	0.38 (0.27)	0.40 (0.22)	0.36 (0.24)	0.05*** (0.02)
Characteristics of the Heads of Household				
Age of Head	44.01 (13.97)	42.20 (13.35)	46.61 (14.46)	-4.42*** (1.11)
Age of Spouse	38.92 (13.92)	36.97 (12.96)	41.76 (14.79)	-4.79*** (1.16)
Years of Education of Head	4.90 (2.69)	5.07 (2.83)	4.65 (2.45)	0.42** (0.22)
Years of Education of Spouse	4.82 (2.68)	5.07 (2.80)	4.44 (2.43)	0.63*** (0.23)
N	639	377	262	

Table 2 Marginal Effects on the Area Remaining in Forest

	(1)	(2)	(3)
Hundreds of Days of Off-Farm Work	0.38*** (0.14)	0.66*** (0.15)	0.56*** (0.14)
Farm Size in Hectares	0.66*** (0.03)	0.68*** (0.03)	0.65*** (0.03)
Walking Distance to the Road	0.62*** (0.18)	0.59*** (0.18)	0.34 (0.21)
Distance via Road to Nearest Population Center	0.12*** (0.03)	0.11*** (0.03)	0.10*** (0.03)
Farm Has Vehicular Access All Year	-2.85*** (0.71)	-2.46*** (0.71)	-3.07*** (0.77)
Soil is Mainly Black	-2.07*** (0.75)	-1.94*** (0.73)	0.04 (0.79)
Duration Since Household Acquired the Farm	-0.21*** (0.05)	-0.18*** (0.05)	-0.16*** (0.05)
Log of Household Size		-3.38*** (0.88)	-2.98*** (0.84)
Fraction Prime Males		-8.71*** (2.37)	-7.41*** (2.32)
Fraction Prime Females		-5.55* (3.31)	-4.67 (3.13)
Fraction Elderly Males		-9.75** (4.12)	-8.48** (4.00)
Fraction Elderly Females		1.91 (4.27)	1.77 (4.14)
Age of Head of Household		-0.03 (0.04)	-0.02 (0.03)
Years of Education of Head of Household		-0.58*** (0.16)	-0.50*** (0.15)
<i>Canton Level Fixed Effect</i>	N	N	Y
<i>Observations</i>	639	639	639
<i>Adjusted R-squared</i>	0.778	0.792	0.820

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3 Marginal Effects on the Percent of Farm Remaining in Forest, IV

	(1)		(2)	
	1 st Stage	2 nd Stage	1 st Stage	2 nd Stage
Hundreds of Days of Off-Farm Work		-1.39 (1.05)		-0.91 (1.44)
Average Number of Off-Farm Days[†]	-0.01 (0.01)		-0.01* (0.01)	
Household has Electricity	0.69*** (0.19)		0.41** (0.18)	
Farm Size in Hectares	0.00 (0.00)	0.64*** (0.03)	-0.01 (0.00)	0.65*** (0.03)
Walking Distance to the Road	-0.15*** (0.04)	-0.00 (0.26)	-0.13*** (0.04)	0.08 (0.26)
Distance via Road to Nearest Population Center	-0.01 (0.01)	0.08*** (0.03)	-0.01 (0.01)	0.08*** (0.03)
Farm Always Has Vehicular Access	0.33* (0.20)	-2.61*** (0.87)	0.23 (0.19)	-2.49*** (0.82)
Soil is Black	0.23 (0.18)	-0.23 (0.87)	0.22 (0.17)	-0.26 (0.84)
Duration Since Household Acquired the Farm	-0.01 (0.01)	-0.22*** (0.06)	-0.02* (0.01)	-0.21*** (0.06)
Log of Household Size			1.40*** (0.28)	-1.23 (2.26)
Fraction Prime Males			2.82*** (0.60)	-4.04 (4.85)
Fraction Prime Females			3.40*** (0.75)	-0.37 (6.38)
Fraction Elderly Males			2.39*** (0.88)	-6.28 (5.73)
Fraction Elderly Females			0.95 (0.90)	2.90 (4.86)
Age of Head of Household			-0.00 (0.01)	-0.02 (0.04)
Years of Education of Head of Household			0.08** (0.04)	-0.38* (0.23)
<i>Canton Level Fixed Effect</i>	Y	Y	Y	Y
<i>Observations</i>	639	639	639	639
<i>R-squared</i>	0.081	0.753	0.174	0.778
<i>F-Stat of Excluded Instruments</i>	7.91***		5.43***	
<i>Hansen-J P-Value[‡]</i>		0.830		0.662

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[†] Average number of off-farm days worked in the past year per prime age adult for the parroquia

[‡] Overidentification test of excluded instruments.

Table 4 Marginal Effects on Hectares in Annuals

	(1) OLS	(2) OLS	(3) IV [†]
Hundreds of Days of Off-Farm Work	-0.07* (0.04)	-0.07* (0.03)	-0.35 (0.29)
Farm Size in Hectares	0.03*** (0.01)	0.03*** (0.01)	0.02** (0.01)
Walking Distance to the Road	0.04 (0.05)	0.06 (0.06)	0.02 (0.06)
Distance via Road to the Population Center	-0.03*** (0.01)	-0.02*** (0.01)	-0.03*** (0.01)
Farm Always Has Vehicular Access	0.37* (0.19)	0.33 (0.24)	0.42 (0.27)
Soil is Black	0.53** (0.24)	0.29 (0.30)	0.35 (0.28)
Duration Since Household Acquired the Farm	-0.00 (0.02)	0.00 (0.02)	-0.01 (0.02)
Log of Household Size	0.76*** (0.28)	0.79*** (0.26)	1.20** (0.57)
Fraction Prime Males	0.76 (0.55)	0.83 (0.52)	1.67 (1.05)
Fraction Prime Females	-0.29 (0.89)	-0.35 (0.86)	0.66 (1.50)
Fraction Elderly Males	1.07 (1.05)	1.38 (0.97)	2.10 (1.35)
Fraction Elderly Females	-0.83 (0.87)	-0.67 (0.82)	-0.30 (0.90)
Age of Head of Household	0.01 (0.01)	0.00 (0.01)	0.00 (0.01)
Years of Education of Head of Household	0.04 (0.03)	0.04 (0.03)	0.07 (0.04)
<i>Canton Level Fixed Effects</i>	N	Y	Y
<i>Observations</i>	639	639	639
<i>R-squared</i>	0.133	0.197	0.144
<i>F-Stat of Excluded Instruments</i>			5.43***
<i>Hansen-J P-Value[‡]</i>			0.508

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

† For first stage results see Table 3.

‡ Overidentification test of excluded instruments

Table 5 Marginal Effects on Hectares in Perennials

	(1) OLS	(2) OLS	(3) IV
Hundreds of Days of Off-Farm Work	-0.28*** (0.08)	-0.25*** (0.08)	0.14 (0.70)
Farm Size in Hectares	0.05*** (0.01)	0.06*** (0.01)	0.04*** (0.01)
Walking Distance to the Road	-0.02 (0.06)	0.11* (0.06)	0.12 (0.12)
Distance via Road to the Population Center	-0.01 (0.01)	-0.00 (0.01)	-0.00 (0.02)
Farm Always Has Vehicular Access	0.89*** (0.26)	1.01*** (0.28)	0.82** (0.36)
Soil is Black	0.17 (0.27)	-0.23 (0.28)	-0.24 (0.30)
Duration Since Household Acquired the Farm	0.04** (0.02)	0.04** (0.02)	0.04* (0.02)
Log of Household Size	1.42*** (0.38)	1.36*** (0.37)	0.72 (1.11)
Fraction Prime Males	4.90*** (0.91)	4.78*** (0.91)	3.53 (2.44)
Fraction Prime Females	1.67 (1.23)	1.60 (1.21)	0.19 (2.91)
Fraction Elderly Males	3.16** (1.60)	2.94* (1.61)	1.93 (2.68)
Fraction Elderly Females	0.11 (1.53)	0.56 (1.49)	-0.19 (1.92)
Age of Head of Household	0.00 (0.02)	0.00 (0.02)	0.00 (0.02)
Years of Education of Head of Household	0.00 (0.06)	0.01 (0.06)	-0.02 (0.09)
<i>Canton Level Fixed Effect</i>	N	Y	Y
<i>Observations</i>	639	639	639
<i>R-squared</i>	0.296	0.323	0.295
<i>F-Stat of Excluded Instruments</i>			5.51***

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

‡ Overidentification test of excluded instruments

Table 6 Marginal Effects on Hectares in Pasture

	(1) OLS	(2) OLS	(3) IV [†]
Hundreds of Days of Off-Farm Work	-0.29* (0.15)	-0.27* (0.15)	1.53 (1.29)
Farm Size in Hectares	0.19*** (0.03)	0.20*** (0.03)	0.21*** (0.03)
Walking Distance to the Road	-0.48*** (0.14)	-0.34** (0.14)	-0.09 (0.22)
Distance via Road to the Population Center	-0.04** (0.02)	-0.04* (0.02)	-0.02 (0.02)
Farm Always Has Vehicular Access	1.36** (0.60)	1.82*** (0.63)	1.25 (0.78)
Soil is Black	1.16* (0.65)	0.57 (0.67)	0.18 (0.77)
Duration Since Household Acquired the Farm	0.11** (0.05)	0.11** (0.05)	0.15** (0.06)
Log of Household Size	0.47 (0.72)	0.51 (0.69)	-2.08 (2.01)
Fraction Prime Males	3.10 (1.99)	2.94 (1.95)	-2.35 (4.15)
Fraction Prime Females	5.19* (3.00)	5.33* (2.98)	-0.93 (5.49)
Fraction Elderly Males	4.33 (3.73)	4.52 (3.62)	0.03 (5.16)
Fraction Elderly Females	-2.91 (3.68)	-2.43 (3.58)	-4.70 (4.29)
Age of Head of Household	0.04 (0.03)	0.03 (0.03)	0.03 (0.04)
Years of Education of Head of Household	0.55*** (0.17)	0.51*** (0.17)	0.33 (0.23)
<i>Canton Level Fixed Effect</i>	N	Y	Y
<i>Observations</i>	639	639	639
<i>R-squared</i>	0.372	0.401	0.236
<i>F-Stat of Excluded Instruments</i>			5.43***
<i>Hansen-J P-Value[‡]</i>			0.359

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[†] For first stage results see Table 3[‡] Overidentification test of excluded instruments

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