The Determinants and Effects of the Off-Farm Employment Decision: A Study of the Northern Ecuadorian Amazon

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Abstract

Katherine Christina Theyson: The Determinants and Effects of the Off-Farm Employment Decision: A Study of the Northern Ecuadorian Amazon
(Under the direction of Richard Bilsborrow and Boone Turchi.)

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—a win-win solution. It has thus come to be promoted by policymakers and economists as a way to address deforestation in environmentally sensitive areas. Nevertheless, research on the impact of OFE on land use and deforestation at the household level continues to be sparse.

This dissertation investigates the economic and non-economic 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. In this dissertation, I use detailed data from a probability sample of over 700 farm households to assess the factors that affect the choices of men and women to engage in OFE and the impact of that OFE on land clearing and land use.

Following development of the theoretical model of the farm household, bivariate probit analysis with household level fixed effects is used to determine the individual characteristics that affect participation in farm work and OFE. Because participation in OFE is a choice variable, the analysis of the impact of OFE on land clearing/use utilizes an instrumental variables framework with community level fixed effects. I find 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. In the concluding chapter I offer further suggestions for policy as well as on improving data collection and extending the empirical model.

For Alex, with the thought that maybe someday he will find this whole thing somewhat more impressive than he does at the moment.

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1. INTRODUCTION

1.1. Motivation for the Dissertation

Over the past few decades, both scientists and the general public have given a great deal of attention to the escalating process of deforestation. There are many reasons to be concerned about the rapid rate of forest loss. The developed world's first and foremost concern often lies in the impact of forest depletion on global warming. Forests, particularly tropical rainforests, act as the "lungs" of the planet, absorbing carbon dioxide, a greenhouse gas, from the atmosphere and replacing it with oxygen, a process which reduces global warming. A second reason for concern comes from the fact that forest loss increases the likelihood of extinction for many species of plants and animals, as their habitat is converted to human use. This concern is most prominent for areas of the world that exhibit high rates of endemism, as the plant and animal species in these areas cannot be found elsewhere. Finally, it is important to consider the economic costs of deforestation. While these costs are hard to quantify, the value of "nature's services" has been estimated at between $18 trillion and $61 trillion annually (Balmford *et al.*, 2002). Balmford *et al* also analyze empirical studies that attempt to estimate the value of preserving natural habitats in specific biomes through sustainable use, when compared to more intensive uses. For each habitat studied, they find that the net present value of retaining natural habitats exceeds the value of the same area when converted to typical human uses[1]. It is their assessment that the "benefit/cost ratio of an effective global program for the conservation of remaining wild nature is at least 100:1" (Balmford *et al.*, 2002).

Wild nature is often lost to human development because of market failures despite the long term economic benefits of its preservation. Specifically, while much of the value of wild nature comes from the public goods that it provides, such as cleaner air or water, converted uses generally confer private benefits. As such, the conversion of land to human uses often makes economic sense to private individuals while also being detrimental to society as a whole.

An additional complication for the preservation of nature lies in the fact that many of the natural habitats which are of the greatest worldwide concern lie in areas of the world where the population is relatively poor. While people in the developed world are often willing, or even eager, to pay for the preservation of nature, those living in developing areas are much more concerned with day to day survival. These people often do whatever they must to increase their standard of living, regardless of the environmental consequences. This is another area where the public good aspects of nature come into conflict with the goal of households or individuals to increase their income or welfare. For example, one of the needs of many living in developing areas is for clean water. However, people living in these areas are often doing things which lead to water contamination, such as clearing land (which increases runoff into water supplies) or dumping waste into waterways. The reason that this behavior continues is that none of the people engaging in these activities believes that their own behavior has any impact on

[1] Analysis of the net present value under various uses was done for periods of 10 to 100 years depending on the study.

the overall level of water quality. This same type of behavior can be seen with respect to forest clearing, where those who do the clearing do not think of their choice as having any significant impact on the overall level of forest in their area. These types of behaviors have led to much of the loss of natural resources in developing regions.

The lack of both physical and social infrastructure may also play a role in forest loss. Households in developing areas of the world often do not have easy access to labor and goods markets, which leads to a greater reliance on land for their economic well-being. The absence of good credit markets may also aggravate this problem. Even if sustainable uses confer greater long term private benefits, as has been argued for sustainable harvesting of forests, it is difficult for households, in the absence of these markets, to convert long term benefits into current consumption.

1.2. The Problem

There are many causes for the continuing loss of forests and other forms of natural habitat, including agriculture, housing, logging, and mining and petroleum extraction. In developing areas of the world, agriculture is by far the largest proximate cause of lost habitat (Geist & Lambin, 2002). The increasing share of land devoted to agriculture in developing countries stems from the need to support populations, which are experiencing rapid rates of growth.

Malthus, in his1798 work “An Essay on the Principle of Population” (1999), supposed that while population increased geometrically, agricultural output could only increase arithmetically. Because of this, Malthus argued, a point will be reached where the produce of the earth will no longer be sufficient to provide for the growing population. In this state, he expects that the poor will be "reduced to severe distress" and the wages of laborers will fall. The low price of labor is then expected to increase the area of land in cultivation, bringing up the quantity of food available until an acceptable level of subsistence is again achieved and the population can again expand. In essence Malthus is arguing that there exists a cycle in which periods prosperity and population growth are followed by a decrease in living standards and likely large scale starvation of the poorer classes.

Despite Malthus' dire predictions, population growth, in general, has not outpaced the level of increase in food production worldwide as the growth of agricultural technology and mechanization have increased land productivity dramatically. In addition, world population growth has been slowing for the past 40 years and is currently about 1.17% per year. This growth, however, is not distributed evenly across the world. While developed countries currently are experiencing a 0.28% rate of increase, less developed regions are growing at a rate of 1.37% (United Nations, 2007). But these different rates of population growth don't fully explain the current trajectories of developed and developing countries with respect to forest clearing and the area of land devoted to agriculture. In order to understand this, it is also necessary to understand how population growth and technology affect agricultural production.

As their population grows, both developed and developing countries experience a greater need for food. However, the impact of this need varies substantially between them. While population growth in any country means that the same area of land must sustain more and more people, in the developed world, new technologies have emerged that increase the productive yield of agricultural lands. These technologies limit the need for agricultural expansion or, in some cases, may even allow for a reduction in agricultural lands. In developing countries, however, technological limitations generally result in greater and greater shares of land being devoted to agriculture. This expansion often occurs on marginal lands that, while valuable as natural habitat, have even lower levels of agricultural productivity (Ehui & Hertel, 1992).

Because agriculture is the single largest proximate cause of forest loss (Geist & Lambin, 2002; Ehui, Hertel, & Preckel, 1990), possibly the best way to preserve forest is to prevent agricultural expansion into forested areas. There have been two disparate schools of thought regarding the means of stemming the extensification of agricultural production. The first school of thought involves increasing the productivity of land with the goal of reducing the area necessary to sustain any given household. The second centers around inducing individuals to voluntarily choose less farming by increasing the opportunity cost of farming either directly, through increased input prices, or indirectly, by creating better outside options (i.e., off-farm employment) for farm families.

In order to understand whether either of these approaches would achieve the desired result, it is important to understand the nature of the decision making process for agricultural households. The time allocation of household members plays an important role in this process, especially in developing countries where agricultural production is labor intensive. The process by which households allocate time between various work options, including household work, farm work and off-farm work, is one decision which is not clearly understood from a theoretical standpoint. It is also an important part of the agricultural household's choice problem which must be better understood before any assertions can be made about the impact of off-farm employment on overall levels of deforestation. As such, this dissertation will consider the factors with influence the decision of whether or not to engage in off-farm employment (OFE) and the impact of that OFE on land use and deforestation.

Because both employment and agricultural production decisions are made within the framework of agricultural households, it is important for policymakers to understand how these households operate before devising any policy whose goal is to reduce deforestation. Like all households, agricultural households operate with the goal of maximizing household utility. However, farm households can be somewhat more complex than their non-farm counterparts, especially in areas where subsistence or mixed subsistence and market agriculture prevail.

1.3. The Context of Ecuador's Amazon Frontier

Any research into this area is incomplete without a thorough understanding of the geographical area being studied. The research contained in this dissertation focuses on an area within the Amazonian rainforests of Ecuador. Ecuador itself is a small South American country that lies on the Pacific coast between Peru and Colombia. Ecuador consists of three distinct geographic zones: the western coastal lowlands, the central highlands, and the eastern Amazonian lowlands, also known as the *Oriente* (East). The study area for this dissertation lies in the northern part of the *Oriente* near the Colombian border in the provinces of Napo, Sucumbíos and Orellana. This area, henceforth known as the Northern Ecuadorian Amazon (NEA), was sparsely inhabited mostly by indigenous groups until the early 1970's.

The NEA is part of Western Amazonia, an area that has been described as the richest biotic zone on Earth which deserves to rank as a global epicenter for biodiversity (Myers, 1986). This area has seen recent rapid population expansion which has led to similarly rapid rates of deforestation. Ecuador as a whole is losing its forest cover more rapidly than any other country in the Amazon Basin, and most of this loss is occurring in the NEA.

The problems in the NEA, however, are substantially more complex than deforestation alone. The combination of deforestation, population growth, poverty and international interests, especially petroleum, has created a complex situation which must be taken into account in any attempt to create or expand policy which could protect the species unique to this region.

The population in the NEA has grown rapidly over the past three decades. Moreover the people living in this region are, for the most part, extremely poor. In 1999, the average annual *household* income of families in the study sample was about $1300, with an average household size of 5.9 people, making the average per capita income about $250, similar to the nominal per capita GDP of countries in the ninth percentile of the world income distribution at the time (International Monetary Fund, 2001). In addition, this level of income falls below the World Bank's extreme poverty level of $1 per person per day. By comparison, Ecuador as a whole is much wealthier with a per capita GDP of $1529 in 1999[2] (United Nations Development Programme, 2001). The high rate of poverty endemic to this area creates additional complications when it comes to addressing the problem of deforestation. Because the goals of economic development

[2] Without adjusting for purchasing power parity

and environmental preservation are often at odds, policy makers struggle with the tradeoffs between them.

1.4. Research Aims

Off-farm employment has been suggested as an activity that does not involve the same sort of tradeoffs as other policies to mitigate deforestation. This is because some studies have found off-farm employment to be both an inherently welfare improving activity for participating farm households and associated with reduced rates of deforestation. These studies, however, have not investigated thoroughly whether participation in OFE reduces deforestation at the household level, a necessary but not sufficient condition for reductions in deforestation. To do this, it is necessary to ascertain whether the transfer of labor from the farm to other occupations reduces household level deforestation. While OFE does diversify the household's income sources, it will not necessarily result in a decrease in the rate of conversion of forest into farm land, if income earned in off-farm activities provides financial resources for the household to "improve" their farm, which may include further forest clearing and hiring of labor.

The goal of this dissertation is to investigate the relationship between household composition, work choices, and land use. As such, I will explore the determinants of work choices for colonist settlers in the Northern Ecuadorian Amazon, in particular, how household composition, characteristics, land availability, and household location affect both on and off-farm work choices of individuals in the farm household. Furthermore, I will explore the relationship between off-farm employment of household members and the household's land use choices. This is a particularly important with respect to household level deforestation choices because for off-farm employment to help reduce the level of deforestation, it is necessary but not sufficient that off-farm work result in lower household level deforestation rates.

1.5. Organization of Dissertation

The dissertation is organized into 7 Chapters. Chapter 1 provides introductory information about the motivation, goals, and context of this dissertation. Chapter 2 details the theory underlying the analysis, focusing on the theory of the agricultural household, employment choice and deforestation. Chapter 3 provides extensive background information on the Northern Ecuadorian Amazon, detailing the process of colonization as well as the current problems the region is experiencing with deforestation. The data is reviewed in chapter 4 including extensive information regarding many of the variables used in the subsequent analysis. Chapter 5 examines the factors that affect the time allocation decisions of agricultural household members, with a particular emphasis on their impacts on participation in farm and off-farm work. Chapter 6 analyzes how household level off-farm work participation impacts land use, including area of retained forest and area in the major regional agricultural uses. Finally Chapter 7 concludes.

2. THEORETICAL BACKGROUND AND LITERATURE

When considering the determinants of the off-farm work choice and its impact on household decisions, many aspects of the household decision-making process need to be understood. The household utility maximization problem underlies all observable choices, from the quantity of market goods purchased, to the time allocation of individual family members. The utility maximization problem, however, does not completely explain these choices. To gain a fuller understanding, it is also important to understand the structure and operation of markets and how they interact with the household. Labor and goods markets play a substantial role in the household's decision-making process by dictating the limits on household decisions. The specific aspects that this dissertation will focus on are the decisions of members of the farm household about when and where to work, and the related use of land within the household's pervue. This makes it necessary to understand theories of labor force participation, in general, and those of agricultural households, in particular. Finally, it is important to understand how labor choices and land use are related within the agricultural household's overall decision-making process.

2.1. Theoretical Perspectives on Household Decision-making

Economists have long debated the nature of household decision-making. Much of this debate centers around whether it is appropriate to treat a household as a single unit, with a single set of preferences, or as a collection of individuals, each with their own unique preferences. Each of these theories has pros and cons. Those containing a single uniform household relinquish analysis of household dynamics in favor of a simple model with clear implications. Giving each individual their own preferences allows for the analysis of intrahousehold resource allocation and individual work choices, but this choice greatly increases the complexity of the theoretical model, making its implications less clear.

2.1.1. Neo-Classical Household Models

The simplest neo-classical theories deal with an individual decision maker or a household which contains a single worker, who maximizes his utility by choosing among different bundles of goods whose prices are given exogenously. The ability to purchase these bundles is determined by the total income of the individual, including non-labor income (Deaton & Muellbauer, 1980).

One of the simplifying assumptions of this model, that the household is made up of a single individual, or single worker, has little basis in any modern economy, where most households have at least two working members. In developing countries, this assumption is even more inappropriate as most households contain multiple workers, with men, women and children all participating in economic activities.

This theory can be expanded to include a multi-person household, operating as a single homogenous unit, by using a vector of individual wages and time spent in market work in the utility function and budget constraint. As such, the household exhibits a joint utility function, maximized subject to a single budget constraint incorporating the earned and unearned income of each family member, and the household makes its decisions in pursuit of a single objective. This type of model does not consider the distribution of income or resources among household members, a shortcoming that subsequent household models attempt to remedy.

2.1.2. Other Household Models

Samuelson (1956) noted that "every close student of the family will have noticed that it behaves neither like a dictator nor a unanimous committee." This observation led to the expansion of the neo-classical household model to allow for differing utility functions of household members. One example of this is the Bergson-Samuelson household welfare function in which the household's total welfare is a function of each member's potentially unique utility function as follows:

$$W = W[U_1(\mathbf{X}, l; \mathbf{Z}), U_2(\mathbf{X}, l; \mathbf{Z}), ..., U_N(\mathbf{X}, l; \mathbf{Z})] \tag{2.1}$$

where there are N members of the household, U_i is the utility function of household member i, $\mathbf{X}$ is a vector of household consumption, l is the leisure of the members of the household, and $\mathbf{Z}$ is a vector of household characteristics. Individual utility functions are weakly separable, so that, the maximization of W implies the maximization of each individual utility function subject to the household budget constraint. Despite this implication, the Bergson-Samuelson model still has the household making a joint choice of the consumption and leisure of all members, while allowing for unequal weighting of household members. (Deaton & Muellbauer, 1980).

The theory of a single decision household was prevalent for many years. More recently, however, economists have argued that households are heterogeneous groups of individuals, each making his or her choices based on his or her own set of preferences. This philosophy led to several new models of household decision-making which have individuals maximizing their own utility or welfare functions (see Apps & Rees, 1996; Chiappori, 1992; Chiappori, 1997). In these models, households make Pareto-efficient decisions, reallocating resources between members in mutually beneficial ways (Chiappori, 1992). This understanding of household resource allocation necessitates a "sharing rule," whereby resources are allocated between household members in order to achieve Pareto optimality (Cahuc & Zylberberg, 2004). The sharing rule is thought to be determined by a number of factors related to the power of individual household members. For example, members who contribute more to household income may have more power and thus receive a higher share of household consumption than those who contribute less to income.

2.2. Potential Shortcomings of Household Models

These models are extremely useful tools, which serve to enhance the overall understanding of household decision making processes. However, each utilizes many simplifying assumptions, some of which may not be appropriate in the context of a developing country. The supposition that there are exogenously determined prices and wages, which do not change with the quantity of goods bought or sold, or the quantity of labor provided, may be problematic. For example, individuals who buy a large quantity of a particular good often receive a lower per unit price than those who buy smaller quantities. In addition, in the context of an agricultural household who sells goods in the market place the opposite may be true. Households who sell larger quantities of agricultural goods may be able to develop better relationships with intermediaries or customers and thus may be able to demand, and get, higher prices for their goods. With respect to the wage rate, the assumption of a constant wage rate is also unlikely to be appropriate, as those who work more hours generally receive a higher wage.

The reasonableness of some of the other assumptions made in these models depends on the particular time period being analyzed. For example, these models also makes no restrictions on the amount of time spent in market work, save that it cannot be negative or greater than the individual's total available time. This assumption is not reasonable when considering a choice of work hours today, when any job is likely to require a certain time commitment, but may be appropriate when considering a long period of time such as a year or more. With a longer time horizon, a worker could move to a different job if he wanted to work more or fewer hours. However, when considering longer periods of time, it is even more unreasonable to expect that wages will remain constant regardless of the hours of work supplied (Deaton & Muellbauer, 1980).

In addition to these objections, there are additional problems with making this type of assumption in the context of a developing country. Because developing countries often exhibit high rates of involuntary unemployment, individual workers may be unable to obtain their desired quantity of work. It has been suggested that this failure of labor markets to clear may be due to the inability of rural wages to adjust downward, even in areas of considerable involuntary unemployment (Hart, 1986). Economists have offered differing reasons for the failure of labor markets to clear ranging from "old-fashioned cultural norms to more modern efficiency wage stories" (Benjamin, 1992).

However, regardless of the cause, the failure of labor markets to clear changes the individual's maximization problem significantly. The nature of this change depends on the structure of the constraint on the availability of market work. If there is an excess supply of labor available in the market place, not every person can find the quantity of work that they desire. Given this, there are three ways that this excess supply can manifest. First, those employed may choose the number of hours they work freely, but a segment of the workforce will remain unemployed. In this context, there may be some probability p of an individual being employed, and employed individuals may choose their total work time l. However, with probability 1-p, the individual will be unemployed and receive $l = 0$. The second possibility is that each individual is constrained in the quantity of work they can choose. Thus the demand for labor is rationed across individuals with each worker choosing their work time $l \leq H$, where H is the maximum time each person can spend in market work (Benjamin, 1992). Finally, there may be some combination of these two situations where some potential workers remain unemployed and even employed individuals may be restricted in the quantity of work that they can choose.

2.3. Theoretical Perspectives on Labor Markets

Labor markets exist on a most basic level because of the existence of comparative advantage and/or economies of scale. Conceptually, labor markets are a form of trade whereby individuals who are more skilled in a particular activity specialize in that activity and trade with individuals with different skill sets. This Pareto improving process allows more output to be produced from a given level of resources.

The labor market can be divided into two components: labor supply, determined by the preferences of those who actually or potentially could work in the marketplace; and labor demand, determined by those who could hire workers. It is the interaction of these two components which determines the level of employment and the wage rate which individuals earn. While labor demand is important for the determination of the wage rate and employment level in an economy, this dissertation is concerned with the factors affecting labor supply. Thus, the study of labor markets, for the purposes of this dissertation will be limited to the supply side.

Labor supply models have much in common with household models, both of which have an individual (or household) who maximizes his utility by dividing his time between labor and leisure. But while household models may focus more on consumption choices, labor supply models focus on the time use choice. Utility in labor supply models is gained through both leisure and consumption of market goods that must be purchased out of either labor or non-labor income. Thus the overall tradeoff that occurs is that of consumption for leisure.

The neoclassical model of labor supply as described by Deaton and Muellbauer (1980) is a simple model where an individual chooses the quantity of consumption goods (q), and the amount of time spent in leisure (l) with a given prices (p_i) in order to maximize their utility, which takes the form:

$$U = U(q,l)\ . \tag{2.2}$$

The bundles quantity of goods which is available to the individual depends on the individual’s budget constraint, which is a function of the number of hours they choose to work such that, given non-labor income (μ) and wage (*w*), the budget constraint will take the form:

$$\mu + wL = pq \tag{2.3}$$

where *L* is the total time spent in market labor. Let *T* be the total time endowment for the individual, then the additional conditions that must be satisfied include:

$$L + l = T,\ L \geq 0, \text{ and } l \geq 0, \tag{2.4}$$

meaning that the total time endowment is divided between labor and leisure and that positive amounts of time must be spent in each.

In this model, the individual can choose to divide their time between work and leisure in any way they choose, which means that they can freely vary work hours, an assumption that, as previously noted, is not likely to be true for most people. Because it is possible for an individual to maximize their utility at the point where total hours worked is zero, the usual conditions for utility maximization do not necessarily hold.

2.4. Theoretical Perspectives on Labor Force Participation

A person’s choice of whether or not to enter the labor force is based on a multitude of factors, the most obvious being the wage that can be earned and the individual’s non-labor income. Increases in the first raise the probability of participating in labor markets, while increases in the second result in a lower probability of working.

Other factors which may come into play include the individual's private valuation of leisure time, other responsibilities, and health status.

2.4.1. General Labor Market Models

Much research has focused on the individual choice of whether or not to work; however, most people do not make this decision in isolation. The vast majority of people, either in the work force or out of it, are members of a multi-person household. Because of this, the characteristics, abilities, and responsibilities of other household members come into play. For example, a person whose spouse has a large earned income would be less likely to work than someone with the same characteristics whose spouse makes significantly less. In the case of a nuclear family with young children present, the husband and wife may make a joint work choice, with the individual with higher earning potential working outside the home, while the other remains with the children. In other cases, adults may alternate shifts to allow one of them to be at home at all times or may turn to other individuals for the care of their children. No matter what work choice is made, the characteristics of the household and its members are sure to influence that choice.

More recent models of labor supply often contain two parts. In the first, a potential worker decides whether or not to take part in the labor market. This choice, known as the participation decision, depends on his own private valuation of his time. This valuation, or "shadow" wage ($w*$), is the minimum wage at which the individual would choose to participate in the labor market. For those who choose not to participate, the opportunity cost of their time is governed by their private "shadow" wage (Deaton & Muellbauer, 1980; Heckman, 1974).

If the worker's desired labor supply is defined as L^*, then the observed labor supply is defined as

$$L = \begin{cases} L^* \text{ if } & w \geq w^* \\ 0 \text{ if } & w < w^* \end{cases} \tag{2.5}$$

Those who choose to participate in the employment market do so because the wage they receive meets or exceeds their "shadow wage." As such their earned wage determines the opportunity cost of their time. Increases in the market wage make it more likely that the prevailing wage is at or above any individual's shadow wage and therefore increase the probability of someone participating in the labor market.

For those who have already chosen to participate in the market, an increase in the wage rate has two effects, known as the substitution and income effects. The substitution effect occurs because increases in the wage rate increase the opportunity cost, or price, of leisure relative to consumption goods. When this happens, the worker will tend to choose less leisure and more other goods based on the relative price change. However, increases in wages also increase the earning potential of individuals, giving them more real income. The higher level of income, combined with the fact that leisure is, by its nature, a normal good, creates the income effect, whereby the individual chooses to consume more leisure, which means working less. These two effects work in opposite directions, making it unclear what the overall impact of a wage increase will be. However, according to conventional wisdom, at low levels of income, additional consumption is preferable to more leisure because the marginal value of consumption goods is higher at low levels of consumption, and the substitution effect dominates the income effect. Thus an increase in the wage rate increases the number of hours worked for workers with low income levels. For those with high levels of income, the opposite is believed to be true, as they have greater levels of consumption goods, making the marginal utility of additional consumption low relative to the marginal value of leisure. This results in a situation where increases in wage rates can cause a decline in work hours.

2.4.2. Rural Labor Market Models

Rural labor market models are more complex than general models of labor markets. In rural areas individuals have both more constraints and more choices than their urban counterparts. The geography of rural areas often limits the scope of available jobs and employers; however, this same geography also provides an additional employment choice not available to urban labor market participants, that of working one's own land.

While participation in labor markets in general depends on the characteristics of the market, individual and household, participation for farm families also depends on the characteristics of the farm, including "the farm's financial status"(Findeis, Lass, & Hallberg, 1991). This adds an additional layer of complexity to the analysis of participation in labor markets. Now, instead of simply choosing between market work and leisure, a potential worker has the additional choice to work on his own farm. This results in a greater level of complexity in the theoretical model.

2.5. The Becker Model

According to Becker (1965) households are not simple consumption units. Instead, they operate much more like firms, taking the inputs of market goods and household member's time and converting them into outputs. These outputs or "home produced goods" are the goods which the household actually consumes. Relying on the basic premise of Becker's theory, all households take part in both production and consumption.

Becker (1965) notes that time spent in paid employment accounts for the minority of an individual's time, especially in the developed world where workers typically spend less than a third of their time in market work. This does not mean that people work less than half the time. On the contrary, Becker notes that while "leisure" activities often involve the use of time and thus have a time cost component, many activities which involve forgone earnings, such as childcare or meal preparation, would not be considered leisure. Becker describes these types of activities as "home production" and argues that in order to understand time allocation we should understand how time inputs contribute to these activities.

Home production, as defined by Becker (1965) is production of goods for the purpose of direct household consumption. This is a fairly narrow band of activities, and does not encompass all non-market activities an individual may choose to participate in. Home based businesses, for instance may be an amalgamation of both market work and home production. This is particularly true of family farms with are possibly the most common form of home based business. In fact, agriculture still provides for the livelihood of a third of the population worldwide (International Labour Organization, 2007).

Farm work is unique because it is not easily classified into one of Becker's two categories. Work on the family farm may be market work, home production or both, depending on the nature of the specific farm and the activities involved. As such, it is important to consider not only market work, home production and leisure, but also time spent in work on one's own farm, in order to complete the time allocation picture of rural populations.

2.6. Models of Labor Force Participation for Those in Agriculture

For farm families, there is an additional factor which must be considered when determining whether or not to participate in the external labor force. An individual must now consider not only their valuation of leisure and market wages, but also the value of time spent working on-farm. Provided that any household member chooses to work at all, they will work off-farm if they can earn more there than they would staying on the farm and/or if they can hire someone to work on the farm for less than they could earn elsewhere (Benjamin, 1992). An additional complication in the tradeoff between market work, farm and household work lies in the possibility of household members multitasking on their farm work in a way that would not be available in off-farm employment. For example, women may be able to work on the farm and take care of children at the same time, a combination which would usually be impossible in market work activities.

It is also important to realize that farming is an inherently risky activity, with income constantly at the mercy of sun, wind and rain. In this context, off-farm work may also become a risk smoothing mechanism. This property has been identified in several papers including Mishra & Goodwin (1997), who find that the off-farm labor supply of farmers is positively associated with the riskiness of on-farm income, and Key, Roberts, & O'Donoghue (2006) whose findings include that increases in crop insurance had a negative effect on off-farm labor supply among American farmers with large farms (over $100,000 in output) while having little or no effect on the labor supply choices of small farmers. This is likely because those with small farming operations only get only a portion of their income from agriculture to begin with.

In the context of developing countries, findings have been mixed with Rose (2001) finding that Indian farmers facing greater risk, in the form of rainfall variability, were more likely to engage in off-farm employment both ex ante and ex post, while Kanwar (1999), also working with Indian data, found just the opposite, that the riskiness in the wage labor market made farmers unable to use it as a hedge against risk in agricultural production.

Previous work on labor participation for farm households has also looked at the effect of household composition, also with rather mixed results. Kimhi (2004) finds that the presence of adult children in a household affects the off-farm work choices of the head of household and his wife. He finds that having three or more adult children in a household significantly reduces the probability of the husband and wife working off-farm. However, this research excludes households where there are non-relatives present as well as those with relatives other than children and their spouses. This type of exclusion is not appropriate for my research as households in the Northern Ecuadorian Amazon are generally larger and more diverse in their composition than households in Israel, the location of Kimhi's study. In addition, Kimhi's own earlier work (1996) found just the opposite result, that more adults in a household increased the probability of working off-farm for the husband and wife.

2.7. The Nature of Farm Households

The farm is an important institution for households in rural areas of developing countries, and many households in these areas are characterized as primarily agricultural. Within the broad category of agricultural households, there exists a wide variety of market orientations. For example, farmers may be fully market oriented, producing commodities for sale at market for the purpose of income generation, without consuming any of their own production. They may also lie at the opposite end of the spectrum, operating at a pure subsistence level, producing agricultural goods solely for their own consumption. In addition to these two extremes, there are a wide variety of households who lie between, ranging from those who produce only a few commodities for their own use, to those who sell goods in the market only when absolutely necessary.

All of these types of households spend a significant share of their time on the farm, in activities which could not be considered leisure. Because the use of the farm lies within the households decision matrix, the choices made on the farm should be considered endogenous to the household decision making process in most situations.

In the past, researchers typically assume that the household and farm decisions are separable[3] from one another. However, this is true only if a number of strong assumptions hold. These assumptions include that households must operate their farm in a market oriented fashion, there must be complete and efficient labor and goods markets, there must be no preferences for working on one's own farm over other types of work, and family and hired labor must be perfect substitutes (Benjamin, 1992).

While research, prominently Benjamin (1992), and Pitt and Rosenzweig (1986), has shown that this assumption holds in some cases, these studies both investigated the validity of separability in the context of Indonesia, using data from the SUESNAS household surveys of 1980 and 1978 respectively. While Pitt and Rosenzweig offer little insight into the nature of their study area, Benjamin, working with Javanese data, provides more information. Benjamin focuses his research on the use of labor in rice farming. This crop was chosen because it is a market oriented crop, rather than a subsistence one. He finds that the average household used 104.5 days of labor in various aspects of rice farming, of which 26.3 days are family labor and 78.2 days are hired. In addition, Benjamin provides further information about the nature of farms in his study area in his previous work (Benjamin, 1989), showing that the average land owning household in Java operates a farm of 0.41 hectares, of which 0.20 hectares are used for the cultivation of rice. These household labor and farm characteristics represent a vast difference from the NEA study area where the average household provides most of its own labor and operates a farm of 27.6 hectares. These differences call in to question the applicability of these Indonesian studies, based on small farms and high density

[3] The household and farm are separable if the utility maximization problem of the household can be solved completely separately from the profit maximization problem of the farm.

populations, to other geographical areas. In addition, because many of the assumptions necessary for separability are unlikely to hold, especially in the context of the Northern Ecuadorian Amazon, the validity of the separability hypothesis is in question and the appropriate course of action is to assume that separability does not hold, until shown otherwise. In this case, the farm, and the decisions made on it, becomes an integral part of the household's utility maximization problem.

2.8. Theoretical Models of Agricultural Households

Agricultural household models vary in form, but, in general, they combine models of the consumer and producer, with the household maximizing some type of utility function subject to a budget constraint and an agricultural production function. Earlier models involve the household maximizing joint utility, which is a function of consumption of two goods: an agricultural good and a market-purchased good, and leisure subject to a production function and time and budget constraints (see Barnum & Squire, 1979; Singh, Squire, Strauss, 1986b; and others). Off farm work is available in these models with the wage exogenously determined and uniform for all household members. In addition, the wages at which labor can be hired for work on the farm are the same as those that can be earned by household members working off-farm. These models generally are concerned with predicting the consumption and production decisions of the agricultural household, with labor (either hired or off-farm) being a component, which allows for the household to choose the quantity of labor necessary to maximize farm profits.

Many of the more recent models of this nature have allowed all represented household members to maximize their own utility function, which, in some cases, is allowed to be either egotistical, which is traditional, or altruistic, with each individual gaining some utility from the utility of others (see Apps & Rees, 1996; Chiappori, 1997; and others). They frequently also allow for differing off-farm wage rates among household members. In addition, they tend to focus more on the question of labor, whether on-farm or off, than do earlier models.

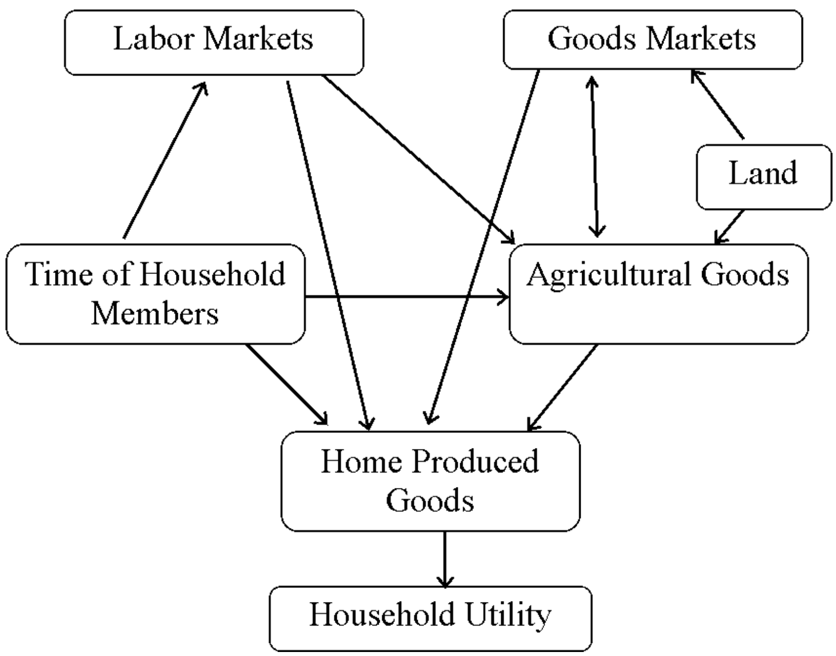


Figure 1 Diagram of an Agricultural Household's Utility Maximization Problem

2.9. Theoretical Perspectives on Deforestation

There are many theories regarding the causes of deforestation and reforestation. Foster & Rosenzweig (2003), with evidence from Indian data, suggest that the increases in the demand for forest products which occur as population and income grow in fact lead to forest growth. As part of this analysis, they refute the claim that rising agricultural productivity in India during the "green revolution," beginning in the 1970's, was directly responsible for the increasing area in forests over this time period. Instead they assert that increases in aggregate demand for forest products were the main driving forces leading to Indian reforestation.

2.10. Theoretical Model

Agricultural households are frequently modeled as holding the dual roles of producer and consumer, resulting in models where the production function of the farm enters into the household's utility maximization problem. A frequent simplifying assumption that the farm and the household operate autonomously and therefore the farm profit maximization problem does not enter the household's utility maximization problem. This assumption, known as separability, is convenient; however, for it to be valid, the household must operate Pareto optimally in the presence of complete and competitive markets (Benjamin, 1992).

Both the Pareto optimality of household decisions and the completeness of markets have been debated in the literature, and have generally been found to hold (see (Benjamin, 1992; Rosenzweig, 1980; Udry, 1996)). There are many assumptions, however, which if violated will invalidate the separability of farm and household. Prominent sources of violations include (1) preferences among farmers for working on their own farm, (2) incomplete or imperfect markets, (3) imperfect substitutability of hired and family labor, (4) differences in the wage rates for buying and selling labor. Questions exist as to whether a remote region, like the Northern Ecuadorian Amazon, is likely to satisfy all these assumptions. For example, if labor markets are incomplete, as is quite likely in this region, household members will be limited in their ability to work off-farm and the on and off-farm work decisions will not be separable (Benjamin, 1992).

Whether or not the Northern Ecuadorian Amazon satisfies these conditions well enough for the farm decision process to be independent from the household utility maximization problem is an empirical question which currently lies outside the purview of this dissertation. Because of the known limitations of markets in this area and the lack of information to the contrary, I will operate under the assumption that these decisions are not separable and that households make joint decisions with respect to their utility and their farm production.

Given the joint nature of this decision-making process, many of the household and farm characteristics are important when it comes to labor allocation decisions. One of the most obvious considerations (and which would be important regardless of whether or not these decisions are separable) is where the labor of each individual is most efficient. If family members can contribute more to farm income than they would receive working off-farm, then the appropriate decision is to keep them on the farm. If the opposite were true, they would be sent to work elsewhere. The size of the farm and allocation of crop area into various types of crop would affect the amount and types of labor necessary to operate the farm and thus should have an impact on both labor hired and off-farm work choices. However, it is possible that the household's choice of crops is also an endogenous one, based on the quantity and types of labor available within the household. Past income, or wealth may affect labor choices both directly and indirectly. In a direct sense, income and wealth will decrease the likelihood of any individual working as the value of their leisure or home time rises. Indirectly, these same characteristics would also affect the crop choices of the household, with wealthier households better able to invest in perennial crops, which might take time to generate income, or cattle, which has large up-front costs that in turn affect labor choice. Perennials and cattle generally require less labor than annuals. This decision becomes more complicated when it comes to women and older children, as the presence of younger children in the household should have a significant effect on their allocation of labor. This is because working on the farm may be compatible with taking care of children, while working off-farm generally would not be.

The relationship becomes more complicated when one considers that on-farm income is decided by both chance (i.e., weather and pest conditions) and choice variables. Thus the choice of cropping pattern may depend on the individual's willingness to accept risk, as well as their education, experience, and other unobservable characteristics

In the end, the household's goal is to maximize its utility, with other decisions being offshoots of this process. Thus I will utilize a utility maximization framework derived from (Huffman, 1991) and (Becker, 1993), where the household maximizes a monotonic, twice continuously differentiable, strictly concave joint utility function subject to a budget constraint, a time constraint, and a production function for the farm.

This is expanded to include Becker's home production model (Becker, 1965). According to Becker, market goods and home time are simply inputs to the home produced goods which the household consumes directly. These home produced goods would include things like meals, which would be created using food inputs (which may be purchased or produced on the farm), and other less obvious 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 home produced goods would be things such as healthy children, a clean house and many other things which in and of themselves are difficult to quantify.

Thus the household maximizes its utility by jointly choosing the time each member spends in market work ($\mathbf{T}_m$) farm work ($\mathbf{T}_f$) and home production ($\mathbf{T}_h$) and the household's consumption of goods used as inputs to home production ($\mathbf{X}$). In this case the utility function can be represented as:

$$U(\mathbf{X}, \mathbf{T}_h; \mathbf{C}_h) \tag{2.6}$$

Which represents the traditional model in which the household gains utility through their consumption of market goods $\mathbf{X}$ and the time of household members spent at home in vector $\mathbf{T}_h$. The utility of the household is also affected by household and area characteristics $\mathbf{C}_h$ such as access to public services, which would increase the utility level of a household, or level of pollution, which would cause utility to fall.

However, following Becker (1993), the household gains utility through these market goods only through their usefulness as inputs into the production of home produced commodities ($\mathbf{Z}_i$). For example a market good such as bread only gives the household utility as a useful input into a home produced good such as nutritious meals. Using this methodology requires the utility function to be redefined as as:

$$U(\mathbf{Z}_1,...,\mathbf{Z}_n;\mathbf{C}_h) \tag{2.7}$$

$$\mathbf{Z}_i = z_i(\mathbf{X}_i, \mathbf{T}_{hi}; \mathbf{H}_h) \tag{2.8}$$

where $\mathbf{X}_i$ 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 $\mathbf{T}_h$ respectively.

The household utility is maximized subject to the following budget constraint:

$$\mathbf{P}_x\mathbf{X} = \mathbf{W}\cdot\mathbf{T}_m + \Pi + Y_n \tag{2.9}$$

where $\mathbf{W}$ is a vector of market or shadow wages for all household members, Y_n is the household's non-labor income and Π is the profit generated from the farm as defined by:

$$\Pi = \mathbf{P}_a \cdot q(\mathbf{T}_f, l_a, l_p, l_c, \mathbf{N}; \mathbf{H}_f, \mathbf{C}_f) - \mathbf{P}_n\mathbf{N} \tag{2.10}$$

in which $\mathbf{H}_f$ is the human capital of the household which is applicable to farming, for example, previous experience in agriculture, knowledge of planting and harvesting techniques, or physical strength. $\mathbf{C}_f$ are farm characteristics, and l_a, l_p and l_c are the hectares of land devoted to the production of annuals, perennials and cattle or other livestock (i.e., pasture), respectively. $\mathbf{N}$ is a vector of purchased inputs, which is dependent on land use choices and for which price an exogenous price, $\mathbf{P}_n$, is paid. $\mathbf{P}_a$ is the exogenous price received for agricultural goods.

The wage of individual *i* is determined by

$$\mathbf{W}_i = W(\mathbf{H}_m, \mathbf{C}_m, \mathbf{J}_m) \tag{2.11}$$

where $\mathbf{H}_m$ is an individual's marketable human capital, $\mathbf{C}_m$ is a vector of local labor market characteristics, and $\mathbf{J}_m$ are 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. The time each individual spends in each activity must be non-negative and the time spent in all activities together must equal the total time available:

$$\mathbf{T} = \mathbf{T}_f + \mathbf{T}_m + \mathbf{T}_h, \quad \mathbf{T}_f, \mathbf{T}_m \geq 0 \tag{2.12}$$

which would be represented as

$$\mathbf{T} = \mathbf{T}_f + \mathbf{T}_m + \sum_i \mathbf{T}_{hi}, \;\; \mathbf{T}_f, \mathbf{T}_m \geq 0 \tag{2.13}$$

if it includes household production. Finally the sum of the land areas in each productive use (l_a, l_p, l_c) and the land left fallow l_f must equal L, the total usable farm area (farm area net of areas in forest or swamp).

$$l_a + l_p + l_c + l_f = L, \;\; l_a, l_p, l_c, l_f \geq 0 \tag{2.14}$$

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

$$\mathbf{P}_x\mathbf{X} = \mathbf{W}\mathbf{T}_m + \mathbf{P}_a \cdot q(\mathbf{T}_f, l_a, l_p, l_c, \mathbf{N}; \mathbf{H}_f, \mathbf{C}_f) - \mathbf{P}_n\mathbf{N} + Y_n \tag{2.15}$$

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

$$\mathbf{P}_x\mathbf{X} + \mathbf{W}\sum_{i=1}^{n} \mathbf{T}_{hi} = \mathbf{W}(\mathbf{T} - \mathbf{T}_f) + \mathbf{P}_a \cdot q(\mathbf{T}_f, l_a, l_p, l_c, \mathbf{N}; \mathbf{H}_f, \mathbf{C}_f) - \mathbf{P}_n\mathbf{N} + Y_n \tag{2.16}$$

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.

Assuming that the household is at an interior solution for all choices, then the farm decisions can be separated from the household decisions because all input and output prices are determined on the external market. This gives us a recursive decision model which can be solved to obtain supply and demand functions for labor, goods and inputs (Huffman, 1991). Equations (A2.5)-(A2.10), found in Appendix 2, can be solved jointly to find the demand functions for household farm labor, purchased farm inputs and land in various uses, where:

$$\mathbf{T}_f^* = D_{\mathbf{T}_f}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{H}_f, \mathbf{C}_f),\ \delta\mathbf{T}_f^* / \delta\mathbf{W} < 0 \tag{2.17}$$

$$\mathbf{N}^* = D_{\mathbf{N}}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{H}_f, \mathbf{C}_f),\ \delta\mathbf{N}^* / \delta\mathbf{P}_n < 0 \tag{2.18}$$

$$l_a^* = D_{l_a}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{H}_f, \mathbf{C}_f), \tag{2.19}$$

$$l_p^* = D_{l_p}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{H}_f, \mathbf{C}_f), \tag{2.20}$$

$$l_c^* = D_{l_c}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{H}_f, \mathbf{C}_f), \tag{2.21}$$

Substituting the input demand functions (2.17) – (2.21) into the production function for the farm results in the following supply function:

$$\mathbf{Q}_f^* = S_{\mathbf{Q}_f}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{H}_f, \mathbf{C}_f),\ \delta\mathbf{Q}_f^* / \delta\mathbf{P}_a > 0 \tag{2.22}$$

which can be substituted into equation (2.15), recognizing that the right hand side of that equation is simply the household's cash income, to give the maximum household cash income as:

$$I_h^* = \mathbf{W}\mathbf{T}_m + \mathbf{P}_a S_{\mathbf{Q}_f}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{H}_f, \mathbf{C}_f) - \mathbf{P}_n\mathbf{N}^* + Y_n \tag{2.23}$$

Solving equations (A2.2) – (A2.4) and (4.5.8) jointly gives the demand function for home time and inputs into home production:

$$\mathbf{T}_h^* = D_{\mathbf{T}_h}(\mathbf{W}, \mathbf{P}_x, I_h^*, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \tag{2.24}$$

$$\mathbf{X}^* = D_{\mathbf{X}}(\mathbf{W}, \mathbf{P}_x, I_h^*, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \tag{2.24}$$

Once these are known, the off-farm labor supply function can be found by substituting the demand for farm time, equation (2.17), and the demand for home time, equation (2.24) into the time constraint, equation (2.12). This substitution yields:

$$\begin{aligned} \mathbf{T}_m^* &= \mathbf{T} - \mathbf{T}_f^* - \mathbf{T}_h^* = S_{\mathbf{T}_m}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, I_h^*, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \\ &= S_{\mathbf{T}_m}(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \,. \end{aligned} \tag{2.25}$$

Thus the off-farm labor supply function contains all the exogenous variables from the optimization problem, indicating the complexity of off-farm work decisions. These decisions require the household to consider a large quantity of information pertaining to not only off-farm wages but also farm and household production.

To obtain a reduced form function for total household income, equation (2.25) is substituted into equation (2.23) resulting in:

$$I_h^* = I_h^*(\mathbf{W}, \mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \,. \tag{2.26}$$

Because the wage is determined, as indicated in equation (2.11) by exogenous individual, job, and job market characteristics, the income function is represented by:

$$I_h^* = I_h^*(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_m, \mathbf{C}_m, \mathbf{J}_m, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \,, \tag{2.27}$$

which means that all the exogenous variables for household production, farm production and market work are included in the income equation.

All of the above outcomes assume that the household and farm are separable and that there is an interior solution for both farm labor (**T**$_f$) and market labor (**T**$_m$). If however; an interior solution is not present for these variables, or there is non-separability, then the household's consumption and farm production decisions must be made jointly. This is because the wage used for one or more household members, in the case of a non-interior solution, is not market determined. Because the individual chooses not to participate in either labor market, his or her individual wage is a shadow wage based on his or her own personal characteristics. Because of this, the wage itself is determined within the system, making the model non-recursive. Thus equations (A2.2)-(A2.13) must be solved simultaneously, resulting in the following demand equations:

$$\mathbf{T}_f^* = d_{\mathbf{T}_f}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.28}$$

$$\mathbf{N}^* = d_{\mathbf{N}}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.29}$$

$$l_a^* = d_{l_a}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.30}$$

$$l_p^* = d_{l_p}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.31}$$

$$l_c^* = d_{l_c}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.32}$$

$$\mathbf{T}_h^* = d_{\mathbf{T}_h}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.33}$$

$$\mathbf{X}^* = d_{\mathbf{X}}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.34}$$

which, when substituted into the farm production function and equation (2.15) yield:

$$\mathbf{Q}_f^* = s_{\mathbf{Q}_f}(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T}) \tag{2.35}$$

and

$$I_h^* = i_h^*(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, Y_n, \mathbf{T})\,. \tag{2.36}$$

If, however, some (but not all) family members work off-farm, then the market wage, or the determinants thereof, would be included in equations (2.28)-(2.36). This means that all the endogenous variables would depend on all the exogenous variables.

3. THE CONTEXT OF THE ECUADORIAN AMAZON

Ecuador lies on the Pacific coast of South America between Peru and Colombia. At just under 110,000 square miles, it is approximately the size of Colorado. Ecuador (Figure 2) contains three distinct ecological and geographical regions: the western coastal lowlands, the central highlands, or Sierra, and the eastern Amazon, also known as the

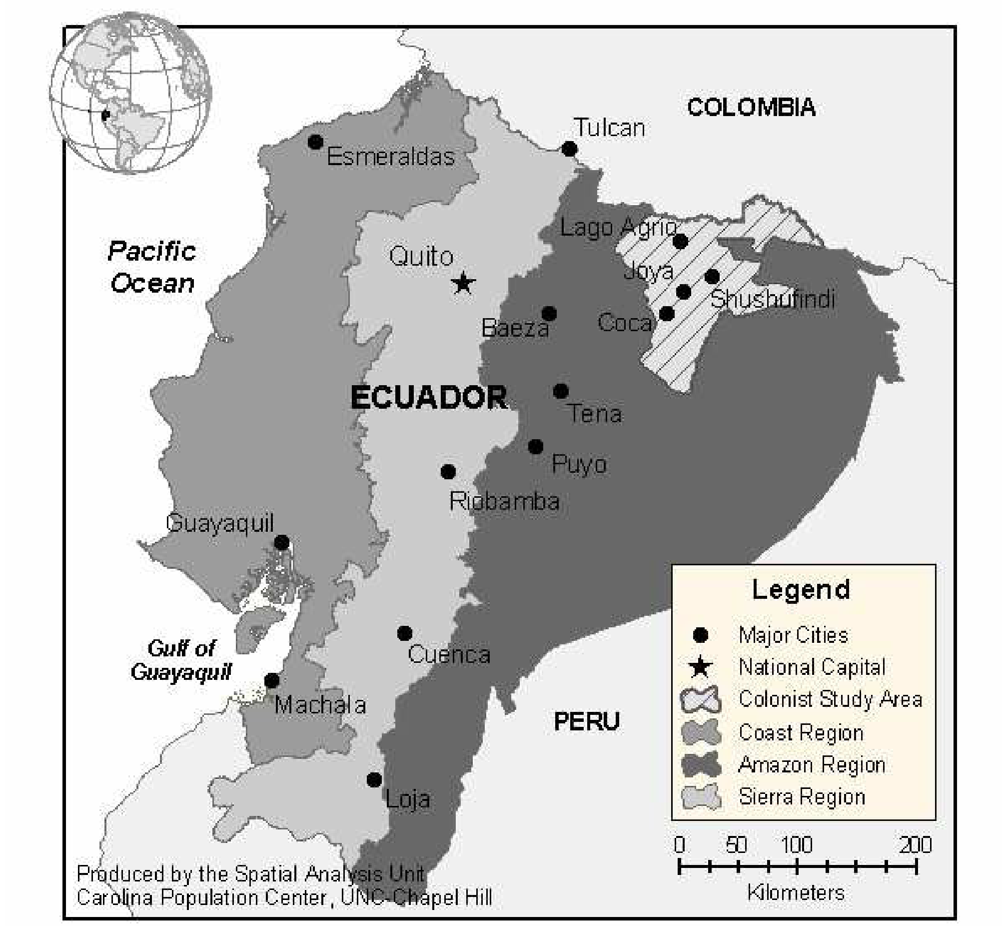


Figure 2 The Location of the Study Area in the Northern Ecuadorian Amazon

Oriente. Ecuador currently has a population of about 13 million (United Nations, 2007), making it the most densely populated country in South America.

The Amazon region in the east of the country makes up over 40% of the total land area of Ecuador (Pichón, 1993). Over the past thirty years, the Amazonian region of Ecuador has been colonized by migrants from other regions of the country. Despite the rapidly rising population, which has grown at over twice the national rate for the past three intercensal periods (Pan, 2007), the area as a whole still remains relatively sparsely populated, containing only 5% of the Ecuadorian population (INEC, 2001). This area is part of Western Amazonia, which is among the most biologically diverse regions in the world. According to Myers (1988), Western Amazonia "is surely the richest biotic zone on Earth" and "deserves to rank as a kind of epicentre of biodiversity." The region is home to thousands of species of plants and animals, and exhibits very high rates of endemism,[4] making it an area of particular concern to ecologists.

3.1. Colonization of the Ecuadorian Amazon

While there have been several historical attempts to settle the Ecuadorian Amazon, colonization there has only recently taken hold. The Spanish attempted to establish communities in the Oriente as early as the mid-sixteenth century, but were unable to attract significant numbers of Europeans to the area. Despite additional attempts by missionary groups and the government to establish communities in the Amazon, it is estimated that the area had no more than two hundred colonists by 1960 (Hiraoka & Yamamoto, 1980). The current population boom in the Oriente began with Texaco-Gulf's discovery of major oil reserves around Lago Agrio in 1967 (Pichón, 1993, Hiraoka & Yamamoto, 1980). By 1972, 340 kilometers of highway had been constructed by the oil companies to facilitate the movement of heavy equipment and the construction and maintenance of oil pipelines in the area. Additional road construction followed, providing direct access to 488,000 hectares of undeveloped land by 1977 (Hiraoka & Yamamoto, 1980).

These oil roads had a profound impact on the rate of migration to the area so that by 1990, the Amazonian population was near 400,000. Since that time, the population growth rate in the Oriente has been about twice the national average according to

[4] The rate of endemism is determined by the percentage of plant and animal species in an area which are not found elsewhere in the world.

censuses taken in 1974, 1982, 1990, and 2001(INEC 1992; INEC 2001). While this growth was initially spurred by the improved access the new roads provided, government policies also encouraged migration to the Amazon. The government's reasons for encouraging in-migration were complex, including both national security and national structural problems. Thus the government of Ecuador saw the colonization of the Amazon as a national security issue because it believed that leaving remote lands unoccupied increased the possibility of loss of territorial integrity (Pichón, 1993). Between 1830 and the present, Ecuador lost more than 70% of its original territory to its neighbors, mostly to Peru. Most of this loss occurred in the Oriente, where there was little population and insufficient government control (Hiraoka & Yamamoto, 1980). Recent colonization of this region served to bolster Ecuador's remaining territorial claims and increase government control of the frontier areas of the country.

The vast swaths of undeveloped land at the frontier were also seen as a natural "release valve" for national structural problems in the more populated areas of the country. In these areas, highly unequal distribution of farmlands and high unemployment contributed to high levels of rural poverty. These problems, in addition to population pressures in the western parts of the country, contributed to the level of dissatisfaction and political unrest (Pichón, 1993). The use of the Amazon as an agricultural frontier can thus also be viewed as part of a larger political strategy to address the problems of landlessness and rural poverty without confronting the need for agrarian reform in other western regions of the country (Trujillo, 1987, cited by Pichón, 1993).

3.1.1. Settlement Patterns

Although settlement in the Northern Ecuadorian Amazon was a mostly spontaneous process, the government has facilitated colonization by a number of means. The most important of these is the *ex post* recognition of the land claims of established settlers (Pichón, 1993).

Because of the importance of roads for access to both farmland and product markets, settlement patterns were designed to maximize the number of farms with road access. As such, the principal organizational system is a linear one, with farms arrayed in "*respaldos*," or layers, along the roads. Thus the first settlers who arrived in the area chose farms in the first layer or *línea* (line) of plots. These farms are required to have a narrow frontage on the road of 200 to 250 meters. Because of this, farms tend to be long and thin with an average length perpendicular to the road of 2000 meters (Pichón, 1993, Hiraoka & Yamamoto, 1980), resulting in standard sized farms of approximately 40 to 50 hectares.

As settlement progressed, new arrivals became unable to obtain lots along the road, and instead occupied the closest available lands to the existing transport routes. These lots were directly behind those established in the first *línea*, on the second *línea* or *respaldo*, two kilometers from the road. As time progressed, new arrivals began occupying lands in *respaldos* further and further from the road. For farms that lie behind the first line, access to the main road can be problematic. Usually the only access to these farms is paths that go along the borders of the farms that lie between them and the road. Typically these paths are several meters wide and run along the edge of each farm. Farmers are not allowed to use this land for agricultural purposes, as they are required to provide access to the road to farms without road frontage along their borders with neighboring farms (Pichón, 1993, Hiraoka & Yamamoto, 1980). If access is provided, these paths must be cleared and maintained by the farmers who use them and are often difficult to navigate by vehicle.

Because of the issues involved with road access, a farm location on the road is extremely beneficial with respect to access to labor and goods markets. For households in the 1999 sample, those on the road had, on average, 79% more on-farm, off-farm, and total income than those where any walking was needed to get to the farm. In addition, these households spent nearly three and a half times as much on hiring farm labor as those who walk to the road.

As the population of the NEA has grown, the number of secondary roads has increased significantly. This has allowed for a greater number of farms to have road access, making it possible for farms on the second line and above to frequently have vehicular access.

3.1.2. Allocation of Farms to Colonists

Until its disbanding in 1993, the Institute for Agrarian Reform and Colonization (IERAC) was nominally in charge of the allocation of farm land in the Northern Ecuadorian Amazon. However, land distribution was governed by a general process, more than formal regulation. Farmers, for all intents and purposes, were initially squatters on public lands. When a large enough group of settlers, usually about twenty to fifty families, had arrived in the area and chosen their land, then they could form a precooperative which would then go to the IERAC and request a survey, for which each farmer would pay a nominal fee based on the number of hectares which they claimed. The next step in the process was to petition for a Certificate of Possession, for which the farmer must pay another much more significant fee based on the value of the land, which is determined by considering several factors including the proximity to main roads. This certificate gives the farmer security of tenure but does not allow for the transfer of title to any other individual. The Homestead Act of 1964 stipulated that a colonist must clear 50% of their land before a full title could be obtained (Hite, 2004; Murphy et al, 1997). However, this provision was never enforced and, by 1999, 45% of farms with full title still had over 50% of their land in forest. Because of this lack of enforcement, farmers with a Certificate of Possession did not need to clear a specified amount before applying for the full title to their land. This step, however, required the payment of yet another more significant fee that depended on the estimated value of the land being titled. Possession of a full title gives the owner the right to sell their land and legally transfer the title, or use the land as collateral when obtaining credit, making the land more valuable in the marketplace.

However, the titling process changed significantly with the disbanding of IERAC in 1993. The government agency that replaced IERAC, INDA, is much weaker, and does not provide most new migrants, or children who inherit plots, with legal land titles. After this agency change, it became necessary to hire a lawyer to handle the paperwork necessary to claim a parcel of land legally. This process is both significantly more expensive and more time consuming and has led to dramatic increases in the number of households without any formal title (either a Certificate of Possession or Full Title).

Between 1990 and 1999, the percentage of sample households who had at least a certificate of possession fell from 93% to 54%, and the percent with full legal title declined from 50% to 40%. As such, the share of households with no documentation increased to 39% by 1999, over five times the share in 1990 (Pichón, 1997a).

Despite the fact that a large share of the populace in this area has no legal documentation of their land ownership, to date, land security has not become an issue. In fact, many people in the area have purchased their land from other settler households without either party having legal documentation to the property. As this area becomes more crowded, it is likely that land disputes will increase, making the obtaining of a certificate or title of more importance that it has been in the past.

The lack of title, however, has impacted households in other ways. For example, among households who have attempted to get credit, but have been unable to acquire it, 25% cite the lack of title as the source of their credit problem. In addition, when asked what type of assistance they most need on their farm, 30% of respondents cite their desire for help in obtaining credit for production and/or procuring a title among their top three needs.

In addition to these stated effects, studies have shown that increased land insecurity may influence land owners' choices, including the permanency of migrant settlements and land use practices (see: Angelsen, 1999; Ferreira, 2004; Goeschl, & Camargo Igliori, 2006; and Mendelsohn, 1994, among others). In the NEA, those with a full or provisional title are less likely to subdivide their property than those without title (Pan, Carr, & Bilsborrow, 2004). This result may be attributable to expectations of future land insecurity, causing those without a secure title to "cash in" on their property while they are still able. Because subdivided properties are usually deforested to a greater extent than those left intact, this expectation of future insecurity likely contributes to the state of deforestation on untitled properties. In fact, farms for which the household possessed a full or provisional title in 1999 had significantly more forest than those for which the household had no title, with titled farms retaining 44% of their land in forest on average, while untitled farms only contained 36% forest.

3.2. Deforestation of the Ecuadorian Amazon

Growth in the Northern Ecuadorian Amazon has had significant environmental consequences. The growth of the regional oil industry and the resultant high population growth have resulted ecological catastrophes, including the contamination of land and water by spilled oil and very high rates of deforestation. The NEA was deforested at the rate of 2.49% per year between 1986 and 1996 and 1.78% per year between 1996 and 2002 (or approx. 11,850 hectares per year for the period 1986-2002). Deforestation rates were much higher in some places, with *parroquia* (parish) level rates reaching 7.63% (Mena *et al*, 2006). By comparison Brazil had a deforestation rate of 0.5% for the period 1990-2000, while Ecuador as a whole had a rate of 1.5% in the same time period, making it the most rapidly deforesting South American country for this time period (Food and Agriculture Organization, 2007). This means that forest cover on sample farms has fallen from the level of nearly 100%, present at the time of settlement around 1970, to 59% by 1990 and 45% by 1999 (Barbieri, 2005; Bilsborrow et al, 2004)

Most of the loss of forest in the study region is associated with agricultural colonization or oil extraction. The people who settled in the Oriente, for the most part, are poor, small scale farmers, who came to the region from more densely populated areas of the country in search of land. Increases in population in combination with the establishment of large scale national parks, conservation areas, and other federally owned lands has restricted settlement in these areas, making people settle on existing farms that need to be subdivided. As a result of these growing population pressures, many parcels of land involved in the study were subdivided between the two years of the survey, either by handing down a portion of the farm to the original owner's children or by selling part of the farm to new settlers in the area. Because of this subdivision, researchers had to interview 416 farms in 1990 and 767 in 1999 on the same land area.

4. THE STUDY FARMS AND POPULATION

The data used in this dissertation were collected for the NASA project under the direction of Dr. Richard Bilsborrow at the Carolina Population Center (CPC). The CPC's Ecuador Projects collected data in the northern part of the Ecuadorian Amazon, near the Colombian border, in the provinces of Napo, Sucumbíos, and Orellana, from a probability sample of over 800 farms. Data were collected through interviews of colonist farmers and their spouses regarding household and farm characteristics, and supported with interviews of community leaders who provided community level information.

Because of the ecological significance of this area of the world, questionnaires were designed to "identify the social, economic and demographic determinants of land use and land cover."[5] To this end, interviews conducted in both 1990 and 1999 were organized to allow researchers to study the progression of land use on individual plots of land or farms.

Participants were chosen in 1990, as shown in Figure 3, based on "fairly up-to-date maps (with settler plots indicated and numbered) from the local offices of the IERAC [Ecuadorian Institute for Agrarian Reform and Colonization]" (Bilsborrow, 1990; Pichón, 1993), to be a scientifically representative sample of about 6% settler households. The original interviews were conducted mainly over the period of June through

[5] Source: Carolina Population Center Website www.cpc.unc.edu

September in 1990 and January through July in 1999. Each interview team consisted of two people, one man and one woman, to facilitate separate, same sex, interviewing of the head of household (*jefe*) and spouse (*esposa*). The head of household provided information on his/her own migration history, land tenure and subdivision, agriculture

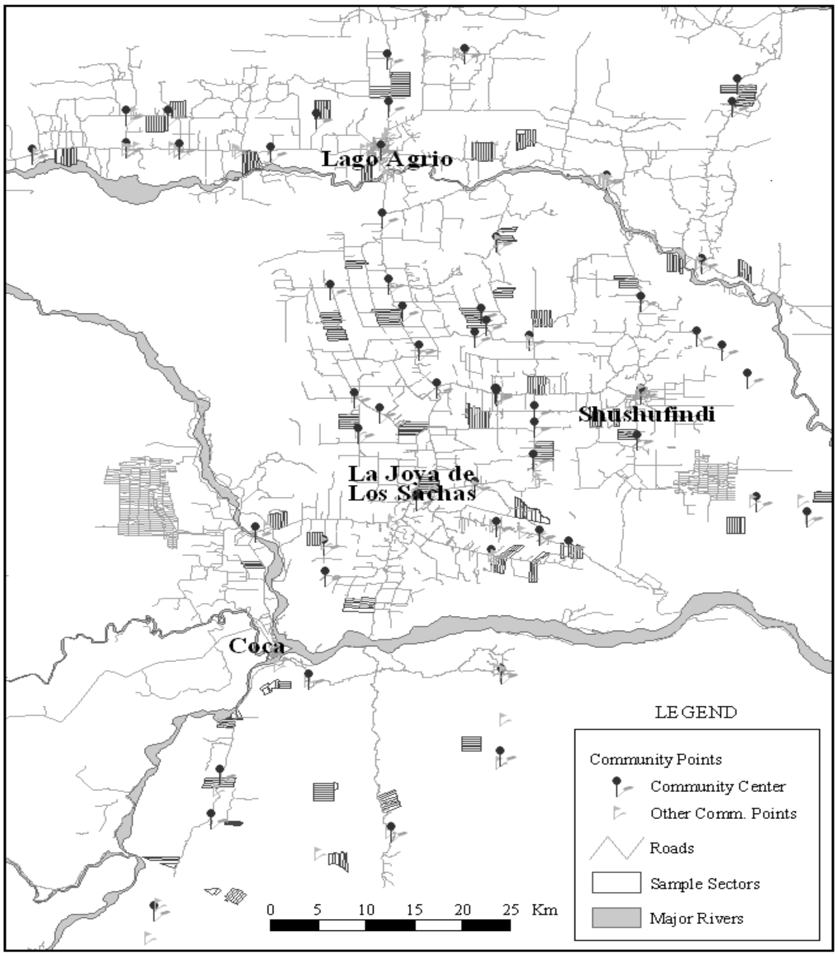


Figure 3 The Location of the Sample Sectors in the Study Area

and land use, production and yields on the farm, plans for future land use, labor force participation, hiring of labor and technical assistance. The spouse was interviewed about household composition, departures of family members from the farm, her own migration history, household living conditions, reproductive health, health of household members, and work of female household members. Both were asked about perceptions of quality of life, attitudes and levels of satisfaction. Refusal rates for these questionnaires were exceptionally low with only 3% of those selected in 1990 refusing to participate. In addition there were interviews conducted with community leaders which provided information on community characteristics. These community characteristics should be useful in developing instruments for the analysis of farm and employment practices.

There are several indigenous groups that live in the Oriente. These groups live mostly in and around two nature reserves which exist as relatively pristine protected rainforest. Most members of these groups still follow their traditional practices regarding land use. Because of this, most indigenous populations live in areas with river access rather than on roads. These groups were surveyed in a separate National Institute of Health (NIH) project by the Carolina Population Center using the same basic protocols as the colonist interviews.

I will focus my research on the 1999 household survey of colonists and their spouses. In this dataset, there are 934 male questionnaires, of which 111 are of *solares*, small non-farm properties, which did not contain data on land use. This leaves 823 questionnaires of farms, of which 761 are complete. There are also 787 female questionnaires, including the 111 *solare* questionnaires. This leaves 676 female questionnaires, of which 31 did not contain information on household demographics. The remaining 645 questionnaires potentially match the 761 remaining male questionnaires. However, due to refusals and failure to complete some of the male questionnaires, there are an additional 6 female questionnaires that are lost due to the unavailability of a male match. As such, there are 761 usable male questionnaires matched with 639 usable female questionnaires. This imbalance occurs because, while the female questionnaire is a questionnaire of the household as a whole, the male questionnaire is for a single piece of property. Thus, households who own multiple plots of land within the survey area have multiple male questionnaires but only a single female questionnaire. Because of this, it was necessary to aggregate male questionnaires within a household in order to obtain an accurate measure of household resources and activities. There was a great deal of data cleaning that needed to generate a dataset based on households, all of which is described in Appendix A, resulting in a total of 639 complete households available for analysis.

4.1. Households

An average household on the Amazonian frontier in 1999 contained 5.84 members, headed by a male head (*jefe*), aged 43 years on average and his spouse (*esposa*), aged 39 years. Neither *jefe* nor *esposa* had finished primary school on average, but the *jefe* has on average 0.3 years more education than his spouse. Present in the household are 2.06 children under the age of 12 and 1.78 others (12 and over).

Households in the Northern Ecuadorian Amazon take on many configurations. The most common is the nuclear family, which comprises 72% of households. These households are smaller than average, with a mean of 4.99 members, compared to 7.98 for households which contain more than one family group. Households containing multiple family groups also vary in composition, but common configurations include married adult children, often with children of their own residing with their parents, or siblings, and their families, residing together. Of households containing more than one family

Table 1 Characteristics of Nuclear and Non-Nuclear Households 1999

Number of Family Groups	Number of Persons	Number of Children Under Age 12	Percent of Household Under Age 12	Farm Size in Hectares	On-Farm Income[6]	Off-Farm Income	Total Income	Percent of Income from Off-Farm Sources	Per-Capita Income	Number of Households
	Mean (std. dev.)	Mean (std. dev).	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	N % of Sample
1	5.01 (2.33)	1.87 (1.65)	32.7 (21.8)	24.66 (21.80)	630.85 (1,013.70)	478.82 (980.71)	1,109.67 (1,618.71)	35.3[7] (37.3)	256.03 (358.00)	462 72%
2	7.06 (2.79)	2.24 (1.83)	28.3 (18.6)	33.50 (24.45)	923.82 (1,206.75)	701.61 (1,915.82)	1,625.44 (2,649.91)	31.3 (36.0)	252.91 (359.26)	129 20%
3	9.26 (2.60)	2.71 (1.80)	27.0 (14.3)	39.41 (25.05)	791.09 (695.23)	467.52 (742.07)	1,258.61 (926.19)	33.6 (35.4)	145.49 (114.16)	34 5%
4 or More	13.71 (5.55)	5.00 (2.51)	35.4 (7.8)	41.77 (20.07)	1,259.55 (2560.44)	1,664.56 (2,025.28)	2,924.11 (3,886.17)	51.8[8] (39.4)	192.72 (188.46)	14 2%
All Households	5.84 (3.04)	2.06 (1.78)	31.6 (22.0)	27.60 (23.00)	712.29 (1,101.82)	549.18 (1,256.72)	1,261.47 (1,938.64)	34.7[9] (37.0)	248.13 (347.25)	639 (100%)

[6] Income in ten thousands of Sucres (10,000 Sucres ≈ $1.00)
[7] For households reporting non-zero total income, N=458
[8] For households reporting non-zero total income, N=13
[9] For households reporting non-zero total income, N=634

group, 73% have two groups, 19% have three groups and the remaining 8% (2% of the total sample) have between four and seven groups.

Table 1 shows a breakdown of household characteristics by the number of family units. While there is a positive correlation between the number of families present within the household and on-farm income, off-farm income and total income, per capita income levels are negatively associated with the number of family units. *A priori*, I assumed that this was likely to be due to the increase in the relative number of children in multifamily households; however, upon further examination you can see that the increase in the size of the household as more family units are added does not translate directly into increases in the percentage of the household under the age of 12. The number of children actually fluctuates with the number of family units, presenting no discernable pattern. If a greater percentage of children in a household is a characteristic of younger households in general, this suggests that young adults may be more productive than older ones. It is also possible that households with multiple family units were created because of the high fertility levels of the previous generation. In this case, older households would have more children who could get married and have children of their own. But because many of these households live in poverty, adult children remain in the household with their parents, increasing the number of family units. A final option is that one family, when doing fairly well, may allow poorer relatives to move in, diluting the per capita income level of the household as a whole.

Table 2 Community Characteristics by Population Level

Community Population	% on Paved Road	% with Electricity	% with Piped Water	% with Primary Schools	Number of Busses and Rancheras Per Day	Distance to Nearest Market	Distance to Nearest Coffee Roaster	Distance to Nearest Sawmill	Number of Communities
	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	N % of Total
<150	18% (40%)	27% (47%)	0% (0%)	9% (30%)	5.73 (10.67)	27.20 (17.51)	15.68 (19.28)	21.20 (18.63)	11 18%
150-299	5% (22%)	55% (51%)	10% (31%)	15% (37%)	3.75 (6.47)	19.75 (14.53)	12.39 (13.57)	17.51 (12.98)	20 33%
300-599	20% (42%)	80% (42%)	10% (32%)	20% (42%)	4.60 (4.14)	15.00 (11.51)	11.70 (11.02)	17.75 (13.29)	10 17%
600-1199	36% (50%)	91% (30%)	73% (47%)	73% (47%)	11.27 (12.06)	15.67 (10.03)	4.01 (6.33)	9.90 (11.45)	11 18%
1200 and Over	38% (52%)	100% (0%)	100% (0%)	88% (35%)	12.25 (10.40)	7.50 (15.74)	3.73 (6.92)	2.13 (6.02)	4 7%
All Communities	23% (43%)	67% (48%)	32% (47%)	35% (48%)	6.77 (9.21)	17.94 (14.86)	10.19 (13.18)	14.78 (14.29)	60 100%

4.2. Communities

In addition to farms, the NEA is scattered with communities. These communities take a variety of forms, ranging from clusters of a few farms to small urban areas. There are four major urban centers in the NEA: Lago Agrio, Coca, Shushufindi and La Joya De Los Sachas. Even the largest of these, Lago Agrio, with a population of about 34,000 (INEC, 2001), would only rank as a small town by most standards. Around the time of the survey, the average population of sample communities was 1,565. However, when excluding the four largest communities, the average population falls to 448 people.

The amenities available at the community level differ substantially based on the size of the community. While the largest towns, as shown in Table 2, all have access to electricity, piped water, schools and markets, small communities often lack even these basic amenities. In addition, larger communities tend to be closer to markets, coffee roasters and sawmills and have better transportation infrastructure, as measured by the number of busses and *rancheras* (smaller vehicles) passing through the town each day.

4.3. Description of Colonists

The colonists who settled in the NEA over the past three decades are generally migrants from other rural areas of Ecuador. Table 3 shows that 89% of the head of household's in this region were born in rural areas. In addition, while the percentage of native born heads increased from 2% in 1990 (Pichón, 1993) to 8% in 1999, most heads are migrants to the region. In-migrants generally were born in Ecuador in the Sierra

(70%) or the coast (17%), however, there are increasing numbers of migrants from Colombia, which represented 3% of household head's in 1999, up from 0% in 1990.

Over 71% of migrants were landless in their last place of residence prior to moving to the NEA. The availability of land was a motivating factor for many of them, with over 53% indicating that land availability was their primary motivation for moving to the area. The presence of relatives in the region was also an important factor and was cited by over 20% of respondents. Nearly 75 % of migrating heads of household report

Table 3 Geographical Region of Birth of Head of Household, 1999

Region	N % of Sample	Rural N % of Sample	Urban N % of Sample
Sierra (Highlands)	451 70%	405 63%	46 7%
Coast	111 17%	93 14%	18 3%
Southern Amazon	4 <1%	4 <1%	0 0%
Northern Amazon	51 8%	50 8%	1 <1%
Columbia	21 3%	17 3%	4 <1%
Galapagos	1 <1%	1 <1%	0 0%
All	639 100%	570 89%	69 11%

having relatives in the region at the time of migration. Having relatives in the area is likely an important factor for the ease of migration as 67% of in-migrant heads with relatives in the area report that they received assistance from their relatives in establishing their farm.

In 1999, the average household occupied a farm of 27.6 hectares, with 13.4 hectares remaining in forest, 1.5 hectares in swamp, 2 hectares in fallow, 5.1 hectares in crops and 5.6 hectares in pasture. Most heads (89%) work on the farm in the core activities of clearing, planting and harvesting, as do 70% of spouses. Off-farm employment is an important source of income for many families, with households having an average of 148 days worked off-farm by household members, roughly equivalent to having one person working half time off-farm during the year. Off-farm employment accounts for approximately 55% of total household income for participating households.

4.4. Agriculture in the Northern Ecuadorian Amazon

The agriculture practices of the Northern Ecuadorian Amazon differ substantially from the practices of most farmers in developed countries. While farms in developed countries are generally operated as businesses, often specializing in a small number of crops, or even a single crop, farms in the NEA are much more diversified. In addition, there is little or no agricultural mechanization in the NEA. There are very few tractors in the region and only 23% of households owning even something as simple as a chainsaw. In addition, fewer than 8% of households own any type of vehicle, a factor which impacts not only agricultural production, but also the ability of households to bring goods to market. Because of this, proximity to the road is important for both farm and non-farm income. Table 4 shows the level of household income from farm and non-farm sources as well as total spending on labor in the past year based on distance from the road. It shows that households with no walking distance to the road have higher levels of both farm and non-farm income than those off the road. In addition, these households spend more on hired labor than those with any walking distance to the road.

Table 4 Income of Households by Accessibility of their Farm of Residence

Kilometers Walk from Farm to Road	Total Land Owned in Hectares	On-Farm Income[6]	Spending Last Year on Labor[4]	Off-Farm Income[4]	Total Income	Number of Farms
	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	N % of Sample
No Walking	29.89 (23.19)	894.16 (1,37261)	97.41 (196.73)	718.42 (1,556.72)	1,612.58 (2,452.64)	354 55%
<2	19.31 (19.51)	546.94 (596.01)	27.94 (79.13)	605.25 (1,300.85)	1,152.19 (1,393.05)	113 18%
2-2.9	23.55 (22.86)	469.10 (619.41)	22.03 (62.37)	286.18 (414.88)	755.28 (720.20)	79 12%
3-4.9	28.71 (21.52)	453.60 (410.33)	30.58 (79.63)	339.89 (601.34)	793.49 (622.78)	47 7%
5-6.9	38.04 (25.06)	513.43 (534.54)	35.67 (71.71)	131.57 (171.54)	645.00 (539.49)	30 5%
7 and over	35.24 (23.03)	456.31 (363.08)	38.05 (114.05)	268.43 (610.90)	724.74 (668.89)	21 3%
All Farms	27.72 (22.96)	716.93 (1,100.42)	66.28 (158.42)	575.90 (1,312.58)	1,292.83 (1,975.28)	644 100%

[6] Income from all farms operated by the household in tens of thousands of Sucres (10,000 Sucres≈$1)

Because of the low incidence of mechanization, farms in the NEA rely heavily on manual labor. The household itself provides most of the labor required to operate the farm, with over 56% of household members aged 12 and older working on the farm "most days." An additional 27% work "sometimes," leaving only 17% of adult household members who do not work on the family farm. Households may also hire labor to supplement the household's labor supply. Table 5 shows the breakdown of fertilizer, labor and land use by farm size, for each individual farm. It shows that 41% of farms used hired labor in the previous year. Farms that are larger are somewhat more likely to use hired labor, although the pattern is not without its deviators. In terms of the amount of labor, however, a clear pattern emerges. For farms using hired labor, increases in farm size are clearly correlated with increases in the total spending on labor. In addition, since wages across the area are fairly uniform, this also indicates that larger farms are using greater quantities of hired labor.

The use of chemicals, is not as unusual as mechanization, but also remains quite low, whether pesticides, herbicides, or fertilizers. Less than 36% of households use any organic fertilizer or chemical herbicide, pesticide, or fertilizer. In addition, while 66% of households use some "modern" agricultural technique, including improved seeds, pruning, integrated pest management, alley cropping or use of organic fertilizer, the vast majority (91%) of these households engage in only pruning and/or use of organic fertilizer, neither of which is particularly modern. This means that only a very small number of households (under 6%) engage in any of the other listed techniques.

Over a third of farms use some chemical fertilizers; however, overall spending on fertilizers remains quite low. Table 5 shows that the average spending on fertilizers for

Table 5 Distribution of Chemical, Labor and Land Use by Farm Size, 1999

					Land Use Shares					
Farm Size in Hectares[7]	**Proportion of Farms Using Chemical Fertilizers** **Mean (std. dev.)**	**Spending on Chemical Fertilizers For Farms Using Same[8]** **Mean (std. dev.)**	**Proportion of Farms Using Hired Labor** **Mean (std. dev.)**	**Spending on Labor for Farms Using Same** **Mean (std. dev.)**	**Hectares in Perennials** **Mean (std. dev.) Mean % of Farm**	**Hectares in Annuals** **Mean (std. dev.) Mean % of Farm**	**Hectares in Pasture** **Mean (std. dev.) Mean % of Farm**	**Hectares in Forest[9]** **Mean (std. dev.) Mean % of Farm**	**Hectares in Fallow[10]** **Mean (std. dev.) Mean % of Farm**	**All Farms** **N** **% of Sample**
<2	0.23 (0.42)	11.27 (8.50)	0.26 (0.44)	23.57 (18.69)	0.65 (0.49) 60%	0.21 (0.41) 20%	0.03 (0.16) 3%	0.04 (0.17) 4%	0.17 (0.39) 13%	48 6%
2-4.9	0.21 (0.41))	23.26 (34.42)	0.25 (0.44)	42.40 (38.39)	1.43 (1.09) 51%	0.43 (0.65) 15%	0.22 (0.60) 7%	0.56 (0.97) 16%	0.36 (0.81) 11%	142 19%
5-9.9	0.37 (0.49)	20.08 (21.63)	0.42 (0.50)	67.11 (49.80)	2.23 (1.60) 37%	0.79 (1.15) 13%	1.22 (1.64) 19%	1.29 (1.63) 22%	0.60 (1.21) 10%	107 14%
10-19.9	0.46 (0.50)	40.25 (55.74)	0.34 (0.48)	95.12 (78.16)	3.31 (2.43) 26%	0.89 (1.03) 7%	3.53 (3.36) 26%	3.43 (3.53) 32%	1.10 (1.93) 8%	89 12%
20-29.9	0.26 (0.44)	25.16 (44.04)	0.38 (0.49)	137.17 (212.75)	3.54 (2.99) 15%	1.31 (2.11) 5%	4.34 (5.14) 18%	12.17 (8.22) 55%	1.75 (3.22) 7%	78 10%
30-39.9	0.44 (0.50)	34.01 (38.97)	0.51 (0.50)	150.00 (160.54)	4.37 (2.77) 13%	1.83 (3.22) 5%	8.67 (8.44) 25%	14.28 (9.37) 49%	2.81 (4.05) 8%	70 9%
40-49.9	0.40 (0.49)	32.79 (59.63)	0.49 (0.50)	160.82 (173.77)	4.91 (4.05) 11%	1.38 (2.00) 3%	7.80 (8.23) 18%	24.43 (12.00) 61%	2.92 (4.83) 6%	129 17%

Farm Size in Hectares[7]	Proportion of Farms Using Chemical Fertilizers	Spending on Chemical Fertilizers For Farms Using Same[8]	Proportion of Farms Using Hired Labor	Spending on Labor for Farms Using Same	Land Use Shares					All Farms
					Hectares in Perennials	Hectares in Annuals	Hectares in Pasture	Hectares in Forest[9]	Hectares in Fallow[10]	
	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	N % of Sample
50 -59.9	0.39 (0.49)	26.19 (41.53)	0.60 (0.49)	196.96 (220.89)	4.14 (3.61) 8%	1.72 (4.26) 3%	10.69 (11.42) 21%	30.70 (12.86) 63%	2.67 (3.80) 5%	84 11%
60 and over	0.43 (0.51)	59.92 (39.37)	0.64 (0.50)	490.29 (316.33)	7.21 (6.46) 10%	4.07 (5.58) 5%	18.71 (20.11) 25%	31.54 (21.26) 49%	7.21 (7.47) 11%	14 2%
All Farms	0.35 (0.48)	29.39 (44.61)	0.41 (0.49)	133.73 (176.99)	3.20 (3.15) 27%	1.11 (2.32) 9%	4.72 (7.82) 17%	12.56 (14.78) 38%	1.65 (3.39) 9%	761 100%

[7] Size of individual respondent farms, not total household land holdings.
[8] Spending in tens of thousands of Sucres (10,000 Sucres ≈$1)
[9] Includes areas in swamp and areas in fallow for more than 7 years
[10] Includes areas left fallow for 7 years or less

farms who buy them is under $30 per year. While the level of spending varies based on farm size, there is no predictable pattern that emerges from the data.

Land Use

Cleared land in the Oriente has many possible agricultural uses; however, these can be broken down into four main categories: perennials, annuals, pasture and fallow. For the most part, annuals are grown for home consumption while perennials, like coffee and cacao, are cash crops. Pasture may be used for both cattle and smaller livestock, and while cattle are mostly raised for sale at market, smaller animals may be used for household consumption. Among these main uses, pasture is generally considered to be the most environmentally devastating as it represents the largest change to the original landscape, introduces additional animals which must be supported by the land, and creates an increased likelihood of waste runoff into surrounding rivers as soils become more compacted by the continued trampling of animal hooves.

Table 5 shows that the distribution of land in various uses varies substantially depending on the size and location of the farm. While the smallest farms rely heavily on perennials and annuals, which occupy 80% of all land on farms under 2 hectares, larger farms allocate greater shares of land to both pasture and forest.

4.5. Subdivision, especially during the 1990's

When the first settlers moved to the Amazon, the land was there for the taking. But over the last thirty years the nature of the region has changed and would now be appropriately classified as a closed frontier. Despite this change, migrants have continued coming to the region leading to further development of population centers and increasing numbers of households competing for land.

This overall increase in population has led to frequent subdivision of the original properties surveyed by IERAC. While there were a few *finca madres* that had been subdivided by 1990, when the first round of the survey was taken, the vast majority of subdivisions were found to have occurred between 1990 and 1999. In 1990, the study designers chose 480 survey farms located on 437 *finca madres*. Of these, there were 418 responding farms representing 376 *finca madres*. By 1999, however, further subdivision had resulted in there being 934 surveyed properties, all of which were part of the 403 original mother farms, or *finca madres*, chosen in 1990. Of these new subdivisions, 111 were *solares*, small non-farm plots of land on which a house is built. This left 823 farms, of which 767 completed the questionnaire. Because the location and subdivision codes were not collected for plots where the participant refused to participate, the data collected only covers 392 *finca madres*, representing 403 of the original 1990 farms, and the data on the number of subdivisions of each property between the two survey years are likely to be underestimates.

While the data indicate that on average *finca madres* were divided about once in the period between 1990, and 1999, the rate of farm level subdivision varies widely. The data on farm subdivision in Table 6 shows that by 1999, the majority of farms (59%) remained whole, while 41% were subdivided. Of these, the majority had only been subdivided once or twice (into two or three smaller farms), but some farms were subdivided into as many as ten parts (nine times) during the nine year period. In total,

Table 6 Subdivision of Farms between 1990 and 1999

Number of Subdivisions	Number of 1990 Farms	Number of 1999 Farms	% of 1990 Farms
0	238	238	59.1%
1	74	148	18.4%
2	44	132	10.9%
3	16	64	4.0%
4	11	55	2.7%
5	10	60	2.5%
6	3	21	0.7%
7	5	40	1.2%
9	2	20	0.5%
Total	403	778	100%

these subdivisions caused a 95% increase in the number of farms being operated in the same land area.

Land value appears to play a major role in determining whether or not a particular farm was subdivided. One of the main factors in determining the value of any piece of land is the quality of the soil. Soil quality determines what can and cannot be grown in a particular area as well as the productivity level of crops. In the NEA, there are three major soil types: black or volcanic soil which is generally fertile, alluvial or sandy soil, with moderate fertility, and red or acidic soils, typical of the Brazilian Amazon, with low levels of fertility. Table 7 shows the farm size, topography and land use shares for farms with these different soil characteristics. Farms with more fertile soil have a greater percentage of their area dedicated to perennials and annuals than do those less fertile soils. In addition more fertile farms have a lesser share remaining in forest.

Soil quality is clearly an important factor in determining whether or not a particular property was subdivided between 1990 and 1999. In 1990, 44% of farms reported having black soil, which is generally more fertile than other types (Pichón, 1993). Table 7 shows that by 1999, this share had risen to 58% of all farms, over a 30% increase over the 1990 share. This can also be seen in the declining average size of black soil farms from 45.4 ha in 1990 to 18.54 ha in 1999. Together these numbers indicate that black soil farms were subdivided into an average of approximately 2.45 smaller farms in the nine years between the surveys. Farms with lesser qualities of soil were subdivided less often, into 1.38 parts. This information is verified further by the self-reported soil quality of the farm. Table 8 shows that farms with “good” or “normal” soil are smaller, on average, than farms with poor soil. Given that finca madres were fairly uniform in size, this smaller farm size in 1999 indicates a greater level of subdivision.

Topography also appears to be a factor in the choice to subdivide, with farms on level ground expanding from 40% in 1990 (Pichón, 1993), to 48% in 1999. The final aspect of land value which determines subdivision is location. More subdivisions take place on farms closer to the road as well as on those closer to major regional population centers.

One effect of farm subdivision is the resultant increase in the number of people a given area of land must support. Because of this, the number of subdivisions is also negatively associated with both the area and the percentage of the farm remaining in forest. Subdivision also affects the household’s land use choices. It is negatively correlated with the area of the farm in annuals, perennials, and pasture, which can be attributed to the fact that subdivided farms are necessarily smaller than if they were un-subdivided. When considering the percentage of the farm in various uses, subdivision is positively correlated with both annuals and perennials, but negatively correlated with pasture. This implies that small properties are less likely to be used for cattle pasture or remain in forest, an expected result as many of the subdivided properties are too small to maintain even a few cows, which require at least on hectare of pasture land per cow.

Table 7 Distribution of Land Use by Soil Type, 1999

Soil Type	Farm Size	Topography: Level	Topography: Rolling Hills	Topography: Steep Hills	Topography: Mixed	Land Use Shares: Hectares in Perennials	Land Use Shares: Hectares in Annuals	Land Use Shares: Hectares in Pasture	Land Use Shares: Hectares in Forest	Land Use Shares: Hectares in Fallow	Land Use Shares: All Farms
	Mean (std. dev.)	N % of category	N % of category	N % of category	N % of category	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	N % of Sample
Black (volcanic, fertile) soils	18.54 (19.23)	290 66%	34 8%	17 4%	90 23%	2.86 (3.00) 29%	1.23 (2.19) 12%	4.33 (7.56) 18%	8.66 (12.89) 31%	1.44 (3.26) 10%	441 58%
Alluvial (moderately fertile) soils	24.28 (21.75)	26 67%	2 5%	3 8%	8 21%	2.25 (2.50) 27%	0.69 (1.30) 6%	4.78 (9.86) 14%	14.56 (17.08) 42%	1.98 (3.44) 10%	39 5%
Red (acid, low fertility) soils	31.13 (18.59)	27 11%	35 14%	92 37%	93 38%	3.67 (3.00) 23%	0.93 (2.64) 4%	5.09 (7.26) 16%	19.55 (15.33) 52%	1.91 (3.50) 6%	247 32%
Other soil type	25.89 (21.10)	18 53%	2 6%	3 9%	11 32%	5.17 (5.10) 33%	1.40 (2.38) 8%	6.97 (11.56) 20%	10.19 (12.06) 32%	2.10 (4.09) 7%	34 4%
All Farms	23.25 (20.06)	361 48%	73 10%	115 15%	212 28%	3.20 (3.15) 27%	1.11 (2.32) 9%	4.72 (7.82) 17%	12.56 (14.78) 38%	1.65 (3.39) 9%	761 100%

Table 8 Distribution of Land Use by Soil Quality, 1999

Soil Type	Farm Size	Farm Has Black Soil	Land Use Shares					All Farms
			Hectares in Perennials	Hectares in Annuals	Hectares in Pasture	Hectares in Forest	Hectares in Fallow	
	Mean (std. dev.)	Mean (std. dev.)	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	Mean (std. dev.) Mean % of Farm	N % of Sample
“Good” soil	19.17	0.81	2.90	1.22	3.95	9.42	1.65	334
	(20.67)	(0.39)	(3.16)	(1.93)	(7.35)	(14.06)	(3.44)	
			30%	12%	16%	31%	11%	44%
“Regular” soil	25.32	0.44	3.46	1.08	5.15	13.98	1.64	376
	(18.95)	(0.50)	(3.19)	(2.73)	(8.06)	(14.53)	(3.46)	
			26%	7%	18%	43%	7%	49%
“Poor” soil	34.72	0.06	3.17	0.65	6.51	22.66	1.72	51
	(17.39)	(0.24)	(2.63)	(1.12)	(8.60)	(15.35)	(2.40)	
			17%	3%	19%	56%	5%	7%
All Farms	23.25	0.61	3.20	1.11	4.72	12.56	1.65	761
	(20.06)	(0.49)	(3.15)	(2.32)	(7.82)	(14.78)	(3.39)	
			27%	9%	17%	38%	9%	100%

4.6. The Economy of the Ecuadorian Amazon

The economy of this region rests largely on oil and agriculture. The oil industry; however, is highly capital intensive and brings in most of its skilled employees from elsewhere for 3 week stints, and therefore does not hire many local colonists, so its influence in the region comes much more at the national level, rather than the farm household level.

Agriculture provides the principal means of support for most households, whether through subsistence or market sales. Many families, however, also acquire a large share of their income from off-farm employment both locally and in surrounding areas. Finally, remittances from family members who have left the farm also provide some small income to households. This impact is marginal, as only about 17% of households receive any level of remittances, and the monetary value of remittances remains quite small relative to other sources of income.

4.6.1. Commodities Produced

The main crops produced by farmers in the Northern Ecuadorian Amazon are coffee, cacao, corn, rice, and plantains. Of these, the first two are perennial cash crops and the last three, annuals, which may be sold or used for own consumption.

Table 9 shows the composition of cropped areas for farms in the survey. Coffee is, by far, the most common crop grown in this area of the Northern Ecuadorian Amazon. Over 83% of all farms grow some coffee, accounting for approximately 11% of all land area in farms, 24% of all deforested land and 61% of the total cropped area. It also accounts for 32% of total farm income, or 18% of all household income. Second to coffee in land area are plantains or cooking bananas, which constitute 4% of cleared land, while cacao and maize each account for 3% of total deforested land area. Income from these crops is small, compared to coffee, but still important, especially among poorer households, with plantains, cacao and maize accounting for 9%, 3% and 5% of mean farm income, respectively. Rice, which occupies only 1% of cleared land, also contributes 5% of farm income.

Pasture and the raising of cattle occupy much of the non-crop land on most farms. Pasture occupies a total of 44% of the non-forested land in the survey area, more than all crops combined. While this area is large, this overstates the importance of cattle many households who have pasture do not have any cattle. In fact, nearly 20% of the total land in pasture in the survey area belongs to households who had no cattle at the time of the interview. Despite this apparent overstatement, cattle ranching is an important activity in the area, providing 15% of total household income, or 26% of farm income.

4.6.2. Product Markets

Most of the products of agriculture in the Ecuadorian Amazon are sold in local markets, the main exceptions being perennial crops, mainly coffee, cacao and African palm, which are exported. Because of this differentiation between locally consumed goods and export goods, there are several markets for the sale of agricultural products: local markets, for the sale of products which are consumed by the local populace, and markets for crops which are sold nationally or internationally.

Table 9 Use Shares of Gross Cropped Area, 1999

	Perennial Crops						Annual Crops				
	Coffee	Cacao	African Palm	Palmito	Fruits	All Perennials	Corn	Rice	Plantain	Vegetables	All Annuals
Mean Proportion of Cropped Area	0.63	0.07	0.01	0.01	0.03	0.75	0.08	0.03	0.11	0.001	0.25
(std. dev.)	0.34	0.15	0.07	0.08	0.12	0.30	0.19	0.10	0.20	0.01	0.30
Range	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-1.0	0-0.25	0-1.0
No. of Producers	637	204	7	13	91	673	196	115	275	7	418
% of Farms[11]	84%	27%	1%	2%	12%	88%	29%	15%	36%	1%	55%

[11] **Only 716 out of 761 farms have reported any area in crops, thus 6% of farms have no cropped area.**

GCA	Hectares
Mean	4.31
(std. dev.)	4.31
Range	0-45
Mean % of Farm in Crops	36%
N	761

Farmers, looking to sell agricultural output have several locations in which to make their sale. They have the option of selling their products to intermediaries along the road or at the farm, if the farm is on the road; or transporting their goods into town to the markets and intermediaries there. Traditionally, one would expect to see higher prices for goods sold in town; however, the data seem to contradict this assumption. In fact, for many goods the farm gate prices seem generally to be somewhat higher than those received in town. While this is an unusual result, it does not seem to pose a significant problem as there is no significant difference in the price for the vast majority of commodities. The only crop which is an exception to this is coffee sold as dried cherries, which had a significantly higher farm gate price, although only at the 10% confidence level. For this particular agricultural product, the mean price in town was 20% below the farm gate price. However, because this was the only agricultural commodity for which a significant difference could be found, and coffee sold as dried cherries only represents 12% of all coffee sales, I will treat the commodities markets in the region as uniform with respect to prices, regardless of the location of sale. However, it should be noted that prices do seem to vary significantly over different zones and provinces. In addition, prices of coffee differ significantly across most cantons.

4.6.3. Labor Markets

Off-farm employment has become increasingly important to households in the region. In 1990, only 35% of households participated in any form of off-farm labor (Pichón, 1993); however, by 1999, this number had risen to almost 59%. This change also understates the increase in the importance of off-farm work, as both the level of participation and the total number of days worked off-farm by participating households has increased.

The data in Table 10 shows that households who participate in off-farm employment, have a higher level of income than those who do not. This extends beyond the higher level of off-farm income that households who participate in off-farm work achieve. Total household income is also significantly higher. But perhaps the most informative measure of overall income achievement is per capita income. This measure is particularly important because households engaging in off-farm employment tend to be larger than those who do not participate. Using this measure of income, households engaging in off-farm employment have a higher level of income at significance levels well under 1%.

The labor markets in the Northern Ecuadorian Amazon are largely agricultural. The vast majority of those working off their own farm do so as agricultural day laborers. Self employment takes up another large chunk of the labor force, and there are a small number of jobs in shops in town or with the oil companies that locals may fill. All told, the labor markets only account for a small percentage of the work age population in this area of the world. Of the 2422 individuals age 12 and up residing within surveyed households, only 544 work off-farm in any form. Of these, 28 report holding two jobs off-farm in the previous year, and one reports three. It is difficult to categorize the individuals holding multiple jobs by occupation, as they are often not all in the same field. Of the 515 workers with only one job, 281 report working as agricultural day laborers, while 92 report being self-employed. Thus these two categories make up over 70% of all off-farm workers. The remaining workers are dispersed fairly uniformly

Table 10 Distribution of Land Use by Gender of Persons Working Off-Farm, 1999

							Land-Use Shares					
Gender of Persons Working Off-Farm	**Household Size** Mean (std dev)	**Farm Size in Hectares[12]** Mean (std dev)	**Off-Farm Income[13]** Mean (std dev)	**On-Farm Income[13]** Mean (std dev)	**Total Income[13]** Mean (std dev)	**Per Capita Income[13]** Mean (std dev)	**Hectares in Perennials** Mean (std dev) Mean % of Farm	**Hectares in Annuals** Mean (std dev) Mean % of Farm	**Hectares in Pasture** Mean (std dev) Mean % of Farm	**Hectares in Forest[14]** Mean (std dev) Mean % of Farm	**Hectares in Fallow[15]** Mean (std dev) Mean % of Farm	**All Households** N % of Sample
No One	5.36	31.67	11.79	808.43	820.21	190.82	4.72	1.29	6.99	16.57	2.11	262
	(2.79)	(22.05)	(115.77)	(974.01)	(1,009.90)	(214.80)	(4.03)	(1.68)	(9.63)	(17.12)	(3.52)	
							23%	7%	21%	42%	8%	41%
Either Male or Female	6.17	24.77	922.64	645.49	1,568.13	287.96	3.16	1.30	4.68	13.73	1.87	377
	(3.16)	(23.25)	(1,526.25)	(1,179.19)	(2,332.22)	(400.17)	(3.31)	(2.90)	(7.96)	(17.45)	(3.92)	
							25%	10%	17%	38%	9%	59%
Male Only	6.04	23.82	819.32	575.25	1,394.58	265.39	3.00	1.33	4.26	13.44	1.77	321
	(2.89)	(23.06)	(1,486.52)	(941.86)	(2,063.64)	(358.82)	(2.94)	(2.98)	(7.42)	(17.31)	(3.90)	
							25%	11%	16%	38%	9%	50%
Female Only	6.29	30.23	625.22	704.25	1,329.47	243.90	4.15	1.08	8.10	12.85	3.88	21
	(3.05)	(19.97)	(401.72)	(668.84)	(884.29)	(206.14)	(3.47)	(1.63)	(10.44)	(15.57)	(4.89)	
							23%	9%	21%	33%	11%	3%
Both Male & Female	7.31	30.26	2,048.66	1,254.35	3,303.00	521.44	4.03	1.18	6.52	16.88	1.64	35
	(4.47)	(26.12)	(1,846.01)	(2,516.85)	(4,024.03)	(687.07)	(5.54)	(2.79)	(10.27)	(19.85)	(3.22)	
							26%	7%	16%	41%	10%	5%
All	5.84	27.60	549.18	712.29	1,261.47	248.13	3.80	1.30	5.63	14.89	1.97	639
	(3.04)	(23.00)	(1,256.72)	(1,101.82)	(1,938.64)	(347.25)	(3.70)	(2.47)	(8.75)	(17.36)	(3.76)	
							24%	9%	18%	40%	9%	100%

[12] Total landholdings of the household included in the survey
[13] In tens of thousands of Sucres
[14] Includes areas in swamp and areas left fallow for more than 7 years
[15] Includes areas left fallow for 7 years or less

across the other categories of work, which include chainsaw operator and other forms of agricultural work, as well as non-agricultural occupations, such as shop employee or professional/technical work.

It is important to consider gender when analyzing participation in off-farm employment and the distribution of off-farm occupations, as men and women differ substantially. Work off-farm is still primarily done by men. In 1999, only 6% of women aged 12 and over work off-farm compared to 35% of men. In terms of occupation, men predominantly participate in agricultural day labor (60%), with smaller shares, ranging from 2-8%, for other occupations. Women's activities are far more diversified with similar numbers of women participating in agricultural day labor (16%), professional or technical work (16%), work in a shop or restaurant (16%), buying and selling products (17%), and other self-employment (22%). There are some categories in which women do not participate, including chainsaw operator and manual labor with petroleum companies, both of which are very physical jobs, as well as contract work on plantations and running a taxi or transportation business.

Table 11 Off-Farm Occupations by Gender, 1999

Occupation	Men N % of Male Workforce	Women N % of Female Workforce	Total N % of Total Workforce
Agricultural Day Labor	270 60%	11 16%	281 55%
Chainsaw Operator	12 3%	—	12 2%
Contract Work on Plantations	12 3%	—	12 2%
Manual Labor with Petroleum Companies	22 5%	—	22 4%
Professional/Technical Work	38 8%	10 16%	48 9%
Employee of Shop, or Restaurant	9 2%	10 16%	19 4%
Run a Taxi or Transportation Business	23 5%	—	23 4%
Buy and Sell Products	15 3%	11 17%	26 5%
Other Self Employment	29 6%	14 22%	43 8%
Other Work	21 5%	8 13%	29 6%
All Agricultural Occupations	294 65%	11 16%	305 59%
All Non-Agricultural Occupations	69 15%	20 31%	89 17%
All Self Employment	67 15%	25 39%	92 18%
Total	451 100%	64 100%	515 100%

4.6.4. Linkages with Other Regions and Beyond

This region of the Amazon is linked with other regions of Ecuador in several ways. One connection with the outside world is made through the out-migration of family members. In the survey sample, 38% of families had at least one member who had migrated off the farm, and of these, 41% included migration of at least one household member to a province outside the study area. The average number of persons departing for households with members who had migrated was 2.7. This migration connection; however, does not result in a large economic connection. In fact, only 19% of households send remittances to members who have out-migrated, while even fewer (17%) receive remittances from those who have left the farm.

In addition, the area is linked to the outside world through agricultural goods markets. Coffee, the major cash crop of this region, is not bought in drinkable form locally, thus the revenues of farmers are at the mercy of trends in the world market. Between 1990 and 1999 coffee markets experienced a great deal of volatility. Coffee prices fell rapidly in the early 1990's, reaching a thirty year low in 1993. During the mid 90's there was a small recovery; however, by mid 1997, prices were heading downwards again, reaching a new all time low in 2001 (FAO, 2003). This had a dramatic impact on income levels of households involved in the NASA survey, with real farm incomes declining markedly between 1990 and 1999.

4.7. Women on the Amazonian Frontier

Women on the Amazonian frontier may take on both traditionally male and female roles. Like women everywhere, they act as caregivers to children and keepers of the home, but women in this area also take on traditionally male roles, including providing part of the labor necessary to operate the family farm and/or providing cash income to the family by working off the farm. The potential on-farm activities of women are diverse, ranging from physically demanding work such as forest clearing or planting and harvesting crops to working in the family garden to caring for small animals. The culture in this area has some machismo aspects present, which leads men to desire their wives to remain at home, when possible, instead of working in the marketplace or on the farm.

4.7.1. Demographics

The spouse of the head of the household (*esposa*) is generally significantly younger and slightly less educated than her husband. The average age of the esposa in 1999 was 39, compared to her husband's age of 44. While the age of the esposa ranges from 15 to 78, it is highly correlated[7] with the age of her spouse. She has not finished primary school, having only 4.8 years of formal education (completed primary being 6 years), while her husband has completed 4.9 years. Educational levels for both men and women in the sample range from no schooling to a few who have completed university.

It is unusual for a woman to either head a household, or live without an adult male present. Within the sample, only 41 of 639 households were headed by women. Most of these women were widowed (19) or separated (16). Of the remaining 6 households, two report the presence of a male spouse of the head, 3 report being in a "consensual union," and two are single. However, regardless of the marital status of the head, there is generally a male presence within the household, with only 8 female heads reporting that there is no adult male (15 years of age or older) present.

While women are less likely than their spouse to work on the farm, all 41 female heads of household report taking part in farm work, with 68% indicating that they work "most days," while the remainder work "sometimes." Of the remaining 598 male headed households, 539 have a spouse present. 16% of these *esposas* report "practically never" working on the farm, while 29% work sometimes and 55% work most days. Having the spouse "practically never" work on the farm seems to be a mark of affluence, with

[7] Correlation coefficient is 0.85

households in this category having, on average, 39% more income than households where the esposa works on the farm. There is little difference between households where the woman works "sometimes" and those where she works "most days," with the second category having 1% more income.

4.7.2. Economic Activities

The economic activities of women in the NEA consist of home production, farm work and a variety of off-farm occupations. All told, 76% of women aged 12 and older participate in agricultural production on the family farm. Farm production includes a variety of tasks in which women participate in varying degrees. Table 12 shows the rate of participation in various farm and household level tasks. The most common farm task for women is the care of small animals such as chicken, pigs and ducks, with over 95% of households reporting participation of women aged 15 and older. This task is a traditional one carried out by women in this region. In addition large percentages of women participate in the harvesting of perennials and work in the family orchard. There are several tasks for which women's participation is less common, most prominently clearing forest and applying chemicals or fertilizers.

In addition to farm tasks, women also normally take part in household production including the care of young children (97.2%), and collecting of water and cooking fuel, if necessary. Nearly 81% of households who have to collect water have women participating in this task, while 77% of households who collect fuel wood have women doing at least part of the collecting. While data were not collected on other

Table 12 On-Farm Work Activities of Women Aged 15 and Older, 1999

Activity	% of Households with Women Aged 15 and Older Participating (std. dev) N[8]	% of Households Participating (std. dev) N
Cutting Trees or Clearing Forest	37.0 (48.3) 395	65.3 (47.7) 639
Planting Perennial Crops	57.4 (49.5) 481	79.7 (40.3) 639
Harvesting Perennial Crops	75.1 (43.3) 527	87.6 (32.9) 639
Planting and Harvesting Annuals	69.0 (46.3) 422	70.1 (45.8) 639
Weeding Crops or Pasture	58.0 (46.3) 528	87.9 (32.6) 639
Caring for Small Animals	95.7 (20.3) 557	91.5 (27.8) 639
Caring for Cattle	69.3 (46.2) 280	45.5 (49.8) 639
Applying Chemicals or Fertilizers	19.8 (40.0) 217	36.8 (48.3) 639
Working in the Family Garden or Orchard	74.1 (43.9) 251	42.4 (49.5) 639
Caring for Children Aged 0-6	97.2 (16.5) 392	61.3 (48.7) 639
All Activities	97.7 (15.1) 602	99.5 (6.8) 639
All Activities Except Childcare	95.0 (21.7) 602	99.1 (9.7) 639
Core Farm Activities[9]	73.8 (44.0) 602	95.0 (21.8) 639

[8] Number of Households participating in this activity who also have women aged 15 and older.
[9] Planting perennials, harvesting perennials and planting and harvesting annuals

household tasks, women in this area typically provide much of the labor for the production of meals and maintenance of the household.

Beyond farm and household tasks, a small number of women also engage in off-farm employment activities. The most common activity among women is the establishment of a *tienda*, a small store, along the road. These stores typically sell drinks, snacks and a few staple items. Table 11presents a complete breakdown of women's off-farm occupations.

4.8. Children in the Ecuadorian Amazon

Children represent a sizeable share of the residents of the Northern Ecuadorian Amazon. Children under 12 represented 38% of the 2695 colonists in our 1990 sample, while those under 18 represented 54% of their numbers (Pichón, 1993).By 1999, the number of colonists in the sample area had increased to 3731, with these groups constituting 35% and 51%, respectively. In fact, the study area has a significantly higher proportion of children than does Ecuador as a whole, with those under 15 years of age representing 45% of the sample population in 1999, compared to only 34% of the total population of Ecuador in 2000 (United Nations, 2007). The greater prevalence of children in this area indicates higher fertility in the region compared with Ecuador as a whole. In addition, the decline in the prevalence of children between the two survey years, though slight, indicates that, while still high by national and international standards, fertility in this region has been declining (Pan, 2007).

4.8.1. Educational Opportunities

Primary education in the Northern Ecuadorian Amazon consists of six years, generally beginning at the age of six with primary schools located for fairly easy access to almost all farms, with 59 out of 60 surveyed communities containing a primary school.

After primary school, there are six additional years of available secondary education which takes place in high schools which are less prevalent but still within easy access for some but not all potential students. Secondary school is divided into two units of three years each, with the first being the equivalent of junior high school. Primary school and the first three years of secondary school are free and compulsory (at least in theory), while the final three years of secondary school is optional.

Additional educational opportunities are available for students who are not able to continue with traditional schooling. Secondary school can be completed via “distance education,” which generally takes place on Saturdays in local primary schools. While not academically equivalent to full time attendance, students can earn their high school diploma by attending Saturday school in approximately the same amount of time as would be required for traditional secondary school. Subsequent to or in lieu of a secondary education, an individual can attend a technical school, which are located only in the largest towns and generally offer a more skills oriented learning environment than would be typical of post-secondary education.

Finally, there are small universities which are available both within the region, in Lago Agrio and Coca, the two largest communities, and outside it. Despite the low cost, attendance is rare, with less than 1% of those aged twenty and older having ever attended university. In addition, the quality of local universities is much lower than those in other areas of the country, and most of the university education which does take place is done on a part time basis.

4.8.2. Educational Achievement

Despite the availability of educational opportunities at the primary and secondary levels, the probability of finishing secondary school is low. In fact, nearly 10% of 7-12 year olds reported not attending school, as did 58% of 13-18 year olds. The numbers are not much better when limiting the age group to 13-15 years, the age range for the "required" first unit of secondary school. In this range 46% are reported as no longer in school; however, 34% of those reported as still in school have not completed primary school, a sign that at the very least they are behind in their schooling.

While the rate of school attendance and graduation is still quite low (and below national levels), there has been a significant increase in the rate and level of schooling for the younger generations, with rates of school attendance at any level increasing steadily. Table 13 shows the highest level of educational attainment for members of various age groups living within the study area. The data show dramatic increases in the percentage of those who have some formal schooling, from 75.3% for those 60 years of age or older, to 98.5% for young people aged 20-29. This has been paired with an increase in the final level of education such that these same young people have on average completed 6.56 years of total education, compared to 2.98 for those 60 and older. In addition, the percentage of young people in the study region getting higher education, while remaining at low levels, has also increased dramatically, with 20-29 year olds between two and five times as likely to attend university as were those in their parents' generation.

Table 13 Education Rates by Age Group, 1999

Age Range	*Highest Level of Education*[10]						*Average Years of Education*	*Standard Deviation*	*# of Obs.*
	No Education	Incomplete Primary	Complete Primary	Incomplete Secondary	Complete Secondary	University			
20-29	1.5%	16.2%	50.3%	21.1%	8.3%	1.5%	6.56	2.75	592
30-39	4.8%	21.1%	52.5%	12.9%	7.4%	0.8%	5.90	2.81	379
40-49	10.6%	38.0%	45.2%	3.6%	2.3%	0.3%	4.48	2.51	303
50-59	17.5%	51.0%	26.5%	3.5%	1.5%	0%	3.58	2.40	200
≥ 60	24.7%	55.9%	16.7%	1.1%	0.5%	0.5%	2.98	2.42	186
≥ 20	8.4%	29.9%	43.3%	11.7%	5.3%	0.8%	5.27	2.95	1660

[10] Percentages do not sum to 100% in some cases because technical school, which is difficult to classify, was excluded

Table 14 Male Education Rates by Age Group

Age Range	***Highest Level of Education***[11]						***Average Years of Education***	***Standard Deviation***	***# of Obs.***
	No Formal Education	Incomplete Primary	Complete Primary	Incomplete Secondary	Complete Secondary	University			
20-29	1.5%	16.5%	50.9%	23.8%	6.2%	0.9%	6.38	2.49	340
30-39	2.9%	18.6%%	55.2%	12.9%	8.6%	1.0%	6.20	2.77	210
40-49	7.1%	34.3%	49.7%	4.7%	3.6%	0.6%	4.92	2.59	169
50-59	13.3%	48.7%	31.0%	5.3%	1.8%	0%	3.96	2.43	113
≥ 60	21.1%	57.8%	17.4%	0.9%	0.9%	0.9%	3.22	2.62	109
≥ 20	6.5%	28.8%	45.4%	13.1%	5.1%	0.7%	5.41	2.82	941

Table 15 Female Education Rates by Age Group

Age Range	***Highest Level of Education***[12]						***Average Years of Education***	***Standard Deviation***	***# of Obs.***
	No Formal Education	Incomplete Primary	Complete Primary	Incomplete Secondary	Complete Secondary	University			
20-29	1.6%	15.9%	49.6%	17.5%	11.1%	2.4%	6.80	3.05	252
30-39	7.1%	24.3%	49.1%	13.0%	5.9%	0.6%	5.53	2.82	169
40-49	14.9%	42.5%	39.6%	2.2%	0.8%	0%	3.92	2.29	134
50-59	23.0%	54.0%	20.7%	1.2%	1.2%	0%	3.09	2.28	87
≥ 60	29.9%	53.3%	15.6%	1.3%	0%	0%	2.64	2.08	77
≥ 20	11.0%	31.4%	40.5%	9.9%	5.6%	1.0%	5.07	3.10	719

[11] Percentages do not sum to 100% in some cases because technical school, which is difficult to classify, was excluded

The levels of educational attainment in developing areas of the world have traditionally varied by gender. Table 14 and Table 15 show the educational attainment levels of men and women respectively. Women, as would be expected, have somewhat lower overall levels of education, with an average of only 5.07 years, versus 5.41 years for men. Women are also almost twice as likely to have no formal education, more likely to not have completed primary school and less likely to have either a complete primary education or incomplete secondary education. Unusually, women are somewhat more likely to have completed secondary school or attended a university. Young women have recently overtaken their male counterparts in terms of their overall average years of education, with women aged 20-29 having 0.42 years more education then men in the same age range.

4.8.3. Work Activities

Children are expected, from a fairly young age, to help out on the farm whenever and wherever they are able. The activities they are engaged in run the gamut from fairly light tasks, such as feeding animals, to heavier work, such as planting and harvesting crops and even clearing forest. In addition many children are called upon to be care givers for younger siblings. By the age of 12, some children even begin working off-farm to earn income for their families. Younger children working off the farm are most frequently employed as agricultural day laborers.

Table 16 shows that over 85% of households with children between the ages of 7 and 14 have them working on the farm in some capacity, with virtually no distinction between males and females. If caring for younger children is eliminated from the group of activities considered, then the percentage of households with boys working on the farm falls slightly to 84% while those with girls participating falls somewhat more to 80%. This difference; however, is not significant at any conventional confidence level.

When breaking the data down by activity, it can be seen that households more often employ boys in the vast majority of farm activities, the only exceptions being the care of small animals and children, which are traditionally in the domain of women. The difference between boys and girls is significant at the 1% level for all activities except work in the family orchard, which is significant at the 5% level, indicating that while households have boys and girls participating in farm work at equal rates, the tasks they perform are different. As would be expected, the more strenuous or dangerous the task, the less likely we are to find children participating. Thus the least likely activities for boys and girls to be participating in are applying fertilizers or chemicals and cutting trees or clearing forest, with girls being significantly less likely to participate in these activities than boys. The most likely activities for boys are harvesting perennials and planting and harvesting annuals, while girls' most likely farm occupations are caring for small animals and harvesting perennials.

Table 16 On Farm Work Activities of Children Aged 7 to 14, 1999

Activity	% of Boys Age 7-14 Participating (std. dev) N[12]	%of Girls Age 7-14 Participating (std. dev) N[13]	% of Households Participating (std. dev) N
Cutting Trees or Clearing Forest	49.3 (50.1) 201	23.2 (42.3) 177	65.3 (47.7) 639
Planting Perennial Crops	60.3 (49.0) 242	33.6 (47.3) 220	79.7 (40.3) 639
Harvesting Perennial Crops	75.1 (43.3) 265	54.8 (49.8) 241	87.6 (32.9) 639
Planting and Harvesting Annuals	72.6 (44.7) 219	44.2 (49.8) 190	70.1 (45.8) 639
Weeding Crops or Pasture	65.4 (47.6) 272	35.0 (47.8) 240	87.9 (32.6) 639
Caring for Small Animals	63.3 (48.3) 281	77.9 (41.6) 249	91.5 (27.8) 639
Caring for Cattle	66.9 (47.2) 142	47.8 (50.1) 134	45.5 (49.8) 639
Applying Chemicals or Fertilizers	24.0 (42.9) 100	8.8 (28.4) 91	36.8 (48.3) 639
Working in the Family Garden or Orchard	61.5 (48.8) 135	46.6 (50.1) 103	42.4 (49.5) 639
Caring for Children Aged 0-6	52.6 (50.1) 194	79.1 (42.9) 190	61.3 (48.7) 639
All Activities	85.6 (35.2) 298	85.6 (35.2) 264	99.5 (6.8) 639
All Activities Except Childcare	83.6 (37.1) 298	80.3 (39.8) 264	99.1 (9.7) 639
Core Farm Activities[14]	72.8 (44.6) 289	55.3 (49.8) 264	95.0 (21.8) 639

[12] Number of Households participating in this activity who also have boys aged 7-14
[13] Number of Households participating in this activity who also have girls aged 7-14
[14] Planting perennials, harvesting perennials and planting and harvesting annuals

4.9. Changes over Time in the Ecuadorian Amazon

A great deal of demographic and socio-economic change took place in the study area between the 1990 and 1999 rounds of the NASA survey. This included an 8% reduction in household size due to a nearly 40% decline in overall fertility levels. The area saw a 97% increase in the number of farm plots on the properties chosen for the survey. In addition, there were 111 *solares*, small non-farm plots, established in this period. This was due to both in-migration and division of original households as children grew up and moved onto their own plots of land and to their own houses on their parents' land. As a result, the area supported a 39% higher population in 1999 than in 1990[15] (Bilsborrow *et al*, 2004).

The increased population pressures resulted in the subdivision of 41% of farms, causing the average farm size to decline from 46.3 hectares to 27.2 hectares. In addition, forest cover continued to decline on sample farms from an average of 57% in 1990 to 38% in 1999.

In addition, Ecuador as a whole experienced both economic and political instability during the study period. In 1999, especially, the value of the Ecuadorian Sucre fluctuated widely leading to the eventual dollarization of the Ecuadorian economy beginning in January 2000. Between February 1999 and September 1999, the months in which the survey was taken, the value of the Sucre fluctuated between 6,880/dollar and 12,500/dollar, and by the end of the year reached a trough of 19,500/dollar.

[15] Population increase excludes 111 solares. Inclusion of solares results in a larger increase in population for the study area.

5. THE DETERMINANTS OF TIME ALLOCATION AMONG FARM AND NON-FARM WORK BY MEMBERS OF COLONIST SETTLER HOUSEHOLDS IN THE NORTHERN ECUADORIAN AMAZON

This chapter presents the analysis of the factors which affect time allocation for agricultural households in the Northern Ecuadorian Amazon (NEA). The results take into account the fact that household members in this region have several possible uses for their time, including work on the family farm, off-farm employment and home production. While it is possible for an individual to allocate his time to a single activity, residents in this area frequently engage in a combination of two or more of these occupations. As such this chapter begins with a descriptive analysis of the data on participation in farm and off-farm work, followed by a discussion of the nature of farm and off-farm work. The following sections present an exposition of the variables which play an important role in the determination of work choice, the development of the empirical model used and finally the regression results.

5.1. Descriptive Analysis

Before undertaking the analysis of time allocation decisions, it is necessary to understand the nature of the work choices available to potential workers as well as the likelihood of any individual worker making a particular choice.

5.1.1. On and Off-Farm work in Agricultural Households

Agricultural households in the NEA often engage in both on and off-farm work activities. Both types of work are important to the livelihood of the household as a whole, with farm income generating on average 65% of the household's annual income while off-farm work generates the remaining 35%. The level of involvement in these two activities varies substantially among households, with the overall percentage of household income from each activity varying between 0 and 100%.

Farm Work

Farm work in the NEA covers a broad spectrum of activities, ranging from the raising of small animals and family gardens, to the clearing of land for agriculture. All of these activities involve significant commitments of labor, as the rate of mechanization in this area is quite low. Most household members participate in some farm work. The two most likely participants in farm work within the household are the *jefe* and *esposa* who engage in farm work at least some of the time at the rates of 94% and 85%, respectively. In addition, 82% of *jefes* and 57% of *esposas* work on-farm "most days." Co-resident children tend to work on the farm at somewhat lower rates, with 57% of sons aged 12 and up working on-farm "most days," while 30% of daughters worked most of the time.

Household members outside of the “core” nuclear family worked on-farm at even lower rates of 46% for men and 20% for women. All this indicates that while a large share of the household participates in farm work, men are participants more often than women and nuclear family members more often than extended family or household members.

Market Work

While paid off-farm employment is less common than on-farm employment in the NEA, over 59% of sample agricultural households still engage in some level of market work. While the quantity and type of this employment varies dramatically, the vast majority of households engage in OFE at a fairly low level, with only 17% of households supplying 300 or more days per year[16] for all household members combined. While a few households have all adult members working full-time off-farm, a typical household supplies a total of 148 days of off-farm labor per year, which translates into an average of 43 days per adult[17] household member per year.

5.1.2. Off-Farm Occupations and the Relationship between On Farm and Off-Farm Employment

The choice of whether or not to participate in off-farm employment varies significantly among men and women. Table 11 shows the numbers of men and women participating in off-farm employment. It indicates that 88% of those participating in off-farm employment (OFE) are male. Partially this is a reflection of the demographic composition of the Northern Ecuadorian Amazon (NEA), which has a greater share of

[16] Three hundred days is approximately equivalent to one full-time off-farm worker.
[17] Adult household members for the purposes of this study include those aged 12 years and older.

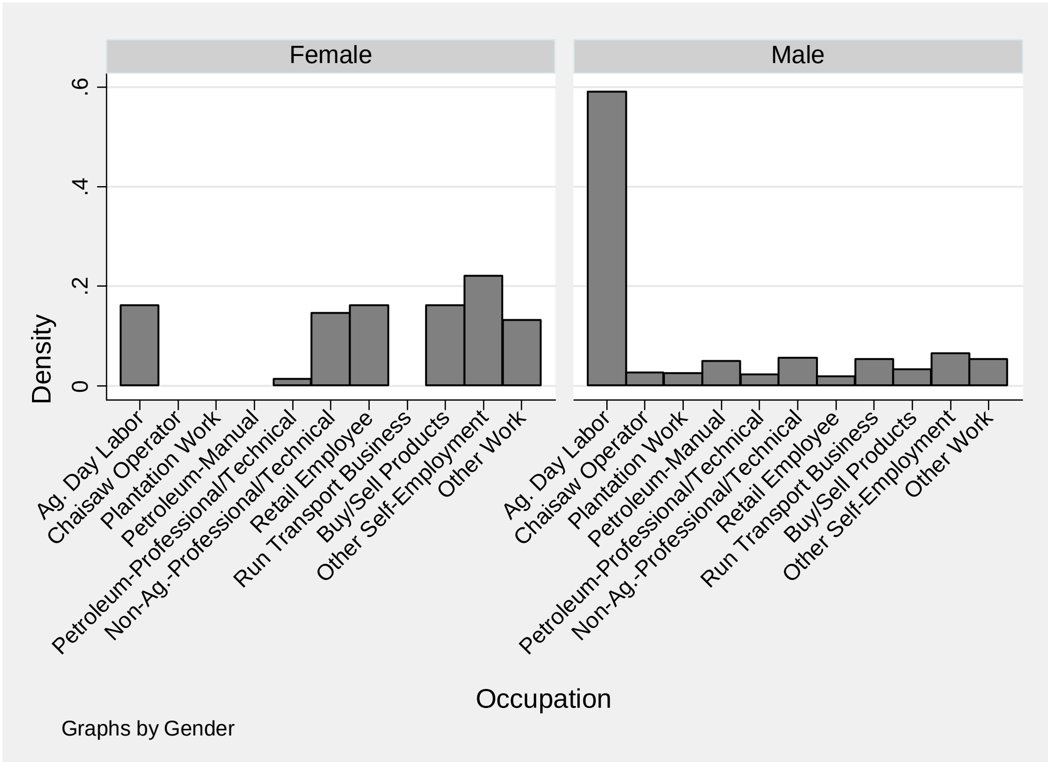


Figure 4 Frequency of Off-Farm Occupations by Gender, 1999

men than average with males composing 56% of the population aged 12 while females make up only 44%. However, the large differences in the off-farm participation frequencies of men and women are not fully accounted for by this demographic factor alone. In fact, women in this area are much less likely to choose to participate in off-farm employment than are men. In fact, while 40% of men over the age of 15 participate in OFE, only 7% of women in the same age range choose to participate.

In addition to the differences in participation rates, the distributions of occupations vary substantially for men and women. Figure 4 shows that men's off-farm occupations are much more concentrated in agricultural occupations with nearly 60% of all men who engage in OFE doing so as agricultural day laborers. Women, on the other hand, mostly choose non-agricultural forms of off-farm employment. The most common off-farm occupation for women is self employment, which accounts for over 20% of women who participate in off-farm employment. Women also differ from men in that they do not seem to concentrate their activities on a single occupational category. There are, however, several categories in which no women participate, specifically: chainsaw operator, contract work on plantations, manual work with petroleum companies, and running a transportation business. These categories may involve very physical labor, as would be the case for chainsaw operators or manual petroleum work,

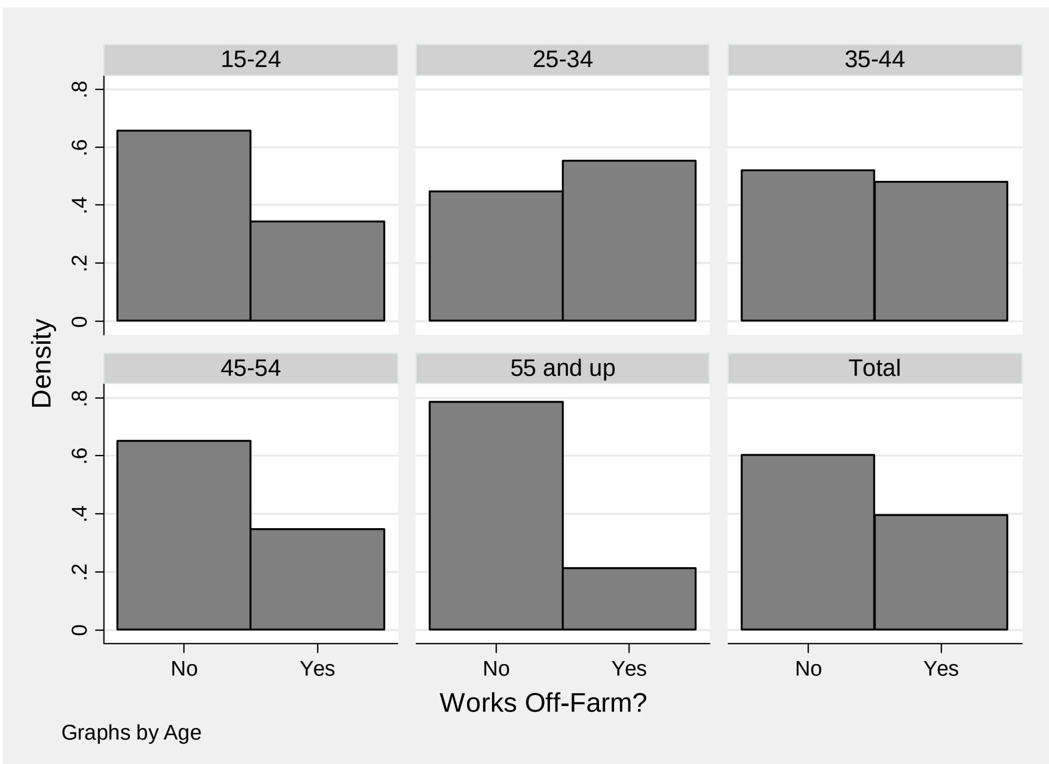


Figure 5 Off-Farm Employment Participation Rates for Men Aged 15 and Up by Age Group, 1999

or, as in the case of transportation, may not be perceived as an appropriate occupation for women.

While gender is clearly an important determinant of participation in off-farm work, it is not the only one. Another factor that must be considered is the age of the potential worker. While 40% of all men aged 15 and up participate in off-farm employment, Figure 5 shows that this participation is not evenly distributed across all age groups. Participation peaks at the age range of 25-34, with over 55% of males engaging in off-farm employment, and falling off slightly to 48% for men aged 35-44. This decline continues with age such that men 55 and older participate at only a 21% rate.

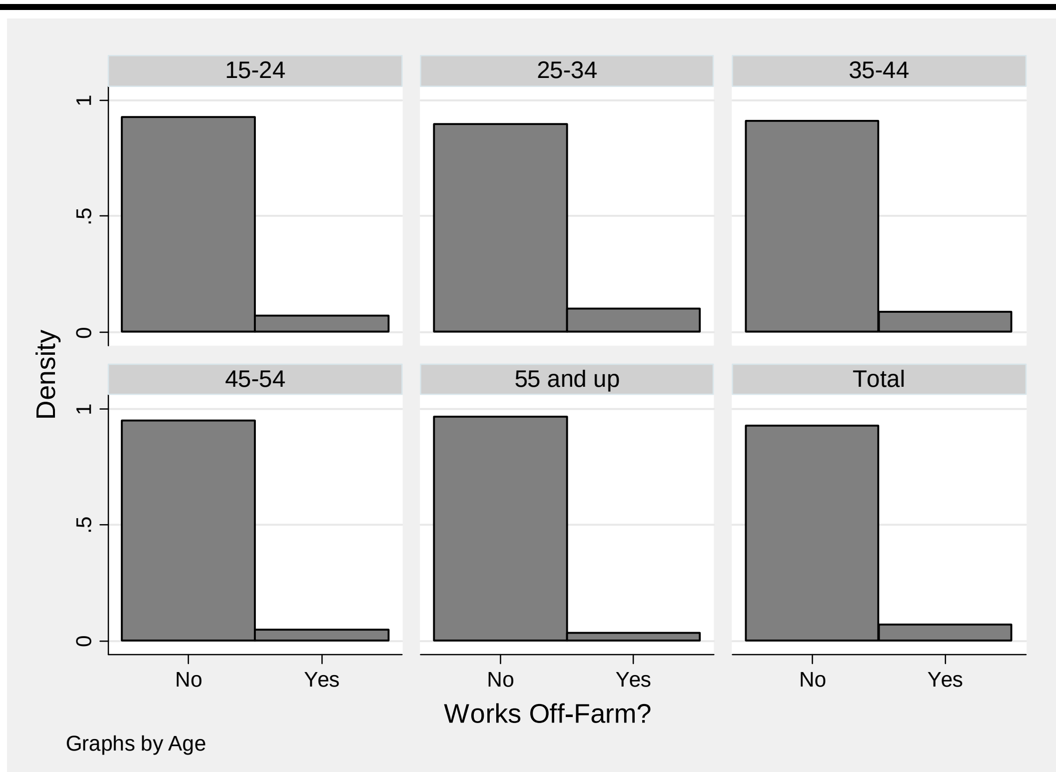


Figure 6 Off-Farm Employment Participation Rates for Women Aged 15 and Up by Age Group, 1999

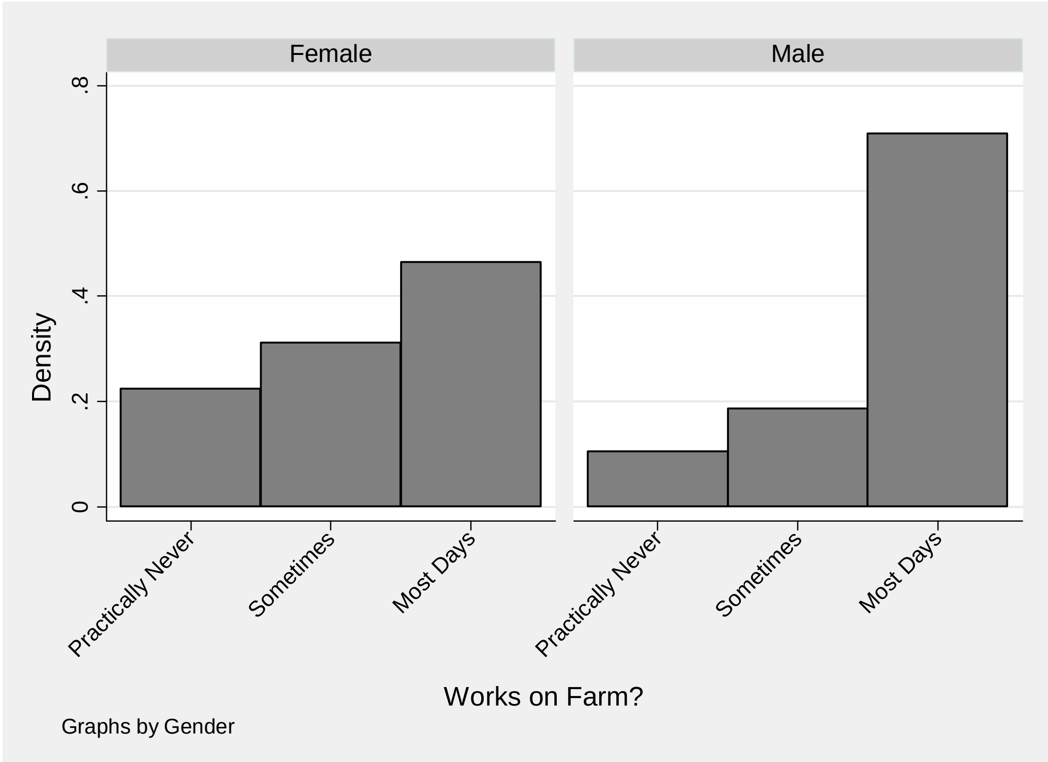


Figure 7 Farm Work Participation for Adults Aged 15 and Up by Gender, 1999

Women, shown in Figure 6, exhibit a similar pattern to men with respect to off-farm work choices with participation peaking at just over 10% at the age of 25-34 and falling to a low of almost 4% by the age of 55 and older. While this pattern of variation in participation levels with respect to age is similar, it should be noted that women's participation rates are not reminiscent of those of men, being significantly lower than men's at all age ranges.

Beyond off-farm work, all households in the dataset own their own farm, which provides another source of occupation for household members. The survey conducted allowed for three possible answers regarding the participation of each individual in farm work: most days, sometimes, and practically never. Figure 7 shows the farm work

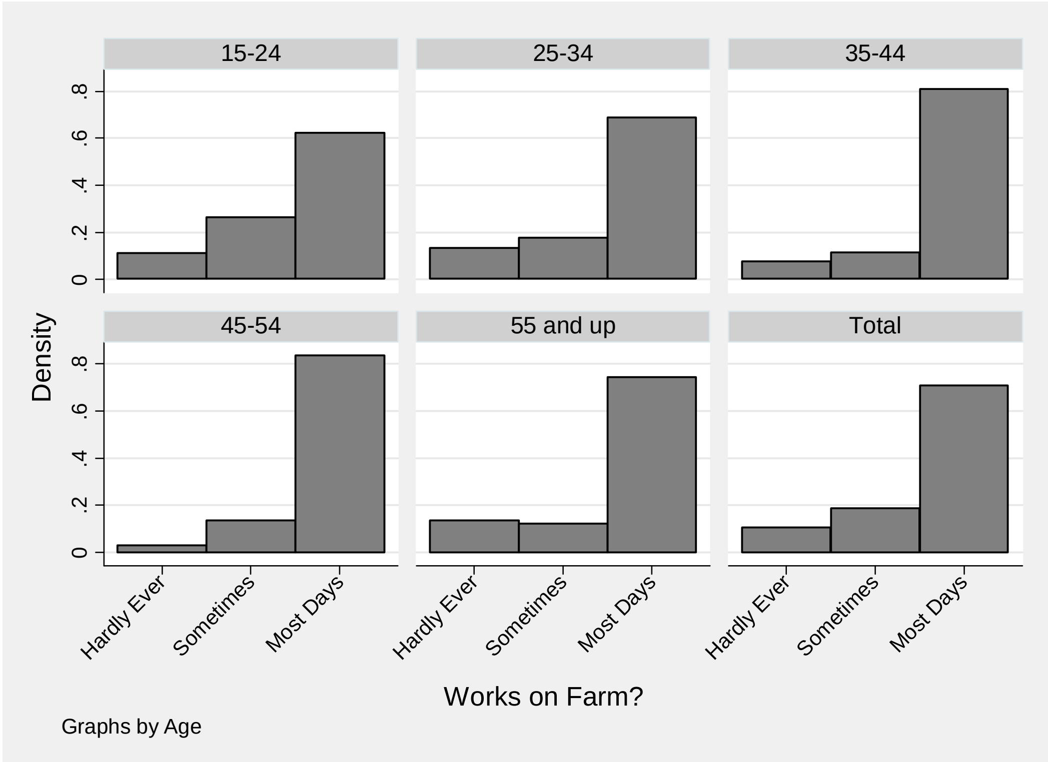


Figure 8 Farm Work Participation Rates for Men Aged 15 and Up by Age Group, 1999

participation rates of men and women aged 15 and older. It shows that men are more likely than women to work on the family farm "most days," while women are more likely to participate "sometimes" or "hardly ever." This is not unexpected as women are more likely to take part in home production activities like housekeeping, childcare and the preparation of meals.

Considering the differing impacts of gender on participation in farm work, it is necessary to consider the impact of age for the two groups separately. Figure 8 shows the level of participation in farm work for men of varying age groups. It shows that men of all age groups engage in farm work "most days" at high levels regardless of age group. The lowest rate of participation occurs at 15-24 years of age, and likely results from some

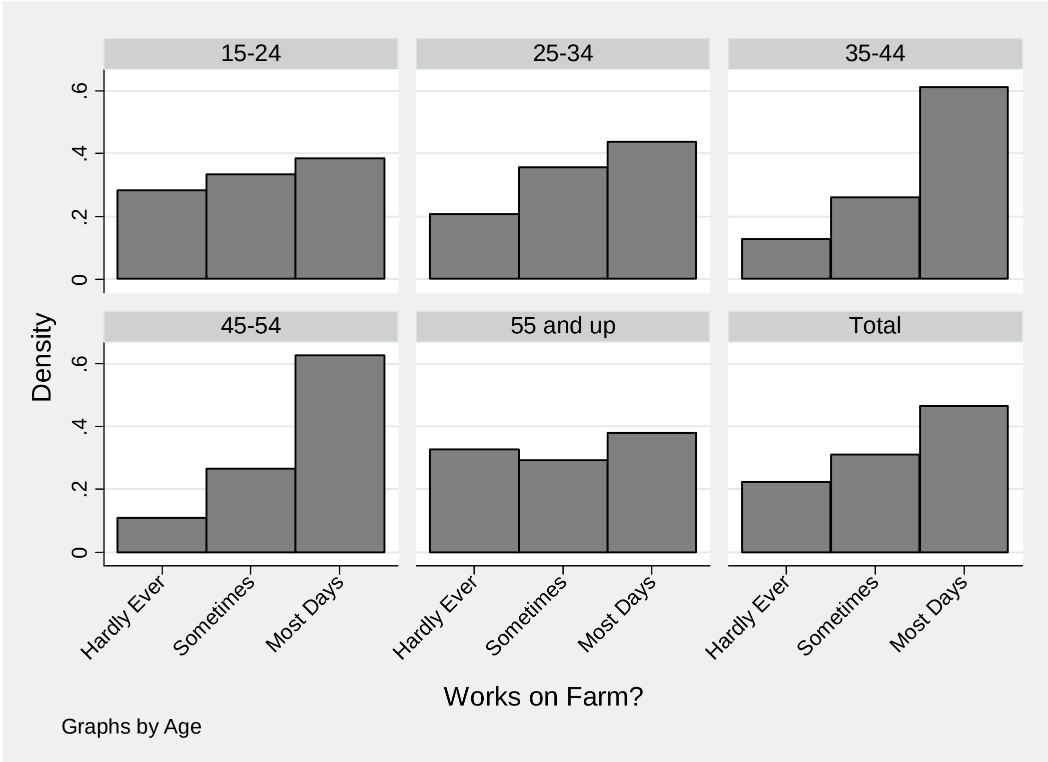


Figure 9 Farm Work Participation Rates for Women Aged 15 and Up by Age Group, 1999

group members still taking part in schooling. There is a small decline in the participation rates for men aged 55 and over, but even at this age, more than 70% of men are participating in farm work on a regular basis. Despite the high level of participation at this age, there is a dramatic increase in the share of men who "hardly ever" work on the farm. The rate of this "non-participation" rises from a low of just under 3% for men 45-54 to over 13% for men 55 and older.

When considering women, the variation in the level of participation in farm work is much more substantial. Women, as noted previously, work on-farm less than men. In addition, the percentage of women working on-farm "most days" peaks at the same age

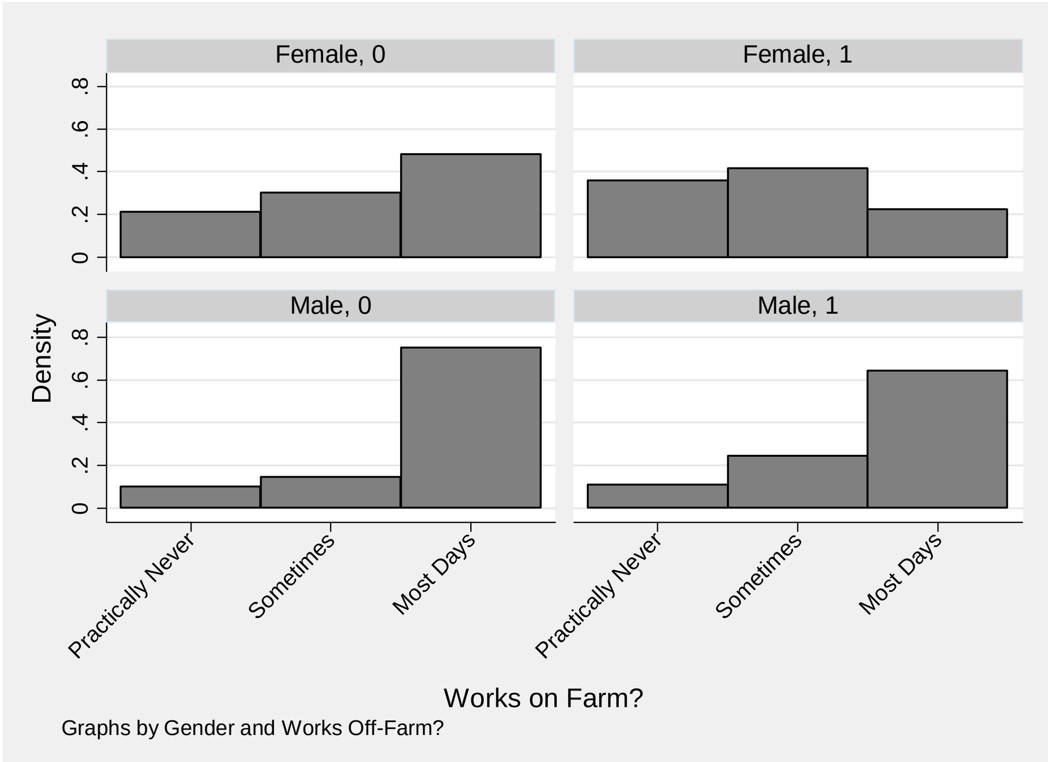


Figure 10 Farm Work Participation for Adults Aged 15 and Up by Gender and Participation in OFE, 1999

range as men and is lowest at the ages of 15-24, when women may be in school or have very young children, and 55 and up.

In addition to all these differences in participation rates with respect to age and gender, participation in OFE affects the probability of engaging in any particular level of farm-work differently for men and women. Figure 10 breaks down participation in farm work by both gender and participation in OFE, with 1 indicating those participating in OFE and 0 indicating those not participating. Men who choose to participate in OFE are somewhat less likely to engage in farm work "most days," and somewhat more likely to do so "sometimes," while the percentage working "hardly ever" is nearly identical, regardless of participation in OFE. Women by contrast change their distribution substantially depending on participation in OFE, with those participating in OFE less than half as likely to work on farm “most days” and more likely to work “sometimes” or “hardly ever.

All these results taken together provide an indication that it is likely that the decision of whether or not to participate in off-farm employment is made jointly with the decision on how much time to allocate to farm work. Because of this, analysis of either of these decisions, such as the off-farm work decision, in isolation may yield biased results. To illustrate this, I begin by analyzing each decision separately using OLS, probit, and logit regressions. Then I progress to joint estimation techniques including bivariate probit and multinomial logit. The results demonstrate that failure to consider an individual’s total choice matrix in this situation leads to biased results. In addition, the nature of the time allocation decisions of men and women often differ substantially. To account for this, I analyze the group of working age adults as a whole as well as dividing them into smaller groups by gender.

5.2. Factors Affecting the Choice of Work Activities

There are many factors that potentially affect the choice of an individual’s work activities. These factors may or may not be observable to the researcher and can be organized into several categories. While individual characteristics are important for participation in off-farm employment, other characteristics also contribute to the decision making process. The characteristics of the household, farm, market and community also play important roles. For example, the characteristics of the household and the labor market are likely to be significant factors in the decision of whether or not to participate in market employment. In addition, in an area like the Northern Ecuadorian Amazon, characteristics of the household's farm may play a substantial role in the decision of whether or not to participate in off-farm employment. One household level characteristic which is likely to be important is the structure of the household. As such, I have analyzed the individual characteristics, presented in the next section, by household type, in particular whether or not the household is nuclear.

5.2.1. Individual Characteristics

There are a variety of individual level characteristics which influence both participation in off-farm employment and occupation type. Table 17 shows the summary statistics for individual level variables used in the analysis of participation in off-farm work.

Table 17 Individual Level Summary Statistics for those engaging in off-farm work by household type, 1999

Variable	***All* (1)**	***Nuclear Household* (2)**	***Non-Nuclear Household* (3)**	***Difference* (4)**
Gender (1=male, 0=female)	0.88 (0.33)	0.90 (0.30)	0.83 (0.38)	0.08** (0.03)
Age	32.33 (12.72)	32.47 (11.77)	32.07 (14.35)	0.39 (1.15)
Years of Education	5.99 (3.01)	5.85 (2.79)	6.27 (3.37)	-0.42 (0.27)
Works On-Farm "Most Days"	0.59 (0.49)	0.65 (0.48)	0.48 (0.50)	0.16*** (0.04)
N	544	355	189	

*** Statistically significant at P>0.01, ** P>0.05, * P>0.10

While men make up the vast majority of the off-farm work force, they make up a significantly smaller percentage when considering non-nuclear households (households make up of more than one family unit). This means that women are more likely to work off-farm if they are members of an extended household. This may stem from the fact that non-nuclear households have a greater number of adult women present. This greater female presence may free some female household members from traditional household roles, allowing them time to work in other settings.

The data also show that off-farm workers in extended households are less likely to work regularly on the farm than those in nuclear families. Again this may stem from the fact that non-nuclear households are larger on average than nuclear households, allowing farm work to be spread among more people. The abundance of labor in this setting could allow farm work to be delegated solely to those who do not engage in other economic activities, while smaller households may not have the labor necessary to undertake this type of specialization. Finally, although not statistically significant at conventional confidence levels in a two-tailed test, the education level of off-farm workers is greater for workers originating in a non-nuclear family as compared to a nuclear one. This result is significant at the 10% level when performing a one-tailed test and may indicate either that non-nuclear households have a higher level of education or that the extended family size allows for a greater selectivity as to which household members are chosen to participate in off-farm employment.

The impact of gender extends beyond the gender composition of off-farm workers and is among the most significant of all individual characteristics. This is because men and women make work decisions differently. Much of this difference originates from the different roles men and women traditionally take within the household. In the case of the Northern Ecuadorian Amazon, men and women have vastly different factors to consider in deciding on their work activities. This society, like many in South America and other areas of the developing world, is male dominated. In these areas, social mores and societal norms lead men and women to very different roles in the household and society as a whole. As these roles vary, so does the probability of engaging in any type of employment and the composition of the occupations, offering some indication that gender itself may be a direct and important factor in employment decisions.

Furthermore, gender may also affect the way in which other individual, household and farm characteristics affect off-farm employment. For example, age and level of education are two variables that are likely to affect OFE decisions. But their impact may in fact be very different depending on the gender of the individual under consideration. For example, because women in this area tend to engage less in agricultural occupations and more in service sectors such as restaurant and shop work and self employment, they are often involved in less physical forms of off-farm employment than are men. This difference in work activities means that variables, such as age, which proxy for physical abilities are likely to have a different impact on men's and women's off-farm work. While age is likely to be a significant factor for both men and women, it may have a smaller overall impact on women's work choices. In a similar manner, because of the types of work women choose, education may matter more for them than for men. This is due to the fact that the types of jobs occupied by women are likely to value education more than would agricultural work, the occupational choice of the majority of men.

In addition to these individual variables, farm level variables such as the size of the household's land holdings may have differing impacts for men and women. Because men are more often engaged in the operation of the family farm, their employment decisions may be impacted to a greater extent by farm size. Other characteristics, such as market access, may have a greater impact on women. Because agricultural employment often occurs on neighboring farms, men may not be as adversely affected by living further from the road or a population center, while these variables would dictate the ability of women to obtain a job in a shop or run a small store.

5.2.2. Household Characteristics

Beyond the characteristics of the individual, household characteristics are also likely to affect the choice of household members as to whether or not to work off-farm. Table 18 shows the household characteristics of all households in the sample (column (1), those participating in OFE (2) and those not participating (3). Column (4) indicates the difference between participating and non-participating households. The data clearly indicate that households who choose to participate in OFE tend to differ from those who choose not to participate. Households who participate in OFE tend to be larger with more household members in all age ranges. Having more members in each age range, however, is likely due to the larger size of participating households, not a difference in household composition. When comparing household composition in terms of the percentage of members in each group, a somewhat different picture emerges. There is no difference between participating and non-participating households in terms of the percentage of the household composed of prime age (15-55 yrs) males. This is somewhat surprising as males in this age range make up the vast majority (81%) of those working off-farm. Instead, the differences in the households lie in the other age groups.

Table 18 Summary Statistics of Household Characteristics, 1999

Variable	*All* (1)	*OFE* (2)	*No OFE* (3)	*Difference* (4)
Household Composition				
Nuclear Household	0.72	0.73	0.71	0.02
	(0.45)	(0.44)	(0.45)	(0.04)
Number of Household Members	5.84	6.17	5.36	0.81***
	(3.04)	(3.16)	(2.79)	(0.24)
Number of Children Under Age 6	1.08	1.17	0.94	0.24***
	(1.11)	(1.13)	(1.06)	(0.09)
Number of Children Age 6 to 11	0.99	1.05	0.89	0.16*
	(1.10)	(1.14)	(1.04)	(0.09)
Number of Adults (12 and Older)	3.77	3.95	3.52	0.42**
	(2.08)	(2.22)	(1.84)	(0.17)
Fraction Prime Males	0.32	0.32	0.32	0.00
	(0.20)	(0.18)	(0.23)	(0.02)
Fraction Prime Females	0.22	0.23	0.21	0.02**
	(0.13)	(0.12)	(0.14)	(0.01)
Fraction Elderly Males	0.04	0.02	0.07	-0.04***
	(0.13)	(0.08)	(0.17)	(0.01)
Fraction Elderly Female	0.03	0.02	0.04	-0.03***
	(0.09)	(0.07)	(0.11)	(0.01)
Fraction Children 14 and Under	0.38	0.40	0.36	0.05**
	(0.23)	(0.21)	(0.24)	(0.02)
Characteristics of the Head of Household				
Age of Head	44.01	42.20	46.61	-4.42***
	(13.97)	(13.35)	(14.46)	(1.11)
Years of Education of Head	4.90	5.07	4.65	0.42**
	(2.69)	(2.83)	(2.45)	(0.22)
N	639	377	262	

*** Statistically significant at P>0.01, ** P>0.05, * P>0.10

Participating households are composed of a smaller percentage of elderly males and females. This decrease in the fraction elderly is offset by greater fractions of both prime females and children. These results suggest that participation in OFE may depend on the ability of non-participating household members to work on the farm and within the household. It is also possible that elderly household members discourage off-farm work of others in some other way. For example, older household members may value "self sufficiency" more and thus may discourage income streams which depend on others in favor of increased farming of household lands. Alternatively, older parents may need to be cared for by their children, limiting the time available for off-farm employment.

In addition to these observable differences in household composition, the head of participating households tend to be younger and better educated than the head of non-participating households. The result that households participating in OFE are different from those choosing not to participate is not surprising, as the theoretical model predicts that the off-farm work decision of any individual will depend on not only his or her individual characteristics, but also on household characteristics.

In addition to the variables in Table 18, there are other unobserved household characteristics which will influence the off-farm work decision. Notably, household preferences for risk may play an important role. Because agriculture is an inherently risky occupation, particularly in developing countries where governments do not provide crop insurance, households who are more risk averse may hedge against farm losses by having one or more household members working for a wage (Arguello, 1981).

5.2.3. Farm Characteristics

There are many farm characteristics that may impact the decision of where to work. Farm size, as noted in Section 5.2.1, is one of these; however, there are several possible ways to measure farm size. Among these are the area of the household's land holdings and the area currently under cultivation. These areas help to determine the quantity of labor needed on the farm, and hence the amount of labor available for work in the market place.

Table 19 provides summary farm statistics for all households in the sample (Column 1), households who participate in off-farm employment (Column 2) and households who did not (Column 3). Overall, most households own or operate farms, although 32 percent have less than 10 hectares (1ha=2.47 acres). The average sample household owns, rents, and/or borrows a total of 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 in the sample area. Households who completed the survey had an average of 27.6 hectares in the survey area. For the typical interviewed household, 40% of their sample area property remained in forest in 1999, with the remaining 60% distributed among perennials (24%), pasture (18%), annuals (9%) and fallow (9%).

Column (4) of Table 19 reports the differences in means for the farm summary statistics by participation in off-farm employment. It is clear that there are some differences between the farms of households who participate in OFE and those who do not. Compared to households who do not engage in off-farm work, households that participate have smaller farms, less absolute area in forest, perennials and pasture, and less total cleared area. It is unclear, however, if these differences in areas under various uses are a result of differences in the household's overall land holdings or if they originate in differences in the household's land use choices. When comparing land use fractions of the farm, households participating in off-farm work allocate a greater percentage of their land to annuals and a smaller share to pasture. Participating

Table 19 Summary Statistics of Farm Characteristics

Variable	*All* (1)	*OFE* (2)	*No OFE* (3)	*Difference* (4)
Farm Characteristics				
Total Land Holdings (hectares)	34.25	30.55	39.56	-9.01***
	(34.01)	(34.90)	(32.00)	(2.71)
Area in Sample Farms	27.60	24.77	31.67	-6.90***
	(23.00)	(23.25)	(22.05)	(1.83)
Total Area in Forest	13.41	13.73	16.57	-2.84**
	(16.50)	(17.45)	(17.12)	(1.39)
Total Cleared Area[18]	12.71	11.02	15.11	-4.09***
	(12.16)	(11.26)	(12.92)	(0.96)
Area in Annuals	1.30	1.30	1.29	0.02
	(2.47)	(2.90)	(1.68)	(0.20)
Area in Perennials	3.80	3.16	4.72	-1.56***
	(3.70)	(3.31)	(4.03)	(0.29)
Area in Pasture	5.63	4.68	6.99	-2.31***
	(8.75)	(7.96)	(9.63)	(0.70)
Area in Fallow	1.97	1.87	2.11	-0.24
	(3.76)	(3.92)	(3.52)	(0.30)
Percent of Farm in Forest	0.40	0.38	0.42	-0.04
	(0.32)	(0.32)	(0.30)	(0.03)
Percent of Farm in Annuals	0.09	0.10	0.07	0.04***
	(0.17)	(0.19)	(0.12)	(0.01)
Percent of Farm in Perennials	0.24	0.25	0.23	0.02
	(0.26)	(0.28)	(0.23)	(0.02)
Percent of Farm in Pasture	0.18	0.17	0.21	-0.04**
	(0.22)	(0.22)	(0.21)	(0.02)
Percent of Farm left Fallow	0.09	0.09	0.08	0.01
	(0.16)	(0.17)	(0.14)	(0.01)
Soil is Black	0.59	0.60	0.57	0.02
	(0.49)	(0.49)	(0.50)	(0.04)
Has Coffee	0.86	0.82	0.92	-0.10***
	(0.35)	(0.39)	(0.27)	(0.03)
Has Cattle	0.46	0.42	0.56	-0.14***
	(0.50)	(0.49)	(0.50)	(0.04)
N	639	377	262	

*** Statistically significant at P>0.01, ** P>0.05, * P>0.10

[18] Area of surveyed properties not in forest or swamp

households are also less likely to have area in coffee, or raise cattle and have a shorter duration of residence on their current farm.

5.2.4. Area Characteristics

The characteristics of a geographic area that may impact work choices are multifaceted. Physical or geographical characteristics such as topography access to waterways and the extent of and density of forest cover all impact the ability of individuals to seek market employment. In addition, the characteristics of the labor market themselves partially dictate the availability of employment and market wage rates.

Physical Characteristics

In many areas of the world, the extent of local forest is particularly important in determining the work activities of women. Because women traditionally are the collectors of firewood, changes in forest cover affect the time necessary for firewood collection and thereby impact the time available for other activities. Studies have shown that, in some areas of the world, deforestation shifts women's time away from agricultural or market work (see Kumar and Hotchkiss, 1988).

These areas, however, tend to be substantially different from the NEA with respect to the area remaining in forest. In the NEA, despite the rapid deforestation that has taken place over the last several decades, the percentage of the land in forest remains high, at nearly 50%. This high rate of forestation decreases the overall impact of forest loss on women's agricultural and market work activities. There are additional factors in this area which limit the impact of deforestation on women's activities directly. First, over 42% of households use gas exclusively for cooking, with the remainder using a combination of wood and gas, 23%, or wood only, 35%. For these wood using households, 46% spread the collection of wood among all family members, while a large share of the others spread the work among various members of each sex. In fact firewood collection is an exclusively female occupation in only 32% of households who use wood for cooking. This spreading of firewood collection between family members also works to limit the impact of deforestation on women's work activities. This does not indicate, however, that off-farm employment is unaffected by the state of the forests, merely that this effect is likely to be much dampened by the lower levels of fuel wood use and its impact spread across both sexes.

Local Labor Markets

Local labor market conditions are particularly hard to assess in the context of a rural area of a developing country. However, certain farm characteristics may proxy for the accessibility of the labor market to household members. Table 20 shows summary statistics for variables which proxy for labor market access. While there is no significant

Table 20 Summary Statistics of Farm Accessibility

Variable	***All* (1)**	***OFE* (2)**	***No OFE* (3)**	***Difference* (4)**
Farm Accessibility				
Distance to Major Population Center (km)	19.38	18.68	20.37	-1.69
	(13.44)	(13.57)	(13.20)	(1.08)
Distance to Farm by Foot	1.17	1.08	1.31	-0.24
	(1.85)	(1.72)	(2.01)	(0.15)
Farm Always has Vehicular Access	0.48	0.49	0.46	0.02
	(0.50)	(0.50)	(0.50)	(0.04)
Vehicular Access Depends on Rains	0.17	0.16	0.18	0.02
	(0.37)	(0.37)	(0.38)	(0.03)
N	639	377	262	

*** Statistically significant at P>0.01, ** P>0.05, * P>0.10

difference in any of the variables between households who participate in off-farm employment (OFE) and those who do not, all the variables indicate that households who participate in OFE have better (although insignificantly) access to markets.

5.3. Empirical Model of Work Choice

The theoretical model presented in Section 2.10 provides a backbone for the following analysis of time allocation decisions. In analyzing these choices, I begin by constructing an empirical model for the probability of an individual participating in farm or off-farm work. From the agricultural household model presented in Section 2.10, we know that, in the absence of political or cultural constraints, an individual allocates time such that the marginal value of participating in all activities is equal. Thus 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 however they are not participating in farm work, then their reservation wage is the marginal value of their home production time, which is much harder to determine. In the same way, a model for participation in farm work would depend on the marginal product of labor on farm as well as the individual's reservation wage and the available market wage.

Analytically, the equation for the reservation wage can be found by setting $\mathbf{T}_m^*$ in equation (2.25) to zero and solving for $\mathbf{W}$=$\mathbf{W}^R$ (Huffman, 1991). This yields:

$$W_j^R = R_j(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{T}) \tag{5.1}$$

where j refers to the j^{th} family member. Thus the reservation wage for family member j (W_j^R) is a function of the price of agricultural goods ($\mathbf{P}_a$), the price of goods used in agricultural production ($\mathbf{P}_n$), the area of land owned by the household (L), the price of market goods used in home production ($\mathbf{P}_x$), household non-labor income (Y_n), as well as the individual's human capital applicable to farming ($\mathbf{H}f$), home production ($\mathbf{H}h$), and market work ($\mathbf{H}m$), the characteristics of the farm ($\mathbf{C}f$), household ($\mathbf{C}h$), and area ($\mathbf{C}m$) characteristics and the household's time endowment ($\mathbf{T}$).

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

$$\begin{aligned} &\Pr(D_j = 1) = \Pr(W_j^R < W) = \\ &\quad = f(\mathbf{P}_a, \mathbf{P}_n, L, \mathbf{P}_x, Y_n, \mathbf{H}_f, \mathbf{C}_f, \mathbf{H}_h, \mathbf{C}_h, \mathbf{H}_m, \mathbf{C}_m, \mathbf{J}_m, \mathbf{T}) . \end{aligned} \tag{5.2}$$

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 (2.11). 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 would increase the opportunity cost of off-farm work, making it less likely. Unfortunately much of the off-farm work available in the Oriente is agricultural in nature. This means that skills which make an individual more productive on-farm would also likely increase their off-farm wage. This makes the impact of certain characteristics, such as education, nebulous *a priori*.

Furthermore, equation (2.28) shows that the time spent in farm work is a function of the same variables as the time spent in off-farm work. As such, it is inappropriate to estimate the off-farm work decision in the absence of the on-farm work choice. Thus the estimation framework must include both on-farm and off-farm work decisions. To this end, the use of a seemingly unrelated regressions framework allows for the simultaneous analysis of these two decisions.

In addition to the above concerns, it is also necessary to remember that there are various unobservable household and community level characteristics that may impact the individual's off-farm work decision. This creates a situation where the off-farm work decisions of household members are unlikely to be independent. As such, it is important to allow for correlation between the error terms of household members, which is achieved through cluster corrections. In addition, to adjust for the unobserved community characteristics, a fixed effects model is employed.

5.3.1. Challenges for the Empirical Model of Work Choice

On a practical level, the process of estimating equation (5.2) is complicated for several reasons. First, the relationships between the dependent variable and independent variables are not always clear and the theoretical model provides very little insight in terms of expected relationships, or even signs of the coefficients on many variables. Second, as many individual, household, and market characteristics in the theoretical model are either unobservable or unavailable, it is necessary to find, within the data, variables which would suffice for those that are unavailable.

5.3.1.1.Expectations for Variables in the Theoretical Model

In understanding the relationship between the dependent and independent variables in the theoretical model, it is necessary to create prior expectations based on both the theoretical model and what is known about the area being studied. The theoretical model makes several predictions with regard to the signs of coefficients of variables. With regard to impacts on time allocation, we know from equation (2.17) that, all else equal, increases in the market wage ($\mathbf{W}$) will decrease the time spent in farm work ($\mathbf{T}_f$) as the opportunity cost of farm work rises. However, this theory does not take into account a complicating factor which is that much of the off-farm employment available is in fact on other farms. This means that increases in off-farm wages are likely to be driven by increases in the marginal revenue product of agricultural labor. These types of increases are likely to originate in higher agricultural prices which would, in turn, increase the marginal revenue product from own farm work. Thus it is very hard to make any concrete prediction about the impact of increases in off-farm wages. In addition to this complication, we do not know the impact of increases in the wage rate on time spent at home ($\mathbf{T}_h$) because increases in the wage rate will have two effects on the choice of market time and home time. The first effect is that higher wages mean that the opportunity cost of home time has increased which, due to the substitution effect, would lead to more time spent in market work and less time spent at home. The second effect is a result of the impact of higher wages on income level. The increase in income will result in the demand for more home time, and therefore less time spent in market work. Because of the divergent nature of these two effects, we have no way to predict the net direction of the impact on time spent in market work ($\mathbf{T}_m$) from a wage increase using the theoretical model alone. If you include considerations for the nature of the study area, an area that is extremely poor, then we might expect that the substitution effect of higher wages will outweigh the income effect and that the coefficient on wages will be negative with respect to the time spent in home production because at low income levels the substitution effect is generally larger than the income effect. However, without the ability to predict the impact of higher wages on time spent in farm work, as described above, this still leaves the issue of the impact of higher wages on market time unresolved.

The wage, however, does not figure directly into equation (5.2). Instead the variables which we have to consider are those which impact the wage, namely marketable human capital ($\mathbf{H}_m$), local labor market conditions ($\mathbf{C}_m$) and job characteristics ($\mathbf{J}_m$). These variables are problematic for several reasons, first, it may be difficult to determine what these characteristics actually are, second, many of these characteristics are difficult or impossible to measure, and finally, many of the variables which could be used in these characteristics may also impact other right hand side variables. For example, on important component of marketable human capital is physical ability; however, the data set contains no variables that directly measure this ability. Instead it is necessary to proxy for physical ability with other available variables. One variable that may provide information on physical ability is age. As a person ages, he generally grows stronger, up to some point beyond which additional age decreases physical strength. In this sense, one might expect that the relationship between age and physical ability would present as an inverted-U. If one expects that greater physical ability would also translate into higher wages, then this same inverted-U shape would be expected to hold when looking at the relationship between off-farm work and age.

However, there exist complicating factors that increase the complexity of the relationship postulated above. First, physical ability is also a component of an individual's human capital applicable to farming ($\mathbf{H}_f$) and their home production human capital ($\mathbf{H}_h$). This means that while a stronger person may be able to command a higher market wage because he or she is able to do more physical tasks, their ability to do these tasks would also increase their marginal productivity in both farm and home production resulting in an ambiguous total effect on participation in off-farm work. In addition, age is an imperfect measure of physical ability and is likely to be related to other components of human capital as well as other right hand side variables. For example, age, as presented in section 4.8.2, is closely related to educational attainment, another component of human capital. In fact, age is negatively and strongly correlated with educational attainment, while it is also likely to be positively related to the level of work experience the individual possess. Both of these variables are likely to be components of all three of the human capital vectors, making their relationship, and hence the relationship between age and participation in off-farm work unclear.

Much of the ambiguity in the impacts of human capital variables results from the close relationship between marketable human capital and farming and home production human capital. While this may be a problem regardless of the setting, it is a special concern in an area like the Northern Ecuadorian Amazon where a large proportion of off-farm employment available is work on others' farms. Because 59% of the study sample members who report taking part in any off-farm work participate in off-farm agricultural work, I expect that marketable human capital and farming human capital will be closely related, resulting in ambiguous impacts of human capital type variables.

The high proportion of agricultural workers there are additional complications in the predictions of other variables as well. First, the local labor market conditions ($\mathbf{C}_m$), which help to determine wage rates, would also be related to the price of purchased agricultural inputs ($\mathbf{P}_n$), as that vector includes hired labor, because tight labor markets, for example, would raise both the off-farm wage and the price that must be paid to acquire hired labor for use on the farm. Agricultural inputs, however includes more than hired labor. An increase in the price of purchased agricultural inputs ($\mathbf{P}_n$), for example higher international fertilizer prices, would impact time allocation in a different way than increases in the wage rate. Any increase in the prices of agricultural inputs will clearly lead to a decrease in the quantity of these inputs (**N**) used on the farm, as indicated in equation (2.18). However, because there is no prediction within the theoretical model as to the impact of this price increase on the quantity of output produced; it is impossible to predict the impact on time allocation. What can be determined, from combining equations (A2.4), (A2.5) and (A2.9), is that relatively more labor will be used on the farm, compared to purchased inputs. If the output of the farm is kept constant, this will result in greater participation in farm labor; however, what happens to market labor is still unclear as this increased farm time could be drawn from time spent at home or in the market or both.

The impact of increases in the prices of agricultural commodities produced on the farm ($\mathbf{P}_a$) is likewise unclear. Higher agricultural prices will lead the household to choose to produce more agricultural goods ($\mathbf{Q}_f$), as indicated in equation (2.22). The model does not tell us the way that the household will choose to do this; however, it does indicate that increases in the price of agricultural goods will increase the marginal revenue product of farm work. This increases the opportunity cost of off-farm work and will lead to a decrease in the probability of off-farm work if market wages remain constant. However, changes in the price of agricultural commodities may have an impact on local wage rates. As noted previously, increases in the market wage rate may in fact be driven by increases in the prices of agricultural goods. However, it should be noted that increases in the prices of agricultural goods do not necessarily equate to an increase in the wage rate. Whether or not wage rates increase in this circumstance depends on whether or not labor markets currently clear. If, as has been postulated by Benjamin (1992), labor markets fail to clear because wages do not adjust downward even when there is considerable involuntary unemployment, then increases in agricultural prices may not lead to increases in wage rates. If, however, market wages fail to remain constant in the face of rising agricultural prices, then while the opportunity cost of off-farm work is rising, so is the opportunity cost of farm work, making the net result on time allocation unclear.

Farm size (L) may or may not have an effect on the probability of participating in off-farm work. This is because while some households in the study area are utilizing their entire farm for agricultural activities, others use only a portion of their land. For households who are utilizing their entire farm, expanding farm size is likely to have a different impact than it would for those who maintain a large share of their land in forest. This is because households who are using a large share of their land are much more likely to expand their agricultural production additional land. Households with small farms, are the more likely to be utilizing most or all of their land, than are those with very large farms. Because of this, the marginal impact of land is likely to differ between these two groups. For small farms, additional land is likely to raise the marginal product of agricultural labor and shift time away from market work to farm work. While the marginal impact of farm size on agricultural production for households with large farms, who have chosen not to use all their land, would be positive if the additional land is in some way superior to some of the land currently in use. However, regardless of the nature of the household's land use choices, on average, one would expect that increasing the land holdings of a household would *ceteris paribus* decrease the likelihood of working off-farm.

Increasing the price of market goods used in home production ($\mathbf{P}_x$), such as purchased foods and cloth used in clothing making, would have the effect of changing the ratio of inputs into home production, with the household using relatively more home time and relatively less market goods in their production function. However as there is no indication of whether this price increase will result in a smaller quantity of home production taking place, or simply a shift in the types of goods being produced towards those that are more labor intensive, there is a no way to predict the effect of this change on the allocation of time.

Finally, increasing the household's non-labor income (Y_n) is likely to increase the demand for home time, decreasing the incentives and time for farm and market work.

This in turn will increase the marginal productivity of farm time (with diminishing marginal returns) and decrease the probability of working off-farm.

5.3.1.2.Creating an Estimatable Model

The second issue which needs to be addressed in the formulation of the empirical model involves determining which variables are available in the dataset that would be best to utilize in the analysis. For some of the theoretical variables, this means determining the appropriate way to measure a variable, for others, such as the human capital variables, it involves determining what is included within that variable, and for still others it entails deciding what, if any, variables to use in place of the ideal theoretical variables which are unavailable.

The theoretical model states that the participation in market work depends on three categories of variables: the prices of goods and inputs, the human capital endowment of the household, and the characteristics of the farm, household and area. The first category includes the prices of agricultural goods, goods used in agricultural production, and home production goods. The third category includes the area of land and other characteristics of the farm that the household owns, the household's characteristics, including its non-labor income and its time endowment, and the characteristics of the area and the labor market. The following sections explain in detail how the estimation model is arrived at, considering the theoretical model and data constraints.

Prices of Agricultural and Consumption Goods

The price of agricultural goods is available in two forms in the dataset. The first is a price per unit sold which would seem to be the most appropriate measurement for the situation. Unfortunately, because the survey respondent provided both the price per unit and the name and size of the unit, the units that goods are measured in are not uniform, so comparing the prices per unit is difficult. A second available measurement, the value of the crop per hectare, also has problems but is more uniform than the first. The benefit of this measure is that it is comparable across observations; however, problems exist, especially with respect to perennials and pasture. For perennials this is because perennial plants always take three to five years to grow before they are ready to be harvested. Because farmers are likely to respond to higher perennial prices by increasing the area of perennials under cultivation, regions with higher prices may have large areas of young, non-producing perennials. This would lead to underestimates of the value per hectare in these regions. With pasture, the issue is twofold; first, grasslands may be identified by the farmer as pasture even if they are not being used for grazing, and secondly, cattle are generally not sold every year. Both of these circumstances would tend to underestimate the value per hectare in pasture.

The problem of underestimating the value of crop and pasture areas may be significant as nearly 14% of households who report having some area in coffee (the most common perennial in the area) report zero income from coffee, and over 53% of those reporting some area in pasture also report zero income from livestock of any kind. Of those with area in pasture but no livestock income, 69% have some type of livestock, whether it be cattle, horses, pigs or other small animals. Most often, these animals are kept for household consumption, which in the case of cattle would be for milk, not beef. This means, however, that nearly 17% of all households with pasture have no livestock at all. These households have an average of 6.2 ha in pasture so that they account for approximately 12% of all pasture in the sample.

In addition to these concerns, value per hectare represents a combination of factors that go well beyond the market price of agricultural goods. Higher values per hectare may be the result of higher agricultural prices, but may also stem from greater land productivity, which could be a result of the natural land quality, more fertilizer, pesticide and herbicide use, and/or the quantity of labor used. As such, data of this form would generate values that are endogenous to the system.

Another option is to use the prices of agricultural goods collected in the community survey. However, these prices are quite uniform with 95% of observations lying within a very small price range. Because of this small level of variation, it is unclear whether or not prices of agricultural goods would provide any explanatory power within the empirical model.

The price of consumption goods, presents the same problems as previously discussed with agricultural prices. There is some price information in the community survey attached to the main household survey; however, prices are fairly uniform among communities and provide little information in the analysis.

Prices of Inputs to Agricultural Production

Prices of inputs to agricultural production are also difficult to deal with as the data on these variables are also not uniform. The dataset does contain information on the use of herbicides, pesticides, and chemical and organic fertilizers, use of hired labor, and use of “modern” farming techniques. Less than a third of all households spend any money on fertilizers or other chemicals, and for households who do use these inputs, prices vary drastically, and are not necessarily comparable across observations as the characterization of the particular product used is fairly general and units vary between observations. One option to deal with this problem is to simply use the aggregate cost of all purchased inputs or cost of inputs per hectare in use. This is usable data; however it is not necessarily accurate as households are unlikely to distribute inputs uniformly across all areas in a particular crop, especially if the parcels are owned by different household members. In addition, this course of action creates a variable that is, by its nature, a choice variable, creating endogeneity problems.

As with agricultural goods, chemical and fertilizer prices from the community survey are problematic because the data are cross sectional and there is not a great deal of natural variation across the survey area. Thus, regardless of the measurement used, the lack of natural variation in these prices will lead to a situation where the analysis is not informative. If everyone in the area faces the same prices, then prices alone cannot explain the differences in their behavior.

A sizable proportion of households (44%) used some type of hired labor in the previous year. Labor, in the NEA can be hired in three forms: day labor, contract labor and permanent workers. Data were collected for these three types of hired labor separately resulting in 202 households who hired only day laborers, 48 who hired only contract workers, 5 who hired only permanent workers, and 23 who hired a combination of two or more types of labor. Information was collected about the nature of the work done by both day laborers and contract workers, but not permanent workers, making permanent workers difficult to compare to the other two groups. Comparing the wage rates of day laborers and contract workers who performed similar tasks, one finds vast differences in the daily wages paid. While *a priori* expectations allow for some difference in these wage rates, with contract workers commanding higher returns to their labor due to the long term nature of their relationship with farmers, the magnitude of these differences is puzzling and leads me to believe that there is a systematic problem with the data,[19] raising questions about the comparability across types for the wage labor data.

Fortunately, there is an alternative that allows for the circumvention of hired labor wages. Because large portions of the off-farm work force work as agricultural day laborers or in other forms of agricultural work, the cost of hired labor can be estimated by using the average daily wage rate received by workers in the surrounding area. This data is exogenous and provides sufficient variation for use in the analysis.

Household Human Capital

Household human capital in the theoretical model is broken up into three categories: marketable, farming and home production. Despite this demarcation, these three categories of human capital are not as different as the theoretical model suggests.

[19] For a full explanation of this inconsistency see Appendix 2

Marketable human capital ($\mathbf{H}_m$) includes individual level characteristics that would be attractive to a potential employer. Ideally these characteristics would include ability, work ethic and other similar factors; however these types of characteristics are nearly impossible to measure in a survey and generally remain unobservable to researchers. To proxy for these, I will use age as a measure of physical ability and education as a measure of mental ability. I expect that age will have an inverted U relationship with off-farm work, and that education will be positively associated with both the choice to work off-farm and the number of hours spent in market work.

Household human capital applicable to farming ($\mathbf{H}_f$) and household human capital applicable to home production ($\mathbf{H}_h$) overlap one another as well as marketable human capital. These vectors include factors which affect the household's productivity on their farm and in home production respectively. These vectors are likely to include things such as ability, willingness to work, and skill level. Specifically addressing farming human capital and its overlap with marketable human capital, because farm work is physical in nature, strength and physical ability play an important role; thus the proxies for physical ability, age, is likely to be an important factor in the on-farm work decision. In addition, the expected relationship is similar to that of market work, an inverted-U. Similarly, household tasks, such as gathering firewood or water also involve strength and thus the age proxy may also be a component of home production human capital. Beyond this obviously overlapping factor, there are a number of characteristics that may affect household human capital. For example women who have had more children may have greater experience raising them and thus have a higher marginal productivity in home production than do those with fewer children.

Household Land Holdings

Land area is a variable available in the data set. The appropriate measure of this variable requires some consideration. The primary question is whether to use the household land holdings in their entirety or to limit the analysis to plots of land which were included in the survey. There are costs and benefits to both choices. If using the entire household land holdings, we get a better estimate of the wealth level of the household, we also can better explain family labor supply as families with additional property outside the survey area will, if they are farming those properties, supply less labor to the market place than would be estimated if only considering surveyed properties. The problem with this approach is that we have very little information on these additional properties. The data on plots owned by the household which are not in the survey are limited to the location, size, tenure status, three main uses and the areas in those uses. Thus when analyzing land use, these areas could be included in only the most basic sense. Because of this, the analysis herein will focus only on the households land holdings that were included in the survey.

Household and Area Characteristics

Household and area characteristics include utility shifters, which simply are non-choice variables that affect the utility level of the household, as well as variables that may affect the off-farm work decision more directly. These shifters would include characteristics such as household size and composition, distance to public transportation, schools, or other public services, and levels of pollution in the surrounding area. More direct variables include the duration of residence, the household's non-labor income and time endowment, and the household's overall wealth level. In particular, duration of residence may affect the off-farm work decision as new residents have a greater need for off-farm employment while establishing their farms.

Farm characteristics such as topography and soil quality affect the marginal productivity of farm labor and in doing so the household's time allocation decisions. While it is hard to create a usable scale for rating topographies, soil quality is easier to deal with. For soil quality there are two variables in the dataset to choose from: the first is the farmer's assessment of the type of soil on his farm and the second is his assessment of the overall soil quality. These can be used individually or in combination to provide information about land productivity. In addition a large number of farms report having swamp or areas that regularly flood. The presence of these areas and/or the physical area involved is another farm characteristic that is helpful in the data analysis.

Area and Labor Market Characteristics

The area and labor market play an important role in the determination of local wages and employment levels. While some of the characteristics of the area and labor market may be hard to measure, certain farm characteristics may be used as proxies for them. For example, important labor market characteristics may include the local demand for labor and the variety of occupations available. These are difficult to measure, but may be proxied for by the proximity of the farm to one of the four major population centers. These population centers provide a greater breadth of occupations for potential workers as well as generating additional employment opportunities. This proximity, however, only provides for the measurement of potential "urban" employment. Because most of the off-farm employment in the NEA is agricultural in nature, this does not allow for the formation of a complete picture of the labor markets. In addition, it is helpful to have a measure of the opportunity for agricultural employment. While this is difficult to measure, another proxy can be found using the percentage of local farms large enough to possibly require hired labor and the portion of farms small enough that they are unlikely to provide a full livelihood for a household. These two measures are used in an attempt to capture the employment opportunities in the surrounding area and the level of competition for those opportunities respectfully.

5.3.2. Estimation Equation

To assess the factors which contribute to the decision to participate in farm work and off-farm work, I estimate an equation where participation in each form of work is a function of individual characteristics and farm and household characteristics, and area characteristics. Individual characteristics include: gender, age, age squared, education, number of own children, and a dummy variable indicating whether or not the individual is the head of household (jefe). Farm and household characteristics include: farm size, area in annuals, perennials, and pasture, household composition, distance from the household to the road, distance along the road to the nearest of the four major population centers in the area, duration of residence, total household assets and a dummy for household electricity availability. Area characteristics are often hard to measure, to account for these; a community fixed effect is included in the analysis.

5.4. Regression Results

The analysis of the estimation equation described above is performed in three stages. First I utilize ordinary least squares analysis to obtain traditional estimates of the marginal impact of the dependent variables on off-farm employment. Second, I account for the fact that the dependent variable is a bivariate participation decision by using probit analysis. Finally, with the understanding that the decisions to work on and off-farm are not made independently of one another, I utilize a bivariate probit analysis that allows for the two equations to be correlated.

Ordinary Least Squares Analysis

I begin by analyzing the impact of various characteristics on the on-farm and off-farm work decisions of adults aged 15 and older. Table 21shows the marginal effects of various characteristics on off-farm work participation using the entire sample aged 15 and older, using OLS analysis. Column (1) shows the results, when using only individual level personal characteristics, while (2) includes household demographic composition and column (3) adds farm and area characteristics. Finally, column (4) includes a local level fixed effect, which accounts for unobservable area characteristics.

The results indicate that age and off-farm participation do produce the inverted-U relationship previously hypothesized. This relationship holds, regardless of the number of control variables included in the analysis. Higher levels of education also increase the probability of engaging in off-farm work, as does head of household status. Finally, the

Table 21 Marginal Effects on Participation in Off-Farm Employment, All Adults, 1999, OLS

	(1)	(2)	(3)	(4)
Age	0.0122***	0.0121***	0.0126***	0.0123***
	(0.0025)	(0.0027)	(0.0027)	(0.0027)
Age Squared	-0.0002***	-0.0002***	-0.0002***	-0.0002***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Years of Education	0.0109***	0.0128***	0.0130***	0.0129***
	(0.0040)	(0.0040)	(0.0040)	(0.0040)
Head of Household	0.1380***	0.1139***	0.1066***	0.1052***
	(0.0312)	(0.0321)	(0.0320)	(0.0323)
Male	0.2602***	0.2644***	0.2739***	0.2823***
	(0.0261)	(0.0271)	(0.0270)	(0.0275)
Number of Own, Co-Resident Children		0.0143	0.0133	0.0142
		(0.0090)	(0.0090)	(0.0091)
Number of Prime Age Males		0.0054	0.0087	0.0112
		(0.0098)	(0.0100)	(0.0099)
Number of Elderly Males		0.0502**	0.0565**	0.0570**
		(0.0252)	(0.0255)	(0.0267)
Number of Prime Age Females		0.0375***	0.0365***	0.0325***
		(0.0115)	(0.0112)	(0.0116)
Number of Elderly Females		-0.0794**	-0.0821**	-0.0922***
		(0.0343)	(0.0344)	(0.0335)
Number of Children Under 15		-0.0079	-0.0090	-0.0094
		(0.0069)	(0.0070)	(0.0072)
Duration of Residence		-0.0047***	-0.0032**	-0.0035**
		(0.0013)	(0.0014)	(0.0014)
Number of Household Assets		-0.0186***	-0.0137***	-0.0137***
		(0.0050)	(0.0052)	(0.0053)
Household Has Electricity		0.0582***	0.0367	0.0436*
		(0.0225)	(0.0234)	(0.0239)
Total Hectares Owned			-0.0003	-0.0004
			(0.0006)	(0.0006)
Hectares in Annuals			-0.0048*	-0.0067**
			(0.0025)	(0.0032)
Hectares in Perennials			-0.0066**	-0.0072**
			(0.0029)	(0.0030)
Hectares in Pasture			-0.0026**	-0.0027**
			(0.0012)	(0.0012)
Distance to Road			-0.0137***	-0.0213***
			(0.0052)	(0.0057)
Distance Along Road to Population Center			-0.0005	-0.0013
			(0.0008)	(0.0011)
Intercept	-0.1552***	-0.0751	-0.0445	0.0777
	(0.0562)	(0.0583)	(0.0627)	(0.0915)
Adjusted R-squared	0.178	0.205	0.217	0.231
Sample Size	2104	2094	2094	2094
Fixed Effect	N	N	N	Y

most significant factor in the off-farm work decision is gender, with men about 27% more likely to work off-farm than women.

The fact that gender is the largest and most significant predictor of off-farm work raises an additional question that must be addressed. Do men and women make off-farm work choices similarly, or do some factors affect women differently from the way they affect men? To address this question, the same type of analysis was repeated separately for men and women. The results of these analyses are displayed in Table 22, for men, and Table 23, for women, and indicate that there are significant differences between men and women in terms of the factors that affect their off-farm work decisions. While age affects both men's and women's off-farm participation decision in a similar manner, the magnitude of this impact varies, with age having almost twice as much impact on men (Table 22) as it does on women (Table 23). This makes sense because men's work is predominantly agricultural and tends to be very physical in nature.

With respect to the variables that measure household composition, the results indicate that men are more likely to work off-farm if they have more of their own children residing with them, while women are unaffected by this variable. This result makes a great deal of sense for men, as men with more young children must work more to sustain their households. While one might expect women's off-farm employment to be negatively impacted by the presence of children, the most common off-farm occupations for women are those that are compatible with childcare responsibilities. Men are also more likely to work off-farm if there are more prime age women residing in the household. This makes sense, because having more women in the household work may allow them to do more work on the farm, thereby freeing up the men to work elsewhere.

Table 22 Marginal Effects on Participation in Off-Farm Employment, Men, 1999, OLS

	(1)	(2)	(3)	(4)
Age	0.0154***	0.0140***	0.0158***	0.0149***
	(0.0046)	(0.0047)	(0.0048)	(0.0048)
Age Squared	-0.0002***	-0.0002***	-0.0002***	-0.0002***
	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Years of Education	0.0028	0.0084	0.0087	0.0092
	(0.0057)	(0.0057)	(0.0058)	(0.0057)
Head of Household	0.1590***	0.0971**	0.0765	0.0828*
	(0.0424)	(0.0494)	(0.0492)	(0.0493)
Number of Own, Co-Resident Children		0.0319**	0.0316**	0.0322**
		(0.0152)	(0.0151)	(0.0150)
Number of Prime Age Males		0.0198	0.0258	0.0308**
		(0.0154)	(0.0162)	(0.0156)
Number of Elderly Males		0.0785	0.0817*	0.0720
		(0.0485)	(0.0493)	(0.0509)
Number of Prime Age Females		0.0460***	0.0423***	0.0343**
		(0.0165)	(0.0164)	(0.0163)
Number of Elderly Females		-0.0407	-0.0463	-0.0509
		(0.0496)	(0.0501)	(0.0486)
Number of Children Under 15		-0.0101	-0.0133	-0.0125
		(0.0105)	(0.0109)	(0.0109)
Duration of Residence		-0.0095***	-0.0072***	-0.0073***
		(0.0019)	(0.0020)	(0.0020)
Number of Household Assets		-0.0291***	-0.0226***	-0.0256***
		(0.0075)	(0.0080)	(0.0079)
Household Has Electricity		0.0527	0.0223	0.0321
		(0.0352)	(0.0376)	(0.0390)
Total Hectares Owned			-0.0006	-0.0004
			(0.0008)	(0.0009)
Hectares in Annuals			-0.0023	-0.0070
			(0.0039)	(0.0050)
Hectares in Perennials			-0.0123***	-0.0142***
			(0.0044)	(0.0045)
Hectares in Pasture			-0.0026	-0.0028
			(0.0018)	(0.0019)
Distance to Road			-0.0165*	-0.0285***
			(0.0088)	(0.0096)
Distance Along Road to Population Center			-0.0003	-0.0017
			(0.0013)	(0.0018)
Intercept	0.1277	0.2813***	0.3206***	0.4426***
	(0.0922)	(0.0961)	(0.1029)	(0.1372)
Adjusted R-squared	0.063	0.118	0.137	0.168
Sample Size	1189	1182	1182	1182
Fixed Effect	N	N	N	Y

This explanation is also consistent with the positive impact that the number of prime age males in the household has on male off-farm employment.

Additional factors that impact men's off-farm work participation include the area in perennials and pasture, the distance to the road and the duration of residence. All of these variables are negatively related to participation in off-farm work. Perennials impact off-farm work negatively because, traditionally, they are lie mainly within the purview of men. Thus additional area in perennials requires additional time on-farm by men and lessens the probability of engaging in off-farm work. The area in pasture has a similar effect, although the magnitude of the coefficient is much smaller. The relative magnitudes of these two coefficients are indicative of the level of work required by each land use. While perennials must be planted, maintained, and harvested, pasture is generally used for cattle grazing and requires a much lower labor input. The distance to the road is a measure of market access. It indicates that men closer to the road have better access to labor markets and consequently are more likely to engage in off-farm employment. The negative coefficient on duration of residence indicates that men are less likely to work off-farm, the longer they have resided on their farm. This result confirms the hypothesis that for many men off-farm employment serves as a stop gap measure during the initial establishment of their farm.

While the distance from the road has a similar impact on men and women, women are not significantly affected by the area in perennials and pasture or the duration of residence. There are also two factors affecting women's participation in off-farm employment that do not affect men similarly: education and number of elderly females. Education has a positive impact on the probability of women working off-farm, with each

Table 23 Marginal Effects on Participation in Off-Farm Employment, Women, 1999, OLS

	(1)	(2)	(3)	(4)
Age	0.0053***	0.0053**	0.0053**	0.0050**
	(0.0020)	(0.0024)	(0.0025)	(0.0025)
Age Squared	-0.0001**	-0.0001**	-0.0001**	-0.0001**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Years of Education	0.0212***	0.0182***	0.0174***	0.0176***
	(0.0051)	(0.0051)	(0.0051)	(0.0051)
Head of Household	0.1228**	0.1150**	0.1036*	0.1014*
	(0.0581)	(0.0571)	(0.0570)	(0.0556)
Number of Own, Co-Resident Children		0.0065	0.0070	0.0077
		(0.0080)	(0.0082)	(0.0085)
Number of Prime Age Males		-0.0067	-0.0073	-0.0093
		(0.0091)	(0.0091)	(0.0101)
Number of Elderly Males		-0.0255	-0.0231	-0.0179
		(0.0221)	(0.0226)	(0.0248)
Number of Prime Age Females		0.0158	0.0165	0.0169
		(0.0119)	(0.0117)	(0.0130)
Number of Elderly Females		-0.0782***	-0.0788***	-0.0758***
		(0.0260)	(0.0267)	(0.0281)
Number of Children Under 15		-0.0078	-0.0085	-0.0090
		(0.0057)	(0.0059)	(0.0064)
Duration of Residence		0.0017	0.0019	0.0017
		(0.0014)	(0.0015)	(0.0015)
Number of Household Assets		-0.0011	0.0003	0.0032
		(0.0049)	(0.0051)	(0.0051)
Household Has Electricity		0.0591***	0.0472**	0.0458**
		(0.0215)	(0.0213)	(0.0221)
Total Hectares Owned			0.0002	-0.0002
			(0.0006)	(0.0007)
Hectares in Annuals			-0.0041	-0.0040
			(0.0027)	(0.0033)
Hectares in Perennials			-0.0001	0.0007
			(0.0025)	(0.0027)
Hectares in Pasture			-0.0016	-0.0015
			(0.0013)	(0.0013)
Distance to Road			-0.0115***	-0.0111**
			(0.0041)	(0.0049)
Distance Along Road to Population Center			-0.0012***	-0.0012
			(0.0006)	(0.0009)
Intercept	-0.1465***	-0.1421***	-0.0945*	0.0400
	(0.0525)	(0.0506)	(0.0521)	(0.1052)
Adjusted R-squared	0.059	0.085	0.097	0.118
Sample Size	915	915	912	912
Fixed Effect	N	N	N	Y

additional year of education making a woman 2% more likely to engage in off-farm employment. This effect of education on women's off-farm employment is likely a result of the differing composition of men's and women's off-farm work activities. While the majority of men engage in agricultural work, women are much more likely to work in shops or restaurants or to operate their own business, which benefit from more education.

The number of elderly females has a large negative impact on women's OFE. Typically, one might expect that the presence of older women in the household may allow younger women a greater opportunity for off-farm work by relieving them of some child care and home making duties, but that does not appear to be the case here. Instead older women are acting as a deterrent to younger women working off-farm, possibly by encouraging younger women to take on more traditional roles within the family. In addition, older women may be at a life stage where they require the care of younger women within the household, which would also inhibit participation in off-farm employment.

Probit Analysis

While OLS regression results provide some advantages, it may not be the most appropriate way to gauge the factors affecting a participation decision. Because the participation decision is a binary variable, probit analysis is better at assessing the impact of the independent variables on the off-farm work participation decision. Probit analysis is based on the idea that there is an underlying latent variable that determines whether or not any individual chooses to participate in an activity. In this case, the participation decision is determined by whether or not the market wage exceeds the individual's reservation wage. The underlying latent variable (y^*) is the desired quantity of work, given the market wage and reservation wage. This quantity may be positive, negative or zero. The desired amount of work, however, is not observed. Instead the researcher observes the choice to participate in off-farm work (y) for those who choose to work. As such, the observed outcome is related to the latent variable as follows:

$$y = \begin{cases} 1 & \text{if } y^* > 0 \\ 0 & \text{if } y^* \le 0 \end{cases}, \tag{5.3}$$

and the probit model estimates the probability of an individual choosing to work off-farm.

The probit results, shown in Table 24, are similar to the OLS results previously discussed, but with some marked differences. While the number of elderly men in the household was found to be significant under OLS, probit analysis indicates that this group is not significant at any conventional confidence level. In addition, the impact of elderly women has fallen off substantially, both in magnitude and significance. With respect to land use, the magnitude of the impacts of area in annuals, perennials, and pasture have all increased, with annuals increasing by approximately 30% and perennials by nearly 40%, indicating that land use has a large impact than indicated by the OLS results.

The full analysis of men and women separately, shown in Table 25, finds similar differences between the OLS and probit results. For men, the magnitude of the impacts of age and age squared both increase substantially, while head of household status loses significance. In addition, the magnitude of the impact of distance from the road increases, as do the impacts of area in both perennials and pasture, with pasture gaining

Table 24 Marginal Effects on Participation in Off-Farm Employment, All Adults, 1999, Probit

	(1)	(2)	(3)	(4)
Age	0.0166***	0.0164***	0.0173***	0.0171***
	(0.0038)	(0.0042)	(0.0041)	(0.0041)
Age Squared	-0.0003***	-0.0002***	-0.0002***	-0.0002***
	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Years of Education	0.0121***	0.0141***	0.0146***	0.0145***
	(0.0041)	(0.0041)	(0.0042)	(0.0042)
Head of Household	0.1371***	0.1139***	0.1039***	0.1059***
	(0.0327)	(0.0369)	(0.0365)	(0.0367)
Male	0.2737***	0.2727***	0.2841***	0.2902***
	(0.0245)	(0.0261)	(0.0261)	(0.0257)
Number of Own, Co-Resident Children		0.0096	0.0087	0.0095
		(0.0104)	(0.0104)	(0.0103)
Number of Prime Age Males		0.0091	0.0134	0.0170
		(0.0109)	(0.0112)	(0.0109)
Number of Elderly Males		0.0287	0.0347	0.0312
		(0.0306)	(0.0310)	(0.0321)
Number of Prime Age Females		0.0352***	0.0328***	0.0295**
		(0.0118)	(0.0117)	(0.0119)
Number of Elderly Females		-0.0590	-0.0610	-0.0641*
		(0.0346)	(0.0345)	(0.0328)
Number of Children Under 15		-0.0074	-0.0093	-0.0092
		(0.0077)	(0.0078)	(0.0080)
Duration of Residence		-0.0044***	-0.0027*	-0.0031*
		(0.0015)	(0.0016)	(0.0016)
Number of Household Assets		-0.0196***	-0.0145**	-0.0148**
		(0.0055)	(0.0058)	(0.0058)
Household Has Electricity		0.0694***	0.0426*	0.0473*
		(0.0253)	(0.0260)	(0.0261)
Total Hectares Owned			-0.0001	-0.0001
			(0.0007)	(0.0007)
Hectares in Annuals			-0.0050	-0.0087*
			(0.0033)	(0.0046)
Hectares in Perennials			-0.0082**	-0.0099***
			(0.0037)	(0.0037)
Hectares in Pasture			-0.0031**	-0.0036**
			(0.0015)	(0.0016)
Distance to Road			-0.0167***	-0.0247***
			(0.0061)	(0.0066)
Distance Along Road to Population Center			-0.0009	-0.0016
			(0.0009)	(0.0011)
Pseudo R-squared	0.181	0.203	0.217	0.234
Sample Size	2104	2094	2094	2094
Fixed Effect	N	N	N	Y

significance at the 10% level. The relative magnitudes of the impacts of these two land uses are indicative of the relative labor required for that particular use.

The fact that women are much less likely to work off-farm than men creates some problems in the full probit analysis. This problem stems from the fact that there are no women working off-farm in 8 of 25 sample sectors. Because of this, the inclusion of sector level fixed effects requires the exclusion of these sectors. Hence, the probit results for women exclude 111 of 912 relevant observations which lie in the affected sectors. To account for these exclusions, Table 25 provides the results of two OLS analyses of women's off-farm participation decision, the first shows the results using the full sample of women aged 15 and up, as shown in Table 23, while the second uses only the sample from sectors where at least one woman worked off-farm. The results indicate that the use of probit analysis affects both the magnitude and significance level of some variables. Prominently, the impact of education, while still positive and significant, falls by more than 50%. Other variables that see substantial impacts on their magnitudes include: age, the number of elderly females, household electricity, the area in annuals, and the distance to the road. Of these, it is notable, that the area in annuals also gains significance, an impact that is expected given that care of annuals in this region often falls to the women of the household.

The time allocation decision, however, extends beyond the choice of whether or not to work off-farm. The choice to engage in either farm work or home production is an equally important part of the time use equation. The survey collected data on whether or not each family member worked on the family farm; however, this data is limited to whether the individual worked "most days," "sometimes," or "hardly ever." For the

Table 25 Marginal Effects on Participation in Off-Farm Employment, 1999, Probit

	Men		Women		
	OLS	**Probit**	**OLS**	**OLS**	**Probit**
Age	0.0149***	0.0247***	0.0050**	0.0055*	0.0068***
	(0.0048)	(0.0069)	(0.0025)	(0.0029)	(0.0027)
Age Squared	-0.0002***	-0.0003***	-0.0001**	-0.0001*	-0.0001***
	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)
Years of Education	0.0092	0.0100	0.0176***	0.0193***	0.0080***
	(0.0057)	(0.0065)	(0.0051)	(0.0055)	(0.0028)
Head of Household	0.0828*	0.0805	0.1014*	0.1017*	0.0901***
	(0.0493)	(0.0553)	(0.0556)	(0.0565)	(0.0500)
Number of Own, Co-Resident	0.0322**	0.0306*	0.0077	0.0077	0.0012
Children	(0.0150)	(0.0170)	(0.0085)	(0.0096)	(0.0068)
Number of Prime Age Males	0.0308**	0.0385**	-0.0093	-0.0097	-0.0055
	(0.0156)	(0.0177)	(0.0101)	(0.0110)	(0.0060)
Number of Elderly Males	0.0720	0.0779	-0.0179	-0.0198	-0.0119
	(0.0509)	(0.0566)	(0.0248)	(0.0278)	(0.0209)
Number of Prime Age Females	0.0343**	0.0404**	0.0169	0.0170	0.0076
	(0.0163)	(0.0182)	(0.0130)	(0.0141)	(0.0070)
Number of Elderly Females	-0.0509	-0.0704	-0.0758***	-0.0870***	-0.0379*
	(0.0486)	(0.0569)	(0.0281)	(0.0317)	(0.0115)
Number of Children Under 15	-0.0125	-0.0148	-0.0090	-0.0092	-0.0032
	(0.0109)	(0.0124)	(0.0064)	(0.0071)	(0.0045)
Duration of Residence	-0.0073***	-0.0083***	0.0017	0.0018	0.0012
	(0.0020)	(0.0025)	(0.0015)	(0.0016)	(0.0010)
Number of Household Assets	-0.0256***	-0.0301***	0.0032	0.0029	0.0023
	(0.0079)	(0.0090)	(0.0051)	(0.0056)	(0.0037)
Household has Electricity	0.0321	0.0350	0.0458**	0.0508**	0.0365**
	(0.0390)	(0.0431)	(0.0221)	(0.0244)	(0.0185)
Total Hectares Owned	-0.0004	-0.0001	-0.0002	-0.0002	0.0000
	(0.0009)	(0.0011)	(0.0007)	(0.0008)	(0.0004)
Hectares in Annuals	-0.0070	-0.0074	-0.0040	-0.0037	-0.0075**
	(0.0050)	(0.0060)	(0.0033)	(0.0034)	(0.0039)
Hectares in Perennials	-0.0142***	-0.0198***	0.0007	0.0007	-0.0003
	(0.0045)	(0.0059)	(0.0027)	(0.0031)	(0.0015)
Hectares in Pasture	-0.0028	-0.0047*	-0.0015	-0.0016	-0.0012
	(0.0019)	(0.0025)	(0.0013)	(0.0014)	(0.0008)
Distance to Road	-0.0285***	-0.0350***	-0.0111**	-0.0128**	-0.0180*
	(0.0096)	(0.0110)	(0.0049)	(0.0056)	(0.0077)
Distance Along Road to	-0.0017	-0.0019	-0.0012	-0.0010	-0.0006
Population Center	(0.0018)	(0.0019)	(0.0009)	(0.0009)	(0.0007)
Intercept	0.4426***		0.0400	0.0211	
	(0.1372)		(0.1052)	(0.1075)	
Pseudo R-squared	0.168	0.144	0.118	0.115	0.216
Sample Size	1182	1182	912	801	801
Fixed Effect	Y	Y	Y	Y	Y

purposes of this analysis, only those who worked “most days” are considered to be participating in farm work.

The theoretical model suggests that the same factors that affect the decision to work off-farm also affect the on-farm work choice. Table 26 shows the results of probit analysis of the factors affecting the decision to work on-farm for the whole sample, as well as men and women separately. Column (1) shows the marginal impacts on participation in farm work for all adults, while (2) displays these same impacts for the sample of men only, and (3) and (4) shows them for the entire sample of adult women, and the sample of women used in the probit analysis of off-farm work, respectively. The results indicate that while some factors affect the on-farm work decision in a manner similar to their impacts on the off-farm work choice, others differ substantially. For the sample of all adults aged 15 and up (column (1)), the results indicate that, while age exhibits the same inverted-U shape, the curve for farm work is deeper than for off-farm work participation. In addition, the impact of head of household status on the probability of farm work participation is over 50% greater than for off-farm work participation, while gender exhibits a substantially smaller (although still large and significant) impact. This is an expected result since farm work tends to be more compatible with home and child care duties that women are usually involved in. This, however, is where the similarities end. The remainder of the factors that affect the on-farm work choice display an effect opposite to the one shown in the off-farm work decision. This means that greater education reduces the probability of on-farm work, as does the number of women in the household. In addition, greater areas in annuals and perennials, and greater distance to the road all increase the probability of engaging in farm work. Some caution should be

Table 26 Marginal Effects on Participation in Farm Work, 1999, Probit

	(1) All Adults	(2) Men	(3) Women	(4) Women
Age	0.0213***	0.0098 **	0.0372 ***	0.0349***
	(0.0038)	(0.0048)	(0.0066)	(0.0071)
Age Squared	-0.0003***	-0.0002 ***	-0.0005 ***	-0.0004***
	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Years of Education	-0.0250***	-0.0287 ***	-0.0178 **	-0.0247***
	(0.0057)	(0.0066)	(0.0076)	(0.0080)
Head of Household	0.2139***	0.2989 ***	0.1521 *	0.1246
	(0.0330)	(0.0474)	(0.0872)	(0.0900)
Male	0.1968***			
	(0.0371)			
Number of Own, Co-Resident Children	-0.0094	-0.0155	-0.0174	-0.0169
	(0.0115)	(0.0146)	(0.0159)	(0.0174)
Number of Prime Age Males	-0.0132	-0.0013	-0.0354 *	-0.0299
	(0.0144)	(0.0157)	(0.0203)	(0.0210)
Number of Elderly Males	-0.0560	-0.0226	-0.0580	-0.0908
	(0.0453)	(0.0558)	(0.0600)	(0.0622)
Number of Prime Age Females	-0.0464**	-0.0335	-0.0481 *	-0.0582**
	(0.0187)	(0.0213)	(0.0277)	(0.0290)
Number of Elderly Females	-0.0220	-0.0019	-0.0443	-0.0870
	(0.0494)	(0.0537)	(0.0825)	(0.0839)
Number of Children Under 15	0.0147	0.0153	0.0154	0.0202
	(0.0095)	(0.0110)	(0.0134)	(0.0141)
Duration of Residence	-0.0002	0.0002	-0.0015	-0.0023
	(0.0023)	(0.0027)	(0.0028)	(0.0029)
Number of Household Assets	-0.0094	-0.0023	-0.0166	-0.0196*
	(0.0071)	(0.0076)	(0.0104)	(0.0111)
Household Has Electricity	-0.0563	-0.1034 **	0.0020	0.0384
	(0.0383)	(0.0409)	(0.0511)	(0.0541)
Total Hectares Owned	0.0011	0.0018	0.0002	0.0007
	(0.0011)	(0.0013)	(0.0014)	(0.0016)
Hectares in Annuals	0.0134**	0.0069	0.0173 **	0.0159**
	(0.0066)	(0.0090)	(0.0074)	(0.0065)
Hectares in Perennials	0.0137***	0.0102 *	0.0175 ***	0.0139**
	(0.0053)	(0.0056)	(0.0068)	(0.0071)
Hectares in Pasture	-0.0006	0.0008	-0.0018	-0.0020
	(0.0021)	(0.0024)	(0.0027)	(0.0028)
Distance to Road	0.0304**	0.0351 **	0.0266 *	0.0342**
	(0.0126)	(0.0147)	(0.0141)	(0.0156)
Distance Along Road to Population Center	-0.0007	0.0003	-0.0024	-0.0036
	(0.0020)	(0.0021)	(0.0026)	(0.0028)
Pseudo R-squared	0.168	0.175	0.136	0.137
Sample Size	2094	1182	912	801
Fixed Effect	Y	Y	Y	Y

used with respect to the interpretation of the impact of annuals, since the area in annuals is chosen every year and is endogenous to the system. Despite this, all these impacts make a great deal of sense, as households who have greater areas in these crops need more labor to tend them, making household members more likely to work on-farm, while farms at greater distances from the road have less access to alternative employment markets, making their members more likely to work on-farm.

It is also important to note that the decision of whether or not to work off-farm is not made separately from the farm work decision. Thus to understand the full impact of these factors on the time allocation decision, the two choices should be analyzed together. To do this, I utilize a bivariate probit model where the two outcomes are participation in off-farm work and participation in farm work. With a bivariate probit model, there are a number of marginal impacts that can be calculated. Table 27 shows the marginal impacts of the independent variables on the two dependent variables in a number of ways. Column (1) shows the unconditional marginal effects on the probability that an individual will choose to work off-farm, while column (2) shows the same for the probability of on-farm work.

The results indicate that, as expected, these two time use decisions are related to one another. The similarity of the overall impact of age on participation in the two forms of work indicates that the physical strength necessary for both types of employment may be similar. Education positively impacts the probability of working off-farm while reducing the probability of engaging in farm work, with each additional year of education resulting in a 1.3% greater probability of working off-farm and a 2.5% reduction in the probability of “full time” on-farm work. This indicates that the returns to education are

Table 27 Marginal Effects on Participation in Farm and Non-Farm Work, 1999, All Adults, Bivariate Probit

	Off-Farm (1)	On-Farm (2)
Age	0.0164***	0.0216***
	(0.0041)	(0.0038)
Age Squared	-0.0002***	-0.0003***
	(0.0001)	(0.0001)
Years of Education	0.0136***	-0.0248***
	(0.0043)	(0.0058)
Head of Household	0.1080***	0.2168***
	(0.0366)	(0.0328)
Male	0.2912***	0.1967***
	(0.0255)	(0.0369)
Number of Own, Co-Resident Children	0.0104	-0.0105
	(0.0102)	(0.0115)
Number of Prime Age Males	0.0183*	-0.0137
	(0.0108)	(0.0143)
Number of Elderly Males	0.0347	-0.0555
	(0.0322)	(0.0447)
Number of Prime Age Females	0.0289**	-0.0459**
	(0.0120)	(0.0187)
Number of Elderly Females	-0.0615*	-0.0234
	(0.0335)	(0.0490)
Number of Children Under 15	-0.0094	0.0151
	(0.0080)	(0.0094)
Duration of Residence	-0.0031**	-0.0002
	(0.0016)	(0.0023)
Number of Household Assets	-0.0149***	-0.0096
	(0.0058)	(0.0071)
Household Has Electricity	0.0463*	-0.0549
	(0.0265)	(0.0383)
Total Hectares Owned	-0.0001	0.0011
	(0.0007)	(0.0011)
Hectares in Annuals	-0.0085*	0.0134**
	(0.0045)	(0.0064)
Hectares in Perennials	-0.0099***	0.0141***
	(0.0037)	(0.0053)
Hectares in Pasture	-0.0035**	-0.0005
	(0.0016)	(0.0022)
Distance to Road	-0.0244***	0.0304**
	(0.0066)	(0.0125)
Distance Along Road to Population Center	-0.0015	-0.0007
	(0.0011)	(0.0020)
Rho	-0.2860	
	(0.0502)	
Sample Size, N = 2094		

likely higher off-farm. Further analysis shows that while higher education decreases farm work for both genders, the impact of education on off-farm work is limited to women[20]. Because education reduces men's participation in farm work without increasing their participation in off-farm employment, this implies that more highly educated men are spending greater time at home. This is a result that is unexpected based on my theoretical model because higher education is expected to raise an individual's market wage, making him more likely to work off-farm. In addition, his education may help with farm operations, increasing the marginal productivity of his labor. Both these effects would, in the theoretical model previously presented, result in increased levels of market and farm work for more educated individuals. And while it is possible that education also increases the productivity of men's household production, social and cultural norms in this area discourage men from engaging in many types of household production. Another and perhaps more likely, possibility is that higher education confers with it a higher social status, including more household assets and more land holdings. In this case, education may reduce the time spent in work through wealth effects, or by increasing the wage necessary to induce the more educated man to choose to work on or off-farm.

Before analyzing the unusual impact of education on men's work activities further, it is important to note that age and education are negatively correlated at the 1% confidence level. This means that younger people, as described in section 4.8.2, have higher levels of education than their older counterparts. Because of this, one explanation of this result may be that younger people are less likely to work on-farm than older ones. This is confirmed by the analysis of the impact of age, which shows a sharp rise in the

[20] See Table 38 and Table 39 in Appendix 4: Bivariate probit results.

probability of engaging in farm work as age increases. And, since the analysis is performed for those aged 15 and up, the results may be picking up the fact that some younger men are still in school, and hence less likely to work on-farm. However, restricting the analysis to those 18 and older, or even 21 and older does not significantly change the impact of education on farm and market work.

The next step is to determine whether more educated individuals within the same household work on-farm less, or whether the results are indicating a difference in behavior between households based on educational achievement. In order to determine if this is a within-household or between-household difference, I incorporate a household level fixed effect into the analysis. This fixed effect takes into account any observed or unobserved household level characteristics, thus any household level characteristics are eliminated from the analysis. The results, shown in Table 37, provide analysis for the intrahousehold impact of individual characteristics on the decision to engage in both types of work. The results show that the impact of education on participation in farm work remains negative, relatively large and highly significant. This indicates that higher levels of education do in fact reduce the rate of participation in farm work, even within the same household.

The idea that those with more human capital would engage in less work is in diametric opposition to most economic theories. However, the theoretical model postulates that the reservation wage depends directly on the level of human capital an individual possesses. For households with low agricultural productivity, men with high human capital may not see farm work as being “worth their time” and may choose not to participate, even in the absence of available market work. The time gained from this choice may be spent in leisure activities, home production or searching for market work.

Household composition has some affect on both farm and off-farm work decisions. The numbers in each age-sex group indicated are calculated for the entire household, excluding the individual being analyzed. The results show that, as with the previous analysis, the number of other prime age females in the household increases the probability of working off-farm while decreasing the probability of adults engaging in farm work. In addition, the number of prime age men in the household is a significant factor in determining whether or not any individual member engages in off-farm work. This result is the main difference between the bivariate probit results and the previous univariate results. These results were expected because greater numbers of men and women in this age range represents a higher endowment of labor for the household. Assuming that there are diminishing marginal returns to farm labor, while the market wage is constant, then households with greater labor endowments are more likely to reach the point where the returns to market work exceed the marginal value of additional on-farm labor, reducing the probability of on-farm work while increasing the probability of market work. The only question here lies in the fact that the impact of women seems to exceed that of men in both magnitude and significance. An explanation for this phenomenon may lie in the difference between men's and women's preferences. (Gronau, 2006) in a study of time use in Russia finds that, when time spent in market work falls, women divide their extra time almost equally between leisure and home production while men shift most of their time to leisure. While Gronau was studying a substantially different phenomenon, his result sheds some light on this particular result.

His results indicate that faced with free time, women are more likely to spend that time in the work activities available to them, which is likely to generate a greater impact on the choices of other household members.

Elderly females in the household decrease the probability of any individual engaging in off-farm work. Further analysis indicates that this impact is restricted to women. In fact, the presence of an elderly woman in the household is the single largest factor in the off-farm participation choice of women. How elderly women affect the work choices of other female household members in unclear, but it is possible that older women have old fashioned or more traditional values on the roles of women in the household. These values may impact the employment choices of younger women.

The duration the household has been in residence is an attempt to measure how long the farm has been in use and how much experience the household has with farming in the area. For farms which have belonged to a single owner, this variable does an excellent job of capturing the first of these. However, because many households in the area acquired their farms from other settlers, this variable is a very imperfect measure of the duration of farm use. This factor is important because farms that are new do not provide much in the way of income for their residents. Because of this, it is likely that households on new farms may have to engage in off-farm work in order to meet their basic needs. The results show that newer households do in fact engage in more off-farm employment, signaling that for some market work may be a stop gap measure while they work to establish their farms. In addition, newer households may have other characteristics that contribute to greater off-farm work. For example, households who have been on their farm for less time may have younger heads and other household members who may be more interested in market work than older households. In addition, newer arrivals generally have less land than those who have been in the NEA longer, a factor that would certainly encourage off-farm participation. Finally, the 1990's brought with them dramatic declines in the prices of many agricultural commodities, most importantly coffee. Thus households who arrived later in the NEA may have come at a time when prices of agricultural goods were extremely low. This would further promote the decision to participate in market work. Further analysis reveals that this impact is limited to men, indicating that men and women may be working off-farm for different reasons.

The number of assets the household owns is a measure of overall wealth. The results show that wealth negatively impacts the probability of individual household members engaging in off-farm work. While the impact is also negative for farm work, the coefficient is not significant. Thus, members of wealthier households are less likely to engage in off-farm work. Looking at the results by gender, the picture becomes quite different. In fact, while men are less likely to engage in off-farm work, the more assets there are in the household, women's off-farm work is positively, although insignificantly associate with total assets. When considering farm work participation, women's participation negatively and significantly associated with higher assets, while men's is not significantly affected. Thus households with more assets are less likely to have men working off-farm and also less likely to have women working on-farm. The impact of assets on male work patterns may be attributable to wealth effects, which raise the reservation wage. The result for women may be attributed to some of the cultural norms of the area. In fact, it is a symbol of affluence for a man to be able to allow his spouse the luxury of not working on-farm[21].

The presence of electricity in the household increases the probability of engaging in off-farm work, while leaving the probability of farm work unaffected. Further analysis shows that electricity affects only the off-farm work participation of women. There are several possible explanations for why women in households with electricity engage in off-farm employment more often. First, electricity may increase the productivity of labor in home production (e.g. cooking), second, electricity may free up time that might normally be spent in collecting fuel wood, and finally the nature of the off-farm occupation choices of men and women may make electricity more important for women's decisions than for men's.

These three possibilities, of course, are not mutually exclusive, but should be addressed individually before looking at them in combination. Increasing the productivity of home production *ceteris paribus*, in the context of the theoretical model presented in section 2.10, leads to increases in the quantity of time spent in home production because higher marginal productivity in this venue would increase the reservation wage for affected households, which is contrary to the empirical results. In addition, it is not immediately clear from the data why only women would respond to the gain in time from the elimination of fuelwood collection, which is generally a shared family responsibility. However, the fact that most cooking and cleaning responsibilities fall to women, means that if there are efficiency gains in home production, aside from the elimination of the need to collect fuelwood, then we might expect women to be more responsive to electrification.

[21] From conversations with Richard Bilsborrow

Dinkelman (2008) cites a combination of increases in the productivity of home production and time freed from wood collection in her analysis of the impact of electrification on labor supply in South Africa. She finds that electricity served as "a labor-saving technology shock to home production in rural areas, which led to a corresponding increase in female labor supply." Essentially, electrification freed women of the burden of firewood collection and increased the level of productivity in home production by increasing production efficiency and allowing home production to be shifted from daytime to nighttime (Dinkelman, 2008). Despite this finding, there exist significant differences between my study area and rural South Africa that need to be considered. Specifically addressing the issue of fuel collection, the data indicate that wood collection in the NEA is significantly less time consuming than in Dinkelman's study area, requiring an average of approximately 3 hours per week, rather than the 16 necessary in South Africa. In addition, while wood collecting in South Africa is a chore of women alone, in the NEA it is generally a shared family responsibility. The combination of these two differences should significantly reduce the impact of the time gained from the elimination of fuelwood collection. In addition, any impact would be expected to be spread throughout the household instead of resting solely with women. A possible explanation in this situation may lie in differences in the preferences of men and women. If women have a higher elasticity of substitution between market work and home work, then this result may possibly stem from this explanation[22].

Whether or not elimination of fuelwood collection combined with increases in home production productivity would yield an increase in female off-farm employment in

[22] (Gronau, 2006) in a study of time use in Russia finds that, when time spent in market work falls, women divide their extra time almost equally between leisure and home production while men shift most of their time to leisure.

the theoretical model depends on the nature of the household's utility maximization problem. As previously noted, if the household's only goal is to consume as many uniform home produced goods as possible, then this increase in the marginal productivity of home production time would likely lead to less time spent in off-farm work, as higher productivity in this non-market activity should lead to an increase in the reservation wage. However, if one considers a situation where the household might choose to consume more than one type of home produced good, the implication of higher home marginal productivity may change substantially. Consider a household, as described in Dinkelman (2008), that consumes two home produced goods, meals and clothing, where meal production is labor intensive and clothing production is market goods intensive. If the household has preferences such that the income elasticity of demand for clothing is greater than that of meals, because meals are more labor intensive than the production of clothing, electricity increases the marginal product of labor for meals more than for clothing. This indicates that the household should shift more labor into the creation of meals and out of clothing since meal production is now relatively more productive. But beyond this, electricity is a labor saving technology and its presence effectively increases the time endowment of the household by reducing the time needed for meal preparation and freeing more women's time. This being the case, the household will demand more of both meals and clothing in response to this increased endowment. In addition, because the demand for clothing is more income-elastic than the demand for meals, household demand for clothing rises faster that its demand for meals. Furthermore, because clothing is market goods intensive, the household will want to dedicate more of their time to market or farm work in order to gain the market goods necessary for clothing production.

The result of this analysis is ambiguous with respect to the overall time spent in market work, but if the endowment effect outweighs the substitution effect the theoretical model might predict the empirical result seen here.

The final possible explanation lies in the differences between the off-farm occupations chosen by men and women. While men primarily engage in agricultural employment, one of the most common occupations for women is the running of a small business. In addition, the most common type of business in this area is the operation of a *tienda*, or small store on the road. This particular type of business is likely to be much more profitable and/or easier to run in the presence of electricity, as much of the sales consist of snacks and drinks, which would need to be kept cold.

The areas in annuals and perennials affect both types of work decision, reducing the probability of off-farm work and increasing the likelihood of working on-farm. This is likely due to the fact that these two crops require a significant quantity of labor for planting, maintenance and harvest. Because of this, increases in the area in these two uses may pull labor away from the market place and onto the family farm.

It should be noted that, while the area in pasture has a negative and significant impact on the probability of participation in off-farm work, it has no impact on the probability of engaging in farm work. This is an indication that pasture affects the off-farm work decision through different means than annuals and perennials. Because pasture tends to require little labor, it will not cause the same type of movement between market and farm work as previously noted for the other crops. Where then does the small decrease in off-farm participation associated with pasture originate? There are two possible reasons for this impact. First, pasture is generally used for grazing of cattle, and cattle themselves are an indicator of higher wealth and higher on-farm income. Because of this, area in pasture may be capturing the impact of wealth and farm income on off-farm work participation, which are expected to be negative. Second, because pasture is used for cattle, it is generally only useful in fairly large quantities. Thus only those with larger farms tend to have areas in pasture. In this case, pasture may proxy for land wealth, rather than any immediate income. In this case, however, it would still be expected that higher wealth levels would result in less participation in off-farm employment.

The final significant factor is the distance from the farm to the road. As expected, members of households further from the road are less likely to engage in off-farm work and more likely to engage in farm work. As the distance from the road is a measure of market access, this indicates that households with less market access also engage in less market work. Farm work is not as readily affected by market access as non-farm work because, agricultural commodities only need to be transported over this distance at well spaced intervals, while those engaging in market work would need to travel this distance for every day worked. Women are more severely impacted by distance to the road as they are much less likely to engage in agricultural day labor, an occupation that generally occurs on surrounding farms and is therefore less impacted by distance to the road.

5.5. Summary

The results herein provide important information for policymakers wishing to address the issues of poverty in rural areas such as the NEA. Because households who engage in off-farm employment have significantly higher incomes than those who do not, policymakers should be interested in policies that promote off-farm employment. In this case, several factors may be of interest in the promotion of off-farm employment.

The factors that impact the choice to work off-farm differ somewhat between the genders with both men and women seeing significant effects from age and the distance from the farm to the road. Of these, distance to the road may be of interest to policy makers as households closer to the road have an increased probability of participation in off-farm work by both men and women. This means that further road construction in this area, by increasing households' access to local labor markets may be a means of encouraging off-farm employment of both genders.

Beyond these similarities, there is little scope for the promotion of off-farm employment by men as none of the other factors affecting men's off-farm work participation decision are relevant for use by policymakers: number of co-resident children, duration of residence, household wealth, and area in perennials and pasture, none of which are easily impacted by policymakers.

There are more policy options available for the promotion of work by women. Women's off-farm employment participation is also impacted significantly by education, head of household status, access to electricity, and the area in annuals. Besides road access, there are two of these important factors stand out for consideration. One is educational level, and the other is access to electricity. My results suggest that higher rates of education and greater electricity access would both improve market participation rates of women significantly, which may be a means to facilitate increases in total household welfare. This could be done through the use of policies that encourage women to stay in school and through expansion of access to electrical service, both of which are actions in the purview of policymakers.

6. THE IMPACT OF OFF-FARM WORK ON THE DEFORESTATION AND LAND USE DECISIONS OF COLONIST SETTLER HOUSEHOLDS IN THE ECUADORIAN AMAZON

The Amazon has been an area of focus for scientists for many years. The diverse array of plant and animal species found in the area provide the basis for research ranging from ecology and botany to infectious diseases and pharmaceuticals. However, a lion's share of the attention garnered by this area has been due to a single phenomenon: the rapid rate at which the Amazon Rainforests and their integral biodiversity are being lost.

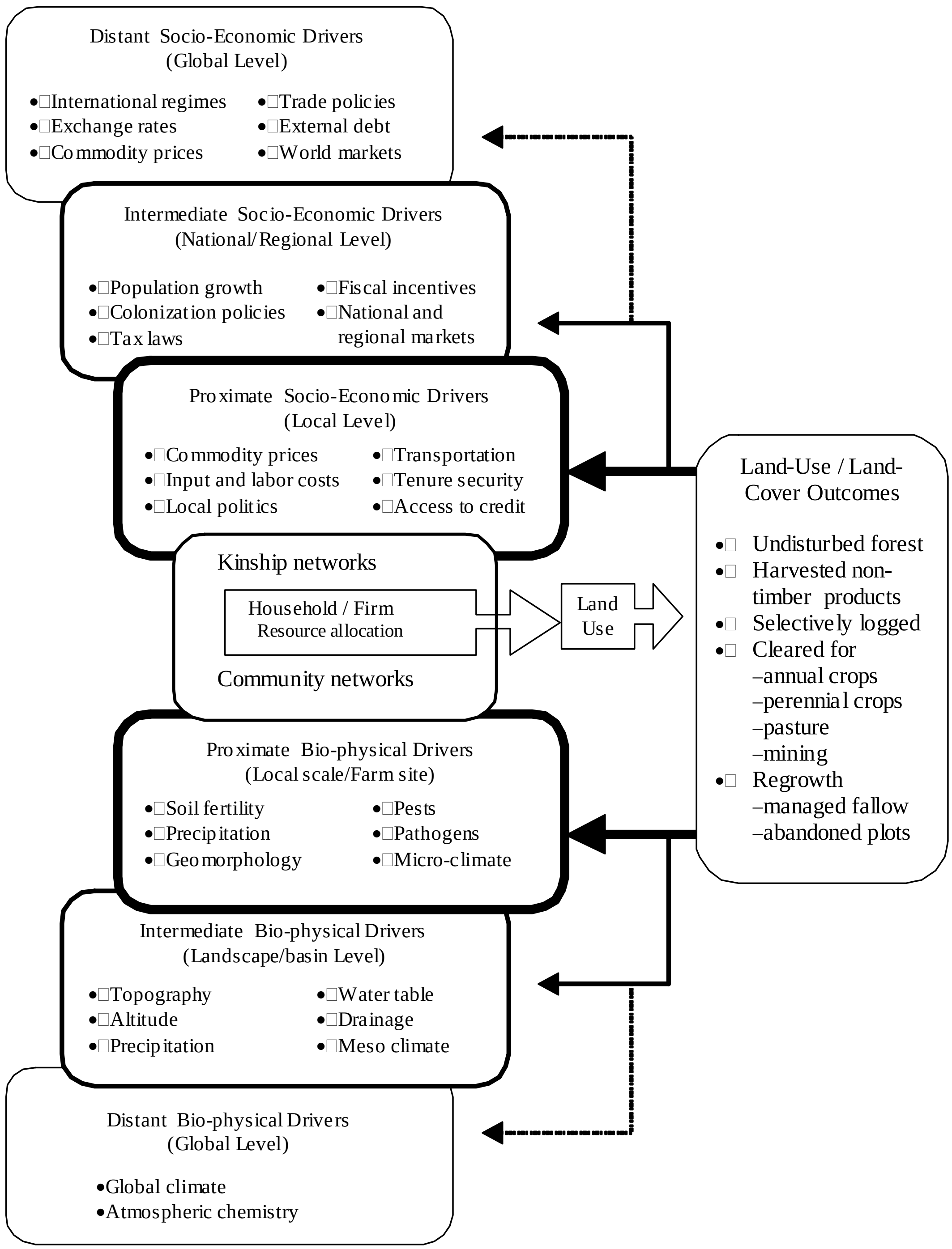
As concern for Amazonian deforestation has mounted, there has been increasing study of factors which may contribute to or slow the pace of deforestation. There are many causes for the continuing loss of forests and other forms of natural habitat, including agriculture, housing, logging, and mining and petroleum extraction. These, causes however, represent only the proximate causes of deforestation. To understand the complete picture it is necessary to consider not only these direct causes but also underlying factors which contribute to the proliferation of activities which cause or encourage deforestation. Angelsen and Kaimowitz (1999) assert that there are four types of variables used to model deforestation: the agents of deforestation, the choice variables, the agent's decision parameters, and the macroeconomic variables and policy instruments. Together, these components form the basis of a household model of deforestation.

Figure 11 shows the different levels at which actions can affect deforestation. On a regional or national level, evidence of a direct impact of macroeconomic variables on deforestation is slim. For example, researchers have found that lower population density is associated with less deforestation. However, empirical results are weak because population density is likely to be endogenous and dependent on a number of other macroeconomic variables.

Researchers focus on the intermediate and proximate factors on deforestation as there is more measurable evidence of their impacts. In developing areas of the world, agriculture is by far the largest proximate cause of lost habitat (World Bank, 1991; Geist & Lambin, 2002). As such, factors that impact the agricultural production decisions of farm families are of paramount importance, as they offer the best hope of stemming the tide of rapid deforestation.

There are numerous suggestions for possible ways to induce reductions in agricultural expansion. Many of these involve providing agricultural households with some incentive to voluntarily reduce their deforestation activities. In this context, there are generally two disparate schools of thought, increasing the marginal revenue product of land, or increasing the opportunity cost of agriculture.

The goal of the first of these two is to increase the income from any given area of land, thus reducing the farm area required to provide for the household's basic needs. There are two possible means of increasing the income yield of land: raising the productivity of the land directly, or increasing the price of the crop. The provision of



Source: **Wood and Porro (2002)**

Figure 11 Variables Affecting Deforestation

agricultural assistance, which is a current policy of a number of development organizations and governments, is thought to help raise the productivity of land, thereby reducing the area needed to produce the same quantity of crops.

The basis for the idea of increasing the marginal revenue product of land as a means of reducing deforestation originated from the Chayanovian model (Chayanov, 1926. The basic premise of this model is that agricultural households are operating in a subsistence based economy, where the household's goal is to achieve some minimum level of consumption. After reaching this threshold, the theory posits that the household will choose additional leisure over additional income or consumption (Angelsen and Kaimowitz, 1999). However, many economists assert that this type of policy may in fact be counterproductive, that by increasing the productivity of the land, the marginal value of converting forest into farmland is actually increased (Pichón, 1997a; Bilsborrow & Hogan, 1999). Because of this, if households do not operate at a pure subsistence level, this type of policy may result in increased levels of deforestation rather than less.

An opposing point of view seeks to reduce farm expansion by increasing the opportunity cost of farm production. The underlying assumption for those advocating this type of policy is that increasing the relative cost of farming will induce a shift in agricultural households towards other economic activities, resulting in less farming and therefore decreasing deforestation. Examples include actions that directly raise the cost of agricultural production, such as increasing the cost of fertilizers, and those that raise the opportunity cost of participation in agriculture by providing better "outside" options to the household such as off-farm employment.

Researchers have looked at the impacts of these types of variables on deforestation and found several which seem to have tangible impacts. Proximate factors which have been shown to have significant effects on deforestation include agricultural output prices, accessibility of roads, and off-farm wages and employment (Angelsen & Kaimowitz, 1999). All three of these variables have the potential to impact both deforestation and household income. Increases in any of these three variables would likely have a positive impact on household income by granting households higher prices for their agricultural output, better access to markets, or better outside work opportunities. Of these three variables, off-farm wages and employment has generated the most research interest. This is because it is generally seen as an opportunity to “kill two birds with one stone” by addressing both poverty and deforestation problems. However agricultural output prices and accessibility to roads have been found to be positively related to deforestation, while off-farm wages and employment have generally been found to be negatively related to deforestation.

Because areas with higher agricultural prices and better road access generally also experience higher rates of deforestation, attempts to use these two variables as a means to reduce deforestation would likely result in lower household incomes, an outcome that is in diametric opposition to the goals of development organizations. Unlike these other variables, off-farm wages and employment are hypothesized to impact household income and deforestation in a manner that would be compatible with both environmental and development goals. Angelsen and Kaimowitz assert that higher wages and employment levels work to decrease the rate of deforestation, citing several papers with support this assertion. However, the econometric techniques employed in these papers may lead to biased results, and further investigation is necessary before advocating policies which might lead to higher wages and/or employment levels.

6.1. Hypotheses on the Relationship between Off-Farm Work and Land Use

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 us 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 deforestation.

6.2. 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.

This research is not designed to evaluate the impact of off-farm employment on the overall level of deforestation. 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 assuming 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 household level. If, however, we cannot assume that market work would never involve deforestation, then the situation is somewhat changed. Now, if off-farm work 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. 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.

6.3. Work Activities and Land Use

A major question in assessing the impact of off-farm employment on farm land use is whether or not there should in fact be any impact whatsoever. To assess this it is necessary to address the issue of agricultural household separability. When separability exists, “supply side variables should not influence labor demand and vice versa (Benjamin, 1992). Separability implies that household characteristics, such as number of household members, and decisions, such as consumption and time use, should have no impact on land use, a farm decision.

Separability itself is an important implication of efficient and complete markets (Benjamin, 1992) and allows for the assumption that household level production and consumption decisions occur independently of one another. However, the existence of separability is not a foregone conclusion, despite its implicit assumption in the frequent use of neoclassical labor supply models. There are many characteristics, of both the household and area, that are necessary for separability to exist, including the presence of efficient labor and agricultural goods markets, and no preference for own vs. hired labor in farm work. If markets are incomplete, as evidenced by the presence of high unemployment or the inability of a potential employer to hire labor, or if households prefer work on their farm to work elsewhere or prefer family labor over hired labor, then separability may not exist. Benjamin (1992) illustrates the idea of separability with the example of Baron Rothschild. His assertion is that "the number of workers in Baron Rothschild's vineyard should not depend on the number of daughters he has" as the Baron is running a profit maximizing business in an environment where he is able to hire as much outside labor as he desires. However, market imperfections such as those described above would interfere with this assumption. So, while the baron would not decide how much land or labor to use in his vineyard based on the number of daughters he has, farm households in areas such as the NEA may make many of their decisions based on household characteristics.

How then is the issue of separability relevant to the current discussion of the impact of off-farm employment? To answer this question, imagine a farm household that exists in a world of perfect labor and goods markets. In this case, the household chooses the quantity of labor for the farm in order to maximize total farm profit. To this end, they also choose the quantity of land used such that farm profits are maximized. In this case, the decision for one or more family members to engage in off-farm employment should have no impact on the quantity of land in use on the farm, and hence no impact on the household's overall level of deforestation. However, if market imperfections exist, as postulated by Chayanov (1926), then households may not be able to hire the quantity of labor necessary to maximize farm profit. In addition, they may not be able to find the quantity of off-farm employment they desire. At the opposite extreme lies an area with no labor market at all. In this case, the household's level of farm production would be limited by the quantity of labor it can supply itself.

Most markets, including the Northern Ecuadorian Amazon, lie somewhere between these two extremes of the perfect and the non-existent labor markets. Whether or not off-farm employment decisions affect land use depends on where on this continuum the particular market under consideration lies. The finding that off-farm employment has an effect on household level land use would therefore imply that there exist market imperfections significant enough that households and their farms are non-separable. For the sake of generality, the assumption used in the analysis to follow is that the household and farm are indeed non-separable.

6.4. Derivation of the Empirical Model

The theoretical model, shown in section 2.10, generates the following supply and demand equations:

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

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

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

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

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 recognizes 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 (**X**), farm inputs (**N**), and the allocation of household member's time to farm, off-farm and household time uses ($\mathbf{T}_f$, $\mathbf{T}_m$ and $\mathbf{T}_h$). In the second stage, the household makes decisions about farm land use which are based on the realized incomes generated from the farm in the previous period and current OFE, and non-labor income, as well as the time household members currently have 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 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:

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

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 not ($W_j^R \geq W$), then the probability of any individual participating in off farm work is determined by:

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

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 (2.11) in the theoretical model. 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 that 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:

$$l_{ij} = \alpha_0 + \alpha_1 w_{ij} + \alpha_2 X_{ij} + \alpha_3 X_j + \varepsilon_{ij} \tag{18}$$

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

$$l_{ij} = \begin{cases} l_{ij}^* & \text{if } l_{ij}^* > 0 \\ 0 & \text{if } l_{ij}^* \le 0 \end{cases} \tag{19}$$

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 $\varepsilon_{ij} \sim N(0,\sigma^2)$, 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 $E[\varepsilon_i \mid X_i, X_j, w_{ij}] = 0$.

Despite the fact that OLS is less sensitive to violations of distributional assumptions, if there are unobservable characteristics of the community, household, or farm that influence both the household's land clearing and land use choices and the decision to participate in off-farm work, estimation of equation (18) using Ordinary Least Squares will be biased. For example, if within the study area, there exist differences in soil quality or terrain that affect the productivity of the land, then these clearly would influence household land use decisions as more productive land is more likely to be deforested and put into use. In addition, because areas with better soil quality are likely to be settled first, these same areas may have greater infrastructure, allowing for easier access to employment opportunities.

Household level unobserved characteristics can also be important. If "motivated" households choose to both clear more land and work off-farm more, then the effect of OFE on forest retention will be underestimated. However, it is also possible that unobserved preferences play an important role. If some households have a greater preference for farm work than others, then these households may choose to clear and use more land, while simultaneously choosing to work off-farm less. In this case, the impact of off-farm work on forest retention would be overestimated.

These possible endogeneity problems can be addressed through the use of various econometric techniques, including fixed effects or instrumental variables. The first of these techniques, fixed effects, estimates the following equation:

$$l_{ij} = \alpha_0 + \alpha_1 w_{ij} + \alpha_2 X_{ij} + \alpha_3 X_j + \mu_j + \varepsilon_{ij}\,, \qquad ()$$

where the unobserved characteristics of a household or community are controlled for through the use of a dummy variable μ_j for each community j. The inclusion of this community fixed effect allows for the analysis of the effect of differing household characteristics within a specific community or geographical area.

Because the analysis is done at the household level, fixed effects analysis will not control for unobserved household characteristics. To do this, the second estimation method, two stage instrumental variables (IV), is used. This technique 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 variable, or 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:

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

where there is some instrument, Z_j, such as a community characteristic, which affects the area job market but does not affect the household land use decision. The second stage determines the impact of off-farm work and other factors on land use as:

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

where $\hat{w}_{ij}$ is the predicted quantity of off-farm work from the first stage regression.

The selection of instruments, Z_j, can be tricky, as it is necessary to find variables that are associated with the choice of the quantity of off-farm work, while simultaneously being unrelated to the area of land in any particular use. To attempt to instrument for the household's number of days of off-farm employment, two community level variables were chosen: the local average wage rate and the average number of days of off-farm work per prime age adult in the immediate community. Both these were calculated at the parroquia level, excluding any wages or work done by the individual household. Because the household's own work days and wages were excluded from the calculations, these variables are exogenous; however, both are expected to impact the household's work choice, while having an impact on land use only through their impact on labor allocation choices. Higher average wages earned by others in the area should be seen as an incentive for household members to seek market employment. Areas with more days of off-farm work per capita may have greater employment possibilities, which would increase the probability of household members engaging in off-farm work; but they may also have greater competition for available jobs, which would have the opposite impact. The net impact of this variable is unclear, and depends on which of these two effects is dominant. Regardless of this qualification, the local level of off-farm employment should have an impact on the household's employment choices, but not have any direct impact on its land use choices. The local wages would only have an impact on land use choices for households for whom a significant share of on-farm labor is hired. Since most households hire very little or no farm labor[23], it is unlikely that the local wage will impact land use choices, other than through the labor allocation choice.

[23] Less than half of households hire any farm labor. Of those who do hire some labor, nearly 40% hired

Table 28 Average Wage and Average Off-Farm Days by Parroquia

Canton	Parroquia	Average Wage	Std. Dev.	Average Off-Farm Days	Std. Dev.
1					
	0	4.65	0.15	49.98	0.74
	1	2.29	0.07	47.78	1.24
	4	3.67	0.68	81.27	17.85
	8	2.15	0.12	57.44	6.57
2					
	1	2.22	0.11	34.67	3.36
	2	3.49	0.19	76.63	22.14
	3	3.16	0.22	52.64	3.92
	5	1.74	0.08	47.44	7.00
	6	2.02	0.40	20.81	6.07
	7	2.71	0.07	62.29	4.33
	8	3.36	0.14	69.31	4.12
3					
	2	6.61	1.14	49.69	7.14
4					
	0	3.88	0.09	40.54	0.94
	2	2.61	0.07	61.95	1.90
	3	1.61	0.06	10.64	1.65
	5	2.90	0.06	40.21	1.00
	6	3.93	0.18	29.48	4.06
	7	4.02	0.15	37.85	8.04
	8	2.48	0.12	47.60	6.89
5					
	0	3.07	0.25	59.70	5.50
6					
	0	5.16	0.18	46.08	1.15
	3	5.60	0.52	63.70	4.09
	5	2.89	0.05	59.08	1.25
7					
	0	3.99	0.34	61.06	5.75
	2	3.24	0.38	31.79	4.50
All	All	3.52	1.14	49.08	12.80

Another useful potential instrument comes on the household level. The presence of electricity in this area is quite sparse, but the results in Chapter 0 indicate that it is a good predictor of off-farm employment, especially for women. Whether or not any individual household has access to electrical service depends on whether or not electrical lines exist nearby. Because these lines were placed in the early 90’s along certain main roads, the presence of electricity in any individual household is determined outside the

thirty days or less in the previous year. While it is possible that this level of hired labor may affect land use choices, this issue will be addressed empirically in subsequent sections.

household's own choices. In addition, because farm tasks are not mechanized, the presence of electricity has no direct impact on the household land use. Instead it operates by influencing the time allocation choice or the value of household time, and through that, land use.

Finally, because it is necessary to control for both unobserved household and community level characteristics, a combination of canton level fixed effects and instrumental variables techniques are used to provide consistent estimates of the impact of off-farm work on land use.

6.5. Regression Results

The three econometric techniques, described in section 6.4 were used to examine the impact of off-farm employment on land use, including forest, annuals, perennials and pasture. The results are presented in two sections. Section 6.5.1 examines the impact of off-farm employment on deforestation, using the area of land remaining in forest as a measure of forest retention. Section 6.5.2 explores the impact of this same variable on the use of cleared land, by analyzing separately the area of land in each of the three major uses in this region.

6.5.1. Deforestation

The area of forest retained on any particular farm can be described as the household demand for forest. The physical area (hectares) in forest is influenced by a number of factors, including farm size, location, and household composition. Table 29 shows the marginal impact of the independent variables on the total hectares of forest retained by the household. The results indicate that OFE has a positive and significant relationship with the area retained in forest, regardless of the specification. The most comprehensive specification indicates an additional half hectare of forest retained for each hundred days worked off-farm by household members.

Column (1) of Table 29 shows the results of the parsimonious OLS analysis. These results include only physical farm characteristics, such as size, soil quality, location and access. Duration of residence is a proxy for the household's experience level in agricultural production in the area. Overall, these results indicate that, while larger farms maintain a greater area in forest, market access, as measured by distance from the nearest of the four major regional population centers and the road and vehicular access, diminishes the area of forest retained by the household. In addition, farms that have better perceived soil quality, as measured by whether or not the farmer reports having black soil, or that have been under cultivation for a longer period of time, also maintain less forest.

The introduction of household demographic variables, in column (2), increases the magnitude of the impact of OFE while maintaining its statistical significance. These demographical variables indicate that larger households maintain less forest as do households who are composed more predominantly of prime age males, prime age females or elderly males. The excluded group in this analysis is children under age 15. This is of particular interest as the joint significance of these variables indicates that household demographic variables play a role in the determination of land use on the farm. This result suggests that the household utility maximization and farm profit maximization

Table 29 Marginal Effects on Hectares of Retained Forest, OLS, 1999

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

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

problems are not separable, as is often assumed. The lack of separability indicates that it is necessary to take household characteristics into account in the regression analysis. Because of this, the absence of these demographic variables in the first regression likely biased the coefficient on off-farm work downwards. This is expected because in the absence of complete markets, larger households will be more likely to deforest more of their land for annual or 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 canton level fixed effects to the full regression, in column (3) decreases the magnitude of the impact of OFE, indicating that there are unobservable area characteristics which affect both the demand for forest and the household's off-farm work choice. In addition, these fixed effects change the magnitude or significance of several variables, including distance to the road and soil quality. This is likely due to the fact that variables like soil quality are much more likely to vary across cantons, rather than within them.

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 this endogeneity, 2SLS analysis was performed, instrumenting for OFE in the first stage. The three variables, discussed in section 6.4, were chosen to test as instruments because they were exogenous to the household problem and likely to affect land use only through their affect on time allocation. These variables were the parroquia level off-farm wage, the average number of days of off-farm work per adult in the parroquia, and whether or not the household has access to electricity. Initial analysis indicated that parroquia level wages were not a significant predictor of the quantity of off-farm employment within the household. While unexpected, this is likely due to the fact that there is little variation in the average wage rates of *parroquias* within the same canton. Because of this, analysis was performed using two instruments, the average number of days of off-farm work per prime age adult, and whether the household has electricity. The results herein are conditional on the validity of these instruments.

Table 30 shows the results of the instrumental variables analysis with canton 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[24]. This result is a strong confirmation of the hypothesized endogeneity bias and has important policy implications because a necessary, but not sufficient, condition for off-farm employment to have a positive impact on regional deforestation is that it reduces

[24] An additional possible specification of the household's level of engagement in market work is days worked off-farm per adult household member (age 15 and up). Use of this specification changes some of the results of the instrumental variables analysis; however, it has no impact on the significance level of off-farm employment. For full results of this analysis, see
Table 41 in the Appendix section.

Table 30 Marginal Effects on Hectares of Retained Forest, IV, 1999

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

household level deforestation. 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, its failure 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 40 more days per year in OFE, while those who live in areas with more intense competition for market employment, as represented by the average number of days of off-farm employment for the area, choose to work off-farm less. Farm size does not impact participation in market work, but has a significant impact on the are remaining in forest. Decreased access to markets for households further 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 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 lacking vehicular access retain more area in forest. Households whose farms are less accessible have more difficult 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, length of time that the farm has been in use increases the percentage of land that has been cleared for agricultural use.

6.5.2. 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 land major 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 greater soil compacting as animal’s hooves trample the ground. This increases the likelihood that there will be waste or other contaminant runoff into the area water supply.

Table 31 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 when taking the endogeneity of off-farm work into account, off-farm employment is not an important determinant of this land use. 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 crops. However, because the results for household composition are not highly intuitive, an area in annuals may not be related to farm area in a linear fashion, so another option is to look at these impacts in a log-linear or log-log format[25]. When considering the log-linear specification with respect to farm size, the results indicate a greater role for farm size in the determination of the area dedicated to annuals, showing that a one hectare increase in farm size raises the area in annuals by 1% for large farms and 4% for small farms. A log-log specification eliminates the need for the distinction between large and small farms and shows that a 10% increase in farm size results in a 15% increase in the area in annuals. The impact of household size is more readily interpretable under the log-log specification, and indicates that a 10% increase in household size generates a 17% increase in annual areas.

[25] OLS results for the log-log specification with respect to household size and log-linear and log-log specifications with respect to farm size are shown in Table 43 in APPENDIX 6: DEFORESTATION AND LAND USE RESULTS.

Table 31 Marginal Effects on Hectares in Annuals, 1999

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

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
† For first stage results see Table 30.
‡ Overidentification test of excluded instruments

The analysis of the area dedicated to perennials is shown in Table 32. 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 0.8-0.9 additional hectares in annuals. 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. Finally, duration of residence proves to be a significant and positive factor in the area in perennials, 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 33. Columns (1) and (2) present the OLS results with and without canton

Table 32 Marginal Effects on Hectares in Perennials, 1999

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

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
‡ Overidentification test of excluded instruments

level fixed effects, while column (3) shows the second stage instrumental variables result. The results indicate that there is little evidence for the hypothesis that off-farm employment impacts the area in pasture, as only the OLS results that do not include canton fixed effects show any significance for that variable. Farm size is a major indicator of area in pasture, regardless of the specification or the overall size category of the farm, although smaller farms allocate a greater share of additional acreage to pasture than do larger farms. OLS indicates that households farther from the road and those farther from population centers devote less land to pasture, although this result is not continued in the IV results. 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, is expensive to get started on. Because of this, livestock acquisition is 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 the two OLS specification, but this effect appropriately 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 30.

Table 33 Marginal Effects on Hectares in Pasture, 1999

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

Robust standard errors in parentheses

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

† For first stage results see Table 30.

‡ Overidentification test of excluded instruments

The modification of the analysis to use per capita off-farm work days as a measure of participation in market work has some impact on the results. The full details of this analysis can be found in Table 42 in Appendix 6. However, despite changes to the significance of the impacts of vehicular access, education of the head of the household, and the small farm dummy, all of which gain significance using this measure of off-farm employment, the overall impact of off-farm employment itself is still insignificant.

6.6. Summary

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 work. These biases, when not accounted for, result in an improper understanding of the impact of off-farm work on deforestation and land use, as OLS results indicate that off-farm employment is associated with retention of additional forest as well as decreases in the areas 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.

7. CONCLUSIONS

7.1. Summary of Findings

This study examines the factors which affect the off-farm employment participation decisions of colonist settlers in the Northern Ecuadorian Amazon and whether or not off-farm employment can be used as a tool to reduce the rate of deforestation in this environmentally sensitive area of the world. The results presented herein indicate that there are many factors that influence the time use decisions of members of agricultural households, and that off-farm employment, despite being lauded in the literature as a means of decreasing deforestation, has no impact on the area of forest retained by colonist settlers in the Northern Ecuadorian Amazon, when taking the endogenous nature of work decisions into account.

Because households in this area who engage in off-farm employment have significantly higher income levels than those who do not, the results of the factors affecting the off-farm work decision provide insights into areas that might be explored to further poverty reduction programs.

7.2. Policy Implications

Many policy makers are concerned with the issues of poverty and conservation. The goal of decreasing the rate of deforestation, especially in environmentally sensitive areas of the world is laudable, but has to date been difficult to address when taking into account poverty concerns. Some have seized on the use of off-farm employment as a means of both reduce the rate of deforestation and increase the economic well being of those living in developing areas. There is evidence that off-farm employment increases the economic well-being of households, with households engaged in off-farm employment earning significantly larger incomes than those not so engaged. The results of this analysis indicate that there are several factors accessible to policy makers that may increase the probability of households engaging in off-farm employment. Closer proximity to a roadway is associated with greater off-farm employment in both men and women, as roadways increase market access for households. This result indicates that policymakers may be able to increase both male and female off-farm employment through the construction of roads in agricultural areas of the Amazon. In addition, there are several other factors that these results indicate support off-farm employment by women. Of these, education and access to electricity are of prime importance to policy makers. Increases in both of these variables leads to an increase in the probability of female off-farm employment. Thus the provision of greater educational opportunities and/or residential electrical service could serve as a means of boosting female employment in this developing area.

Despite the identification of policy instruments that may encourage off-farm employment, the results here, which are conditional on the validity of the instruments used in this analysis, 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 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 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, presented in section 4.5, indicates that subdivided properties preserve a smaller land share in forest. This means that increasing migration into an area of high employment may lead to additional deforestation as more properties are subdivided.

7.3. Gaps and Recommendations for Future Research

There are several gaps in the research presented here which need to be filled in order to present a complete picture of the effects of off-farm work on the ecology of the NEA. One important consideration is the instruments used in this analysis. Because these instruments are not as statistically significant as desired, it is important to continue searching for instruments that may better predict participation in off-farm employment. To this end, suggestions for the collection of data that may serve this role are made in section 7.4.

The impact of hired labor also needs to be more carefully assessed. Because many off-farm workers are employed in agriculture on other farms, often neighboring farms, even if their OFE were associated with clearing less of their own land, this could be countered by more land clearing on other farms. Thus the full impact of off-farm work on deforestation should take this into account.

Another complication which has not been considered herein is that increases in local wages and/or employment levels may lead to further migration to the region. This additional in-migration is likely to increase the rate of deforestation as new arrivals claim currently unclaimed land or cause an increase in subdivisions on existing farms and the total land area must support more and more people. In order to assess the overall impact of off-farm employment on deforestation, it is necessary to determine the effect of higher wages and/or rates of employment on in-migration and the subsequent subdivision of farms.

The finding that off-farm work does impact deforestation and land use lends credence to the idea that, in this area of the world, households, for the most part, do not operate their farms totally as businesses: while farmers in this region may be price takers, they are not operating in the context of competitive and efficient markets. Because of this, the consumption functions of households and the production aspects of their farms are likely to be non-separable. Further study is necessary to determine whether or not the separability of households and farms holds in the context of the NEA, although it appears unlikely from the evidence here so far.

In addition to the question of efficient market allocation, there is the question of efficiency in intra-household resource allocation. It would be useful to determine whether households allocate resources between members in a Pareto optimal manner, as studied by Udry (1996). While Udry addressed the efficiency of resource allocation between husbands and wives, the low incidence of female land ownership in this area makes this dataset more relevant instead to the question of resource allocation between parents and children. In this case, there are two particular questions which may be asked. First, is the allocation of resources between plots owned by members of the same household, which are frequently subdivisions of the original "mother farm," Pareto optimal? And second, is the allocation of resources between family members dependent on co-residence? This would be indicated if there is a difference in the allocation of resources to the plots belonging to children based on their place of residence. In particular, do farm plots belonging to children living in the same dwelling as their parents receive a different share of household resources than do plots belonging to children who live in a separate dwelling close to that of their parents (i.e., elsewhere on the same farm or *finca madre*)? And do they use land differently? Is there evidence of joint planning of land use on the larger *finca madre*? The data available in the survey permit identifying when familial relationships exist among owners of subdivided farms, making this data set particularly useful for investigating these questions.

7.4. Suggestions for Future Data Collection

In order to continue the present line of research, as well as other research suggestions mentioned above, further data collection would be helpful, and in some cases necessary. Before presenting my suggestions, I want to emphasize the necessity that any future data be collected in a way that is compatible with the most recent (1999) data set for purposes of longitudinal analysis. This means that whenever possible the questions should be numbered and coded in a way identical to the 1999 dataset, and that any new questions should be implemented, not as replacements for current questions, but as sub-questions that expand upon the original question. For example, it would have been useful for me to have greater information on time spent in farm work by family members. Currently, the question reads “does he/she work on the farm?” With the potential answers of: “most days,” “sometimes,” and “practically never.” Efforts to expand this information should leave this intact but follow it up with something on the order of: “in an average week, how many days would you say he/she works?” And “how many hours would he/she work in a typical day?” This would maintain the compatibility of the two surveys, while expanding our knowledge about aspects of interest.

The research presented in this dissertation could also be enhanced with more information regarding the amount of time spent in farm and non-farm work. The latest survey requests only a frequency of participation in farm work, while participation in off-farm work is assessed in terms of number of months worked and number of days per month, giving a passable estimate of days worked per year. My suggestions for the collection of farm work data are mostly addressed by the preceding paragraph; however, it would also be helpful if we had some information about the amount of time spent in various farm activities.

With respect to the collection of off-farm employment data, while the current method seems reasonable at the outset, analysis of the data shows that days per year may not be providing the information desired. For example, some people claim to work off-farm more than 365 days per year. This mostly occurs for those who hold two or more jobs, who report working large numbers of days in each. The extreme case was a man who reported three self-employment type jobs, claiming to work 30 days per month, 12 months per year at each of the jobs, resulting in a total of 1080 days of off-farm work, a feat that would be impossible if he were working "full-time" hours in each. For this reason, I suggest adding "about how many hours does he/she work on a typical day." This information is also important to calculate a wage rate from which the analysis of off-farm work can be done. In addition, many persons are reported as working off-farm 30 days per month. While this is not impossible, it is unlikely. It is possible that people reporting 30 days per month were simply attempting to convey the concept of full-time work, rather than asserting that they work every day. To address this, however, would require that the data be reported twice, in order to keep the data between the two dates comparable. So we might proceed as in 1999 regarding the collection of off-farm employment, but for those who assert more than 25 days per month of off-farm work, a follow up question may be asked to the effect of: "do you mean that you work off-farm more than 5 days every week?" If the respondent changes his answer at this point, the change should be recorded in a separate place to maintain consistency between years.

Another problem that may need to be resolved is the data on hired labor. As noted in appendix 3, the method of collecting wage data for contract workers may have led to an inflation of the daily wage rate. Question g 1.5 of the *jefe* survey asks: “how much did you pay? (on average)” with the assumption that the wage is reported per day. But this does not seem to have been the case, as wage rates for contract workers, shown in Table 35, appear vastly inflated over those of day-laborers doing similar jobs. An important follow up to this question would thus be “this is what you paid per day?”

An addition to the collection of education data would also prove helpful. At this point we have information regarding whether they have complete or incomplete primary or secondary education and whether or not they have any technical school or university. It would be much more helpful if we knew exactly how many years of education the individual had completed, so adding a follow-up question, “how many years did he/she complete at this level?” would yield total years of education, rather than only a crude categorical variable.

For the next round of the survey, it would also be helpful if the migrations/origins section was asked of all respondents, not just of those not interviewed in the earlier round. An additional question can be inserted at the beginning regarding whether or not this particular person had been interviewed before in a previous round of the survey (as earlier responses may be more accurate), but changes in the questions asked between the two years, as well as inconsistencies in matching households between the two datasets, have made this section difficult if everyone is not asked these questions.

Finally, it is necessary to turn our attention to the collection of variables that might be of use as instruments for off-farm employment and hired labor. To this end I suggest that we attempt to collect data on whether or not the father of the *jefe* or the mother of the *esposa* ever worked in an off-farm role. These variables may be helpful as instruments for these choices as the choice of the own-gender parent often provides a role model for the child's future behavior. In addition, these variables should be independent of any land use choices made by the household. Collection of data as to whether the own-gender parent of each household member ever worked off-farm may be more difficult to get, but should also be considered as it would be helpful in the analysis of the individual level off-farm employment decision.

APPENDIX 1: VARIABLE DEFINITIONS FOR THE THEORETICAL MODEL

Table 34 Definition of Variables Used in the Theoretical Model

Variable	Definition
$\mathbf{C}_f$	Vector of farm characteristics
$\mathbf{C}_h$	Vector of household and area characteristics
$\mathbf{C}_m$	Vector of local labor market conditions
$\mathbf{H}_f$	Vector of household human capital applicable to farming
$\mathbf{H}_h$	Vector of household human capital applicable to home production
$\mathbf{H}_m$	Vector of individual marketable human capital
$\mathbf{J}_m$	Vector of job characteristics
L	Farm size
l_a	Area of land in annuals
l_c	Area of land in pasture for cattle
l_p	Area of land in perennials
$\mathbf{N}$	Vector of purchased inputs for farm production
$\mathbf{P}_a$	Vector of prices of agricultural goods
$\mathbf{P}_n$	Vector of prices of purchased inputs used in farm production
$\mathbf{P}_x$	Vector of prices of market goods used in home production
$\mathbf{T}$	Vector of time endowments of household members
$\mathbf{T}_f$	Vector of time spent in farm work by household members
$\mathbf{T}_h$	Vector of time spent in home production by household members
$\mathbf{T}_m$	Vector of time spent in market work by household members
$\mathbf{X}$	Vector of market goods used in home production
Y_n	Household non-labor income
$\mathbf{Z}$	Vector of home produced commodities
Π	Profit of the farm

APPENDIX 2: DERIVATION OF THE THEORETICAL MODEL

The household maximizes its utility subject to the budget constraint and the non-negativity constraints using the Lagrangian:

$$
\begin{aligned}
&L(\mathbf{X}_1,\ldots,\mathbf{X}_n,\mathbf{T}_{h1},\ldots,\mathbf{T}_{hn},\mathbf{T}_m,\mathbf{T}_f,l_a,l_p,l_c,l_f,\mathbf{N}) = \\
&= U(Z_1,\ldots Z_n) + \lambda[\mathbf{W}\mathbf{T}_m + P_a q(\mathbf{T}_f,l_a,l_p,l_c,\mathbf{N};\mathbf{H}_f,\mathbf{C}_f) - \mathbf{P}_n\mathbf{N} - \mathbf{P}_x\mathbf{X}] + \\
&+ \gamma(\mathbf{T} - \mathbf{T}_m - \mathbf{T}_f - \sum_{i=1}^{n}\mathbf{T}_{hi}) + \mu(L - l_a - l_p - l_c - l_f)
\end{aligned}
\qquad \text{(A2.1)}
$$

with the following Kuhn-Tucker conditions:

$$\frac{\delta L}{\delta \mathbf{X}_i} = \frac{\delta U}{\delta Z_i}\frac{\delta \mathbf{Z}_i}{\delta \mathbf{X}_i} - \lambda \mathbf{P}_x = 0 \qquad \text{(A2.2)}$$

$$\frac{\delta L}{\delta \mathbf{T}_{hi}} = \frac{\delta U}{\delta Z_i}\frac{\delta \mathbf{Z}_i}{\delta \mathbf{T}_{hi}} - \gamma = 0 \qquad \text{(A2.3)}$$

$$\frac{\delta L}{\delta \mathbf{T}_m} = \lambda \mathbf{W} - \gamma \le 0,\ \mathbf{T}_m \ge 0,\ \mathbf{T}_m(\lambda \mathbf{W} - \gamma) = 0 \qquad \text{(A2.4)}$$

$$\frac{\delta L}{\delta \mathbf{T}_f} = \lambda \mathbf{P}_a q_{\mathbf{T}_f} - \gamma \le 0,\ \mathbf{T}_f \ge 0,\ \mathbf{T}_f(\lambda \mathbf{W} - \gamma) = 0 \qquad \text{(A2.5)}$$

$$\frac{\delta L}{\delta l_a} = \lambda \mathbf{P}_a q_{l_a} - \mu \le 0,\ \ l_a \ge 0,\ \ l_a(\lambda \mathbf{P}_a q_{l_a} - \mu) = 0 \qquad \text{(A2.6)}$$

$$\frac{\delta L}{\delta l_p} = \lambda \mathbf{P}_a q_{l_p} - \mu \le 0,\ \ l_p \ge 0,\ \ l_p(\lambda \mathbf{P}_a q_{l_p} - \mu) = 0 \qquad \text{(A2.7)}$$

$$\frac{\delta L}{\delta l_c} = \lambda \mathbf{P}_a q_{l_c} - \mu \le 0,\ \ l_c \ge 0,\ \ l_c(\lambda \mathbf{P}_a q_{l_c} - \mu) = 0 \qquad \text{(A2.8)}$$

$$\frac{\delta L}{\delta l_f} = -\mu \le 0,\ l_f \ge 0,\ l_f(-\mu) = 0 \qquad \text{(A2.9)}$$

$$\frac{\delta L}{\delta \mathbf{N}} = \lambda[\mathbf{P}_a q_{\mathbf{N}} - \mathbf{P}_n] = 0 \qquad \text{(A2.10)}$$

$$\frac{\delta L}{\delta \lambda} = \mathbf{W}\mathbf{T}_m + \mathbf{P}_a q(\mathbf{T}_f,l_a,l_p,l_c,\mathbf{N};\mathbf{H}_f,\mathbf{C}_f) - \mathbf{P}_n\mathbf{N} + Y_n - \mathbf{P}_x\mathbf{X} = 0 \qquad \text{(A2.11)}$$

$$\frac{\delta L}{\delta \gamma} = \mathbf{T} - \mathbf{T}_f - \mathbf{T}_m - \sum_i \mathbf{T}_{hi} = 0 \tag{A2.12}$$

$$\frac{\delta L}{\delta \mu} = L - l_a - l_p - l_c - l_f = 0 \tag{A2.13}$$

where equations (A2.6)-(A2.8) show that land will be allocated so that the marginal revenue product of all uses of land minus the marginal cost of using the land is equal to μ/λ and equation (A2.9) shows that the marginal value of fallow (μ) is less than or equal to zero. Combining these, we see that land will be left fallow ($\mu = 0$) only if the marginal value of using the land is negative (i.e. the marginal revenue product is less than the marginal cost). Equation (A2.4) is the optimality condition for off farm work. If $\mathbf{W} - \gamma/\lambda < 0$, then the wage that the individual can earn off-farm is less than the marginal value of the individuals home or farm time, and their off-farm work hours will be zero; however, if the equality holds, then we find that the off-farm work hours will be positive, and will equal the marginal value of home time. The same holds true for equation (A2.5) which is the optimality condition for on-farm work, so that if $\mathbf{P}_a q_{\mathbf{T}_f} - \gamma / \lambda < 0$ then the individual will have zero hours of farm work. Thus, if anyone chooses to work both on and off-farm then the wage must equal the marginal revenue product of farm time and the marginal value of home time.

Finally, combining equations (A2.2) – (A2.4) we find that, as expected, the ratios of marginal products for the inputs to household production equal the ratios of their prices. Thus an increase in the wage rate will result in a substitution of purchased inputs for home time in the home production function.

APPENDIX 3: DISCUSSION OF INCONSISTENCIES IN THE HIRED LABOR DATA

Wages for hired labor on the farm vary widely. In addition, the manner of this variation leads me to believe that, in some cases, the data is not accurately portraying the true cost to hire labor. The survey methodology for acquiring the household's spending on hired labor was as follows: farmers were allowed to report two general types of labor, single day hires, and contract workers, and specify one or more of six possible categories for the type of work done by these workers, finally they were asked what they paid per day for the workers that they hired..

My a priori expectation was that contract workers may command a somewhat higher price compared with people hired for a single day because the long term relationship between the farmer and his contract worker would reduce the risk of the worker shirking. However, upon inspection of the data, I found that the daily rates for contract workers, on average, are substantially higher than the rate for day laborers.

From table A2.1, it can be seen that hiring of day labor is much more common than the use of contract workers. In addition, while the average wage for day labor ranges from approximately $1.75 to $1.89 per day with a standard deviation less than 0.55 in all cases, the average wage for contract workers ranges from approximately $2.72 to $43.06 with much larger standard deviations ranging from just over one to just under 88.

While it was impossible to test if these are significantly different in any meaningful way due to the fact that only 16 farmers report hiring both day and contract labor, visual inspection indicates that there are massive differences between the reported wages of the two groups. This leads to one of two conclusions. First it is possible that some of the contract labor hired was highly specialized and thus demanded higher wages than could day laborers. While this is possible, especially for those whose work falls in the “other” category which is inherently difficult to define, it seems unlikely that all of these categories would have areas specialized enough to demand such a wage premium.

The second possible explanation for these differences lies in the way the nature of contract work and the particular way in which questions were asked. Respondents to the survey were asked to first report if they used each type of labor, for how many days in the past 12 months, the primary type of work done by the workers, and finally the daily wage rate paid. While this poses no problem for day laborers whose daily wage would be foremost in the respondents mind; the wage of contract workers may be set on a somewhat longer scale. Thus the respondents may have been inadvertently giving the wage for a longer period of time, from a week, if wages were paid weekly, up to the entire contract period. If this is the case then the daily wage rate would need to be calculated by dividing the reported wage by the number of days in the wage period.

Unfortunately it is difficult or impossible to assess whether the wage premium, or misstatement of the daily wage rate is the true explanation for this inconsistency. Although the consistency of the daily wage rate across work types for day labor suggests that the second possibility is the more likely. In addition, the absence of further information regarding the length of the wage period being reported by farmers results in a situation where any calculation of daily wages would be a guess on my part as to the mindset of the respondent.

Finally, the problem being manifest here may not be the result of either of the above possibilities; rather it may be one of data entry. This problem is more likely here than in some situations because the low value of the Sucre in 1999 led to a situation where all wage rates had a significant number of zeros at the end. For example a wage rate of approximately a dollar a day would be recorded as 10,000 Sucres, while a wage of $10 would be 100,000 Sucres. Keeping in mind that there are no commas to mark the thousands place or millions place in most data entry software and these numbers begin to look remarkably alike (`10000` vs. `100000`). This may have lead to a situation where the data was recorded incorrectly with either zeros added, as suspected with daily wage rates of $100 or $200, or missing, as is likely with the reported wage rate of $0.20 or $0.50 per day.

Table 35 Wage Rates for Hired Labor

Job	***Day Laborers***			***Contract Workers***		
	Average Wage[26]	**Range**	**# of Obs.**	**Average Wage**	**Range**	**# of Obs.**
Clear Forest	1.75 (0.49)	1.50 – 3.00	10	4.35 (3.54)	1.00 – 10.00	12
Plant and/or Harvest Annual Crops	1.85 (0.44)	1.00 – 3.00	41	3.65 (2.50)	1.50 – 10.00	13
Plant and/or Harvest Coffee	1.73 (0.45)	0.20 – 3.00	98	2.72 (1.04)	1.50 – 5.00	11
Weed Crops and/or Pasture	1.80 (0.53)	0.20 – 3.50	151	7.74 (17.89)	0.50 – 100.00	43
Extract Wood or Trunks	1.75 (0.35)	1.50 – 2.00	2	—	—	0
Other	1.89 (0.42)	1.00 – 2.50	9	43.06 (87.74)	3.00 – 200.00	5
All Jobs	1.78 (0.49)	0.20 – 3.50	223	9.61 (28.11)	0.50 – 200.00	65

[26] In ten thousands of Sucres (10,000 Sucres≈ $1)

APPENDIX 4: BIVARIATE PROBIT RESULTS

The following presents the bivariate probit results for the probability of engaging in farm and off-farm work for men and women. The results do not indicate the marginal effects of variables; rather they are presented here for the purpose of analyzing the significance of various variables on men and women separately.

Table 36 Raw Bivariate Probit Results for Women with Household Level Fixed Effects

	(1) Off-Farm	(2) On-Farm
Age	0.0712***	0.0706***
	(0.0261)	(0.0141)
Age Squared	-0.000927***	-0.000885***
	(0.000358)	(0.000177)
Years of Education	0.111***	-0.0548***
	(0.0281)	(0.0176)
Head of Household	0.742***	0.467**
	(0.259)	(0.215)
Number of Own, Co-Resident Children	-0.0392	0.0406
	(0.0446)	(0.0304)
Constant	-3.277***	-1.036***
	(0.451)	(0.271)
Rho	-0.332***	
	(0.0915)	
Sample Size	912	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 37 Raw Bivariate Probit Results for Men with Household Level Fixed Effects

	(1) Off-Farm	(2) On-Farm
Age	0.0496***	0.0215
	(0.0163)	(0.0135)
Age Squared	-0.000785***	-0.000390***
	(0.000198)	(0.000148)
Years of Education	0.00304	-0.0906***
	(0.0158)	(0.0188)
Head of Household	0.302**	0.814***
	(0.125)	(0.132)
Number of Own, Co-Resident Children	0.0698**	-0.0215
	(0.0330)	(0.0366)
Constant	-1.096***	0.554**
	(0.294)	(0.272)
Rho	-0.325***	
	(0.0632)	
Sample Size	1182	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 38 Raw Bivariate Probit Results for Women with Community Level Fixed Effects

	(1) Off-Farm	(2) On-Farm
Age	0.0827**	0.0939***
	(0.0324)	(0.0167)
Age Squared	-0.00115***	-0.00117***
	(0.000442)	(0.000212)
Years of Education	0.0893***	-0.0449**
	(0.0286)	(0.0193)
Head of Household	0.625**	0.384*
	(0.263)	(0.226)
Number of Own, Co-Resident Children	0.00868	-0.0459
	(0.0810)	(0.0404)
Number of Prime Age Males	-0.0589	-0.0884*
	(0.0735)	(0.0511)
Number of Elderly Males	-0.118	-0.145
	(0.262)	(0.151)
Number of Prime Age Females	0.0892	-0.120*
	(0.0882)	(0.0703)
Number of Elderly Females	-0.923**	-0.115
	(0.465)	(0.212)
Number of Children Under 15	-0.0288	0.0393
	(0.0554)	(0.0335)
Duration of Residence	0.0150	-0.00411
	(0.0120)	(0.00700)
Number of Household Assets	0.0201	-0.0438*
	(0.0462)	(0.0261)
Household Has Electricity	0.446**	0.00639
	(0.190)	(0.129)
Total Hectares Owned	-0.00106	0.000548
	(0.00523)	(0.00366)
Hectares in Annuals	-0.0888*	0.0439**
	(0.0457)	(0.0188)
Hectares in Perennials	-0.00261	0.0442***
	(0.0185)	(0.0171)
Hectares in Pasture	-0.0144	-0.00455
	(0.0102)	(0.00682)
Distance to Road	-0.228*	0.0671*
	(0.120)	(0.0356)
Distance Along Road to Population Center	-0.00672	-0.00634
	(0.00855)	(0.00676)
Constant	-2.460***	-0.873
	(0.701)	(0.602)
Rho	0.31059***	
	(0.08623)	
Sample Size	912	
Fixed Effect	Y	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 39 Raw Bivariate Probit Results for Men with Community Level Fixed Effects

	(1) Off-Farm	(2) On-Farm
Age	0.0644***	0.0324**
	(0.0178)	(0.0149)
Age Squared	-0.000899***	-0.000545***
	(0.000214)	(0.000166)
Years of Education	0.0254	-0.0878***
	(0.0173)	(0.0210)
Head of Household	0.204	0.961***
	(0.146)	(0.154)
Number of Own, Co-Resident Children	0.0862*	-0.0546
	(0.0449)	(0.0459)
Number of Prime Age Males	0.104**	-0.00890
	(0.0462)	(0.0482)
Number of Elderly Males	0.218	-0.0795
	(0.149)	(0.171)
Number of Prime Age Females	0.104**	-0.102
	(0.0484)	(0.0671)
Number of Elderly Females	-0.175	-0.00921
	(0.157)	(0.167)
Number of Children Under 15	-0.0409	0.0496
	(0.0329)	(0.0344)
Duration of Residence	-0.0224***	0.000496
	(0.00652)	(0.00851)
Number of Household Assets	-0.0804***	-0.00602
	(0.0237)	(0.0237)
Household Has Electricity	0.0981	-0.322**
	(0.114)	(0.127)
Total Hectares Owned	-9.13e-05	0.00544
	(0.00284)	(0.00405)
Hectares in Annuals	-0.0193	0.0216
	(0.0159)	(0.0271)
Hectares in Perennials	-0.0525***	0.0337*
	(0.0156)	(0.0174)
Hectares in Pasture	-0.0129**	0.00292
	(0.00655)	(0.00764)
Distance to Road	-0.0933***	0.113**
	(0.0291)	(0.0468)
Distance Along Road to Population Center	-0.00533	0.000718
	(0.00493)	(0.00656)
Constant	-0.448	0.135
	(0.428)	(0.473)
Rho	-0.297***	
	(0.0639)	
Sample Size	1182	
Fixed Effect	Y	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 40 Raw Bivariate Probit Results for All Adults with Community Level Fixed Effects and Cross Product Terms for Women

	(1) Off-Farm	(2) Farm Work
Age	0.0652***	0.0289*
	(0.0178)	(0.0149)
Age Squared	-0.000907***	-0.000498***
	(0.000214)	(0.000165)
Years of Education	0.0236	-0.0869***
	(0.0171)	(0.0205)
Head of Household	0.205	0.968***
	(0.144)	(0.151)
Male	2.365***	0.936**
	(0.561)	(0.423)
Number of Own, Co-Resident Children	0.0808*	-0.0561
	(0.0447)	(0.0449)
Number of Prime Age Males	0.0968**	0.00449
	(0.0462)	(0.0489)
Number of Elderly Males	0.218	-0.000342
	(0.147)	(0.164)
Number of Prime Age Females	0.105**	-0.110*
	(0.0486)	(0.0620)
Number of Elderly Females	-0.149	-0.0505
	(0.158)	(0.165)
Number of Children Under 15	-0.0377	0.0525
	(0.0330)	(0.0337)
Duration of Residence	-0.0224***	0.00116
	(0.00645)	(0.00837)
Number of Household Assets	-0.0745***	-0.00268
	(0.0236)	(0.0234)
Household Has Electricity	0.0841	-0.245**
	(0.111)	(0.125)
Total Hectares Owned	-0.000620	0.00405
	(0.00274)	(0.00381)
Hectares in Annuals	-0.0185	0.0360
	(0.0156)	(0.0292)
Hectares in Perennials	-0.0492***	0.0411**
	(0.0154)	(0.0169)
Hectares in Pasture	-0.0121*	0.00225
	(0.00642)	(0.00773)
Distance to Road	-0.0787***	0.0982**
	(0.0278)	(0.0446)
Distance Along Road to Population Center	-0.00421	0.00155
	(0.00464)	(0.00623)
Female * Age	0.0195	0.0605***
	(0.0364)	(0.0212)
Female * Age Squared	-0.000275	-0.000603**
	(0.000488)	(0.000254)
Female * Years of Education	0.0643*	0.0430*
	(0.0346)	(0.0252)
Female * Head of Household	0.410	-0.653**

	(1) Off-Farm	(2) Farm Work
	(0.299)	(0.278)
Female * Number of Own, Co-Resident Children	-0.0814	0.0118
	(0.0876)	(0.0555)
Female * Number of Prime Age Males	-0.125	-0.0986
	(0.0800)	(0.0625)
Female * Number of Elderly Males	-0.335	-0.231
	(0.294)	(0.187)
Female * Number of Prime Age Females	-0.0290	0.0156
	(0.0920)	(0.0841)
Female * Number of Elderly Females	-0.880*	-0.0211
	(0.463)	(0.249)
Female * Number of Children Under 15	0.00837	-0.0168
	(0.0641)	(0.0430)
Female * Duration of Residence	0.0372***	-0.00444
	(0.0130)	(0.00936)
Female * Number of Household Assets	0.0705	-0.0505*
	(0.0486)	(0.0306)
Female * Household Has Electricity	0.383*	0.211
	(0.210)	(0.146)
Female * Total Hectares Owned	0.000641	-0.00245
	(0.00509)	(0.00448)
Female * Hectares in Annuals	-0.0773*	-0.00145
	(0.0449)	(0.0303)
Female * Hectares in Perennials	0.0352*	-0.00403
	(0.0208)	(0.0186)
Female * Hectares in Pasture	-0.00332	-0.00687
	(0.0118)	(0.00871)
Female * Distance to Road	-0.222*	-0.0298
	(0.129)	(0.0429)
Female * Distance Along Road to Population Center	-0.0103	-0.00802
	(0.00847)	(0.00509)
Constant	-2.617***	-0.791
	(0.559)	(0.533)
Rho	-0.297***	
	(0.0554)	
Observations	2094	
Fixed Effect	Y	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX 5: SPLINES

This appendix contains the information about splines performed to ascertain the overall relationships between dependent and independent variables.

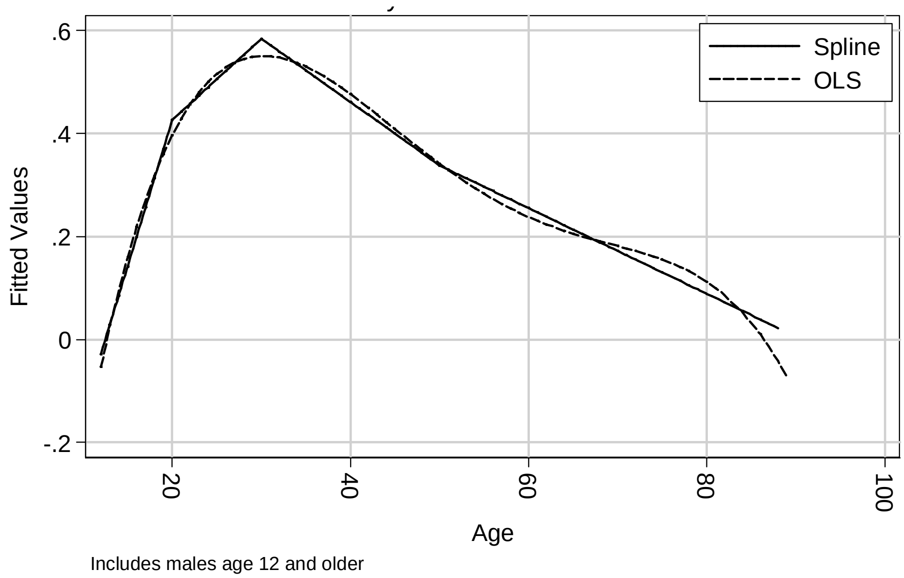


Figure 12 Spline of Relationship between Age and Probability of Participation in Off-Farm Employment for Men Aged 12 and Up, 1999

The solid line in Figure 12 shows the relationship between age and the probability of participation in off-farm work as a four part piece wise regression. It shows that the probability of engaging in off-farm work rises most rapidly between the ages of 12 and 20. This is likely to be due in part to the fact that over this age range young men are finishing their schooling and becoming more productive members of the household. Participation rates continue to rise between the ages of 20 and 30, and fall after age 30. This relationship confirms the original hypothesis that age and off-farm employment are related in an inverted-U fashion. The dashed line shows an OLS estimate of off-farm work participation using Age, Age^2, Age^3 and Age^4. This expression provides the closest fit to the data; however, Age^3 and Age^4 don't provide significant explanatory power. Because of this, the analysis of work choice utilized a quadratic expression of age.

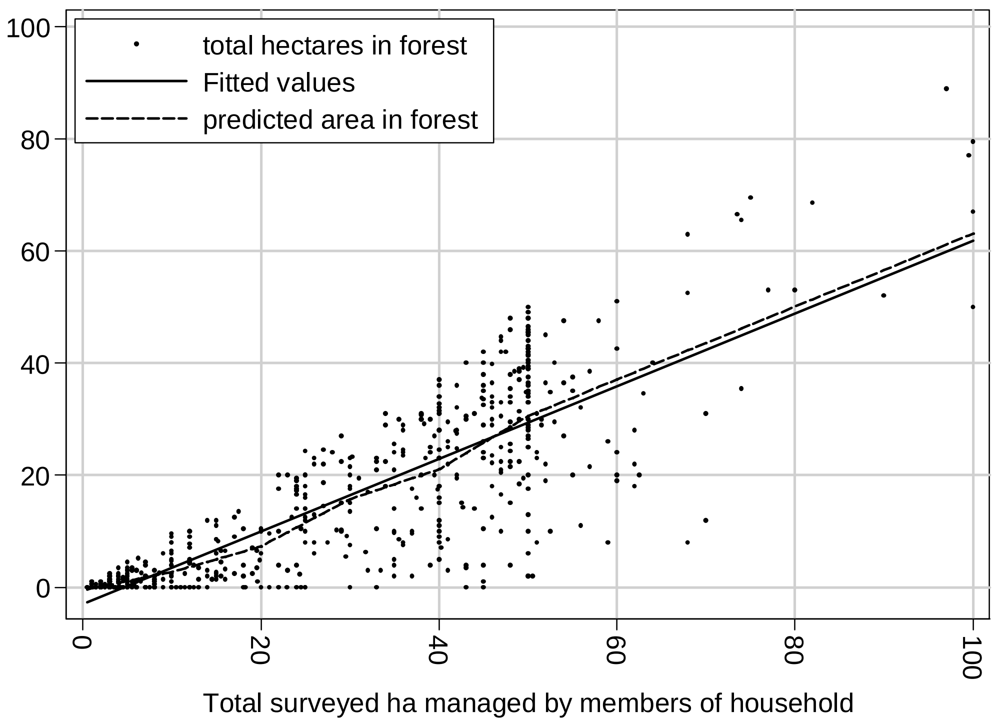


Figure 13 Spline of the Relationship between Farm Size and Area in Forest

Figure 13, shown above, shows the relationship between total farm size and the area remaining in forest. Predicted area in forest is the area predicted through the use of a spline, while the line for fitted values shows the linear prediction. It is easy to see that the spline and the linear prediction are extremely similar. Because of this, a linear relationship between farm size and area in forest was used in the data analysis. The spline deviates most from the linear prediction at small farm sizes. Because of this, a dummy variable for small farms was added in combination with a variable formed by crossing the small farm dummy with farm size. This allows for the teasing out of differences in the marginal impact increases in farm size for smaller and larger farms.

APPENDIX 6: DEFORESTATION AND LAND USE RESULTS

This appendix provides results of secondary regressions in the analysis of the impact of off-farm work on land use and deforestation. These results differ from those in Section 6.5 in how they measure off-farm work participation. While the regressions included in that section measure household participation in off-farm work on the basis of total household days of off-farm employment in the previous year, these regressions measure the rate of off-farm work as days of off-farm employment per adult aged 15 and up. As with the regressions included in the body of the dissertation, off-farm work shows no impact on area of retained forest (Table 41) or area in annuals (Table 42) once the endogeneity of the off-farm employment decision is accounted for. The instruments used to account for this endogeneity are the same as described in Chapter 0.

Table 43 shows the impact of the use of log-log and log-linear specifications for the area in annuals. The results indicate that the analysis is not sensitive to the particular form used, and that the use of a dummy variable to differentiate small farms from large ones is an adequate means of accounting for the differing impact of marginal farm size on land use choices.

Table 41 Marginal Effects on Area of Retained Forest Using Off-Farm Days Per Capita as a Measure of Off-Farm Activity, IV, 1999

	First Stage	Second Stage
Days Worked Off-Farm Per Capita†		-0.01
		(0.01)
Average Number of Off-Farm Days§	-0.41**	
	(0.20)	
Household has Electricity	17.88***	
	(5.55)	
Farm Size in Hectares	0.25	0.03**
	(0.17)	(0.01)
Walking Distance to the Road	-5.03***	0.06
	(1.38)	(0.06)
Distance via Road to the Population Center	-0.23	-0.02***
	(0.19)	(0.01)
Farm Always Has Vehicular Access	1.05	0.57**
	(5.96)	(0.24)
Soil is Black	9.14*	0.27
	(5.47)	(0.25)
Duration Since Household Acquired the Farm	-0.70**	-0.00
	(0.34)	(0.01)
Log of Household Size	-9.62	0.64***
	(6.71)	(0.24)
Fraction Prime Males	-6.22	0.67
	(16.83)	(0.52)
Fraction Prime Females	22.48	-0.47
	(21.82)	(0.91)
Fraction Elderly Males	-43.75	0.89
	(26.78)	(1.01)
Fraction Elderly Females	-13.09	-0.70
	(30.87)	(0.76)
Age of Head of Household	-0.02	0.00
	(0.25)	(0.01)
Years of Education of Head of Household	2.59**	0.05
	(1.16)	(0.04)
Small Farm ($\leq$ 10 Ha)	43.58***	0.19
	(11.64)	(0.61)
Small Farm * Farm Size	-3.98**	0.01
	(1.68)	(0.05)
Canton Level Fixed Effect	Y	Y
Observations	639	639
R-squared	0.157	0.155
F-Stat of Excluded Instruments	6.98	
Hansen-J P-Value‡		0.338

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 by the household per adult aged 15 and up.

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

‡ Overidentification test of excluded instruments.

Table 42 Marginal Effects on Area in Pasture Using Off-Farm Days Per Capita as a Measure of Off-Farm Activity, 1999

	(1) OLS	(2) OLS	(3) IV§
Days Worked Off-Farm Per Capita†	-0.010*	-0.008*	0.039
	(0.005)	(0.005)	(0.032)
Farm Size in Hectares	0.181***	0.187***	0.175***
	(0.042)	(0.041)	(0.043)
Walking Distance to the Road	-0.502***	-0.399***	-0.154
	(0.131)	(0.139)	(0.207)
Distance via Road to the Population Center	-0.044**	-0.044**	-0.030
	(0.023)	(0.022)	(0.023)
Farm Always Has Vehicular Access	1.313**	1.488**	1.265*
	(0.601)	(0.618)	(0.654)
Soil is Black	1.204*	0.722	0.295
	(0.635)	(0.661)	(0.744)
Duration Since Household Acquired the Farm	0.109**	0.105**	0.133**
	(0.053)	(0.051)	(0.059)
Log of Household Size	-0.059	0.015	0.364
	(0.683)	(0.659)	(0.742)
Fraction Prime Males	2.215	2.099	2.129
	(1.978)	(1.970)	(2.094)
Fraction Prime Females	4.443	4.781	3.502
	(2.957)	(2.950)	(3.258)
Fraction Elderly Males	3.207	3.564	5.358
	(3.766)	(3.691)	(3.832)
Fraction Elderly Females	-3.333	-2.925	-2.892
	(3.658)	(3.605)	(3.928)
Age of Head of Household	0.040	0.031	0.033
	(0.032)	(0.031)	(0.033)
Years of Education of Head of Household	0.559***	0.520***	0.363*
	(0.173)	(0.170)	(0.219)
Small Farm (≤ 10 Ha)	-0.942	-1.233	-3.236*
	(1.568)	(1.515)	(1.946)
Small Farm * Farm Size	0.134	0.152*	0.332**
	(0.083)	(0.083)	(0.161)
Canton Level Fixed Effect			
Observations	639	639	639
R-squared	0.373	0.399	0.299
F-Stat of Excluded Instruments			6.98
Hansen-J P-Value‡			0.321

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
§ For first stage results, see Table 41.
† Average number of off-farm days worked in the past year by the household per adult aged 15 and up.
‡ Overidentification test of excluded instruments.

Table 43 Marginal Effects on the Natural Log of Area in Annuals, 1999

	(1) OLS	(2) OLS
Hundreds of Days of Off-Farm Work	-0.02**	-0.02**
	(0.01)	(0.01)
Farm Size in Hectares	0.01***	
	(0.00)	
Natural Log of Farm Size in Hectares		0.15***
		(0.02)
Walking Distance to the Road	0.02	0.02
	(0.01)	(0.01)
Distance via Road to the Population Center	-0.00**	-0.00**
	(0.00)	(0.00)
Farm Always Has Vehicular Access	0.14**	0.14**
	(0.06)	(0.06)
Soil is Black	0.15***	0.15***
	(0.05)	(0.05)
Duration Since Household Acquired the Farm	0.00	-0.00
	(0.00)	(0.00)
Log of Household Size	0.17***	0.17***
	(0.06)	(0.06)
Fraction Prime Males	0.08	0.08
	(0.16)	(0.16)
Fraction Prime Females	-0.27	-0.29
	(0.22)	(0.22)
Fraction Elderly Males	0.12	0.12
	(0.29)	(0.29)
Fraction Elderly Females	-0.16	-0.19
	(0.28)	(0.29)
Age of Head of Household	0.00	0.00
	(0.00)	(0.00)
Years of Education of Head of Household	0.01	0.01
	(0.01)	(0.01)
Small Farm (≤ 10 Ha)	-0.26***	
	(0.10)	
Small Farm * Farm Size	0.03**	
	(0.01)	
Canton Level Fixed Effect	Y	Y
Observations	639	639
R-squared	0.204	0.202

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX 7: DATA CLEANING WORK

Aggregating into Households

The original purpose of the data I am using was to track deforestation in the Northern Ecuadorian Amazon. Thus the data was collected separately for each property so that the changes in land use and land cover could be tracked. When the original round was conducted in 1990, there were a few families who owned multiple plots of land; however, by 1999 plot subdivision had resulted in 101 households which owned multiple plots. Because my research concerns the household as a unit, I had to aggregate the multiple plots owned by these households into a single household observation.

Originally, the questionnaire for the head of household (jefe) was collected for each plot which could be separately identified while the questionnaire for the spouse of the head of household (esposa) was collected for the household as a whole. Thus in any situation where there were multiple plots of land, regardless of whether there was a single owner or multiple owners, there was a single uniform esposa survey to which they were matched. Thus variables which were collected in the esposa questionnaire described either the entire household or the characteristics of the esposa herself, and thus required no manipulation to create the household observation. The jefe questionnaire; however, contained some variables which described the individual plot of land as well as others which described the household. Still others, particularly those in the section on land tenure and subdivision of the farm, described the individual who was answering the questionnaire. Thus to accurately aggregate the surveys it was necessary to determine if all plots were owned by the same individual or if there were multiple owners within the household.

To determine this, it was necessary to refer to the household roster on the original questionnaires as identifying information was not encoded in the dataset. There were a total of 235 jefe surveys and 103 esposa surveys which needed to be examined at this stage. During the examination, the general family relationship between the various questionnaires and any obvious discrepancies were noted.

After the examination of the questionnaires, there were two sets of questionnaires matched in the dataset were dropped (mcuest 469 & 512). For one of these sets, I could not determine why the two questionnaires were matched with one another. For the other, the questionnaires were answered by an employee of the owner of the property and the information on the esposa questionnaire was that of the employee, not the owner.

In the calculation of total household land holdings, there were several problems to overcome. Firstly, there were a number of cases where the farm sizes on the various household questionnaires did not match. For example, questionnaires mcuest=83 & 89 represented properties owned by the same household. Survey 83 identified the size of the property as 50 hectares, while on survey 89 it was identified as an additional property of 60 hectares. Likewise questionnaire 89 indicated a property size of 27 hectares, while the other survey identified this property as 30 hectares. When a case such as this arose, the size of the property was assumed to be correct on the survey for that property. This is because the surveyor had additional information on the property which they were surveying, while they merely took the word of the jefe with regard to the size of additional properties. Thus the sizes of farms recorded as additional on any survey were recoded to match the size of the farm as reported on the questionnaire for that particular farm.

After the household surveys were internally consistent, total household land holdings were determined by summing each of the following: the area of surveyed properties (c4), the area of other farms owned (c10), and the area of other farms rented, borrowed, or sharecropped (c11). From these, the total land in use, not included in the survey was determined by the following formula:

$$\text{Total Additonal Land} = \frac{(c10 + c11) - (n-1)c4}{n}$$

Where *n* is the number of jefe surveys completed by the household. However, this formula does not work if more than one person filled out jefe questionnaires. Thus it was again necessary to know who was interviewed. For many of these surveys, the relationships between the questionnaires was clear from the notes previously made, and the value of this variable was recoded appropriately. There were 62 surveys that needed to be examined a second time to determine more explicitly the relationship between all the people answering the questionnaires. For example if there were three questionnaires and two were noted as sons of the third it was necessary to determine if these were the same son or different sons.

Income from properties which were not included in the survey area were imputed by looking at the areas reported in the three most important crops for that farm and assigning the average income per hectare for that crop to the areas. This was included in the dataset separately from on-farm and off-farm income which had been computed previously.

During the collection of the data, every questionnaire was originally numbered with, in most cases, matching numbers for the jefe and esposa questionnaires for each household. Thus, to maintain this order for households with multiple jefe questionnaires, the one which corresponded numerically to the household esposa questionnaire was designated as the primary survey and the others were deleted leaving a single observation for each household.

Off-Farm Work Data

The Off-farm work data had several problems which needed to be solved. First and foremost among these was that there were a number of entries where the person number for a worker referred back to a blank entry in the household roster. This seemed to generally occur because the code for relationship to the head of the household was used in place of the person number. Thus a son, who was number 5 in the household roster, may have been coded as a 3 because that is the code for "son or daughter." These particular entries were just the tip of an iceberg however; as the more frequent occurrence was for this to simply refer back to the wrong person. This was particularly important to my research since the age and gender of the person working off-farm is a particular interest in my dissertation. Thus it was necessary to verify the validity of this code in all surveys. This was done utilizing the age of the individual from the household roster and the age of the worker recorded in table G4 (the off-farm work table). If these ages matched, then I considered the code to be correctly referring back to the household roster, if however; these ages were different, I looked at the data for the household and the worker to attempt to verify if the code was correct. In many instances, the difference in age was small (a year or two) and could be simply a difference in member between the jefe, who answered the off-farm work section, and the esposa, who completed the household roster. In these cases, the age in the household roster was considered to be correct, except when the individual under consideration was the jefe. In this case, I recoded the age of the jefe in the household roster to be the age he had reported for himself in the off-farm work section. For instances where the age difference was larger, I attempted to determine if the problem was with the age variable or the household roster reference number. In some of these situations I could determine that it was the reference number and fix the problem, in the remaining cases, I had to look at the physical surveys where the names of the individual was recorded in both places. This allowed for a definitive match in the remaining cases.

The second problem occurs with individuals who were outliers in terms of their reported income. For example in the category of “day laborer in agriculture,” the reported daily wage rates range from 5,000 Sucres to 600,000 Sucres, with an average of 24,872 Sucres. Likewise, for those reporting monthly wages, the range is from 15,000 to 3,500,000 Sucres with an average of 660,455 Sucres, which seems to be a reasonable average given the average daily wage. There are several possibilities for these outliers. Firstly for the daily wage rates, for some of the individuals, the wages may have been entered at a monthly rate rather than a daily one. This is also possible in the reverse incarnation for those reporting a monthly wage. Also, there may have been a problem with the data entry which created a difference of one or even two orders of magnitude between what was reported and the value coded. An additional consideration for those reporting a monthly wage is the number of days worked per month. However, this does not seem to fix the problem because the number of days worked does not seem to align properly with the monthly wage rate. For example, one individual reported working 6 days per month for which they earned 360,000 Sucres, or 60,000 Sucres per day while another reported working 12 days per month but earned only 15,000 Sucres or 1,250 Sucres per day. In addition the most extreme outlier earned 3,500,000 Sucres per month but reported only working 12 days resulting in a daily wage rate of nearly 300,000 Sucres. This problem must be fixed in some way, the method used is still not determined.

A third problem exists with those reporting daily wage rates, in order to calculate their earnings, it is necessary to multiply these wages by the number of days worked per month and the number of months worked per year. However, there may exist a problem with the days worked per month as many people reported working 30 days per month, which is fairly unlikely. In thinking about this problem, people working full time may have answered 30 days even when they only worked 5 or 6 days a week as there are roughly 30 days in a month. For others working the same number of days, the reporting could be as low as 20 days (5 days per week x 4 weeks per month). The question arises as to whether someone reporting working for 30 days actually worked more than someone reporting only 20 days of work. This is important because using the numbers reported we may be giving as much as 50% more income to the first individual even if they worked the same amount and hence earned the same income.

Merging the 1990 and 1999 datasets

The first step in merging the 1990 and 1999 datasets was to reconstruct the 6 digit id number assigned to the household in 1990. This was composed of three variables in the 1999 dataset. Then a preliminary merge was done using this number as the merge variable. This resulted in many cases of multiple households being matched to the same household in 1990 as there was a great deal of subdivision between the years and all households living on the property were identified with the 1990 id number for the farm regardless of whether or not they were living on the property at the time. Thus any households who had moved onto the property in the intervening years had to be eliminated. This was done by looking at the physical surveys to see if the names of the jefe and/or esposa were the same in the two years. I created a variable merge9099, which indicated the status of the 1999 household. Households which were the same in the two years were given a value of 1 while those that were different were assigned a value of 0. In addition, there were a number of households for which I was not certain if they were the same of different. An example of this would be a child who had taken over the household or in some cases, the household was on the 1990 survey but noted as living in a different house from the esposa who was surveyed. These unclear observations were coded with a 2. Additional notes were made if the new jefe or esposa was a child in the 1990 household. At the very end of this process I discovered a note on one of the surveys which led me to a variable constructed by a past user which seemed to be identifying whether or not the 1999 household was the same one interviewed in 1990. However, this variable did not coincide perfectly with the one I had created. The observations for which there was a difference between my assessment and the previous one were recoded with a value of 3 and I have plans to go back and check them again before I am finished merging the data. Once this process is completed all observations which do not appear in both datasets or which do not have a value of 1 in the merge9099 variable will be dropped leaving us with a longitudinal dataset which contains only households present in both years. There were a number of observations for which the 1990 id number was wrong. For these I recoded the id number to correspond with the id number of that household's 1990 survey.

Unfortunately, the steps previously outlined were necessary but not sufficient for the merge to take place. Upon closer inspection of the 1990 data, I realized that there were more problems than I had anticipated. I understood that the variables had different names in the two datasets, but I came to see that they also frequently had different coding and in some cases were different questions all together. For example, the question of vehicle access to the farm in 1999 (A25) asked "Is there vehicular access to the finca?" with the possible answers of 0=No, never, 1=Yes, all year, and 2=Yes, but it depends on the rains. The closest question to this in 1990 was named FACCESS which was "Vehicular access exists to ___________ line" with possible entries of 1-12. In order for these two questions to be compatible, the 1990 survey was modified to create a variable labeled A2590 which was given a value of one if the value of FACCESS was greater than or equal to the number of the line the farm was on, and zero otherwise. This makes the two variables similar, but still not the same. Given the limitations of the data from 1990, for the two questions to be truly compatible, the 1999 survey would have to be modified to recode values of 2 to 1. This has not yet been done, and I was wary of undertaking it unless absolutely necessary. In the end, I chose to create a series of compatible variables with the same naming system as the 1999 survey. Unfortunately, this proved to be a much more intensive task than I had anticipated and I had to abandon the attempt to merge the data midstream. As it currently lies, there are some variables for which I have created compatible variables, and some for which I was unable to do so. The task of merging these two datasets will require a great deal of additional time and effort before the two surveys will be able to be analyzed as a cohesive unit.

REFERENCES

Abdulai, A., & Regmi, P. P. (2000). Estimating labor supply of farm households under nonseparability: Empirical evidence from Nepal. *Agricultural Economics, 22*(3), 309-320.

Angelsen, A. (1999). Agricultural expansion and deforestation: modeling the impact of population, market forces and property rights. *Journal of Development Economics, 58*, 185-218

Angelsen, A., & Kaimowitz, D. (1999). Rethinking the causes of deforestation: Lessons from economic models. *The World Bank Research Observer*, *14*(1), 73-98.

Apps, P. F., & Rees, R. (1996). Labour supply, household production and intra-family welfare distribution. *Journal of Public Economics, 60*(2), 199.

Arguello, O. (1981). Estrategias de supervivencia: un concepto en busca de su contenido. *Demografia y Economia, 15*(2), 190-203.

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R. E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K., & Turner, R. K. (2002). Economic reasons for conserving wild nature. *Science*, *297*(5583), 950-953.

Barbieri, A. F. (2005). People, land, and context: Multi-scale dimensions of population mobility in the Ecuadorian Amazon. (Ph.D., University of North Carolina-Chapel Hill).

Barbieri, A. F., Bilsborrow, R. E., & Pan, W. K. Y. (2005). Farm household lifecycles and land use in the Ecuadorian Amazon. *Population & Environment, 27*(1), 1-27.

Barnum, H. N., & Squire, L. (1979). An econometric application of the theory of the farm-household. *Journal of Development Economics*, *6*(1), 79-102.

Becker, G. S. (1965). A theory of the allocation of time. *The Economic Journal*, *75*(299), 493-517.

Becker, G. S. (1993). *A treatise on the family* (Enlarged). Cambridge, Mass.: Harvard University Press.

Benjamin, D. (1989). An econometric analysis of farm labor demand in rural java. (Ph.D., Princeton University).

Benjamin, D. (1992). Household composition, labor markets, and labor demand: Testing for separation in agricultural household models. *Econometrica, 60*(2), 287-322.

Bhalotra, S., & Heady, C. (2003). Child farm labor: The wealth paradox. *The World Bank Economic Review, 17*(2), 197-227.

Bilsborrow, Richard E. (1990). Sample Design for Survey on Colonization and Deforestation in the Provinces of Napo and Sucumbíos (Ecuadorian Amazon Region). Chapel Hill, NC: Carolina Population Center, June, pp. 1-12.

Bilsborrow, Richard E., & Hogan, D. (1999). *Population and Deforestation in the Humid Tropics*. Paris, France: IUSSP.

Bilsborrow, R. E., Barbieri, A. F., & Pan, W. K. Y. (2004). Changes in population and land use over time in the Ecuadorian Amazon. *Acta Amazonica, 34*(4), 635-647.

Cahuc, P., & Zylberberg, A. (2004). *Labor economics*. Cambridge, Massachusetts: The MIT Press.

Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics*. New York: Cambridge University Press.

Cameron, A. C., & Trivedi, P. K. (2009). *Microeconomics Using Stata*. College Station, Texas: Stata Press.

Caviglia-Harris, J. L. (2004). Household production and forest clearing: The role of farming in the development of the Amazon. *Environment and Development Economics, 9*(2), 181-202.

Caviglia-Harris, J. L., & Sills, E. O. (2005). Land use and income diversification: Comparing traditional and colonist populations in the Brazilian Amazon. *Agricultural Economics, 32*(3), 221-237.

Chayanov, A. V. (1926). In Thorner D., Kerblay B. H. and Smith R. E. F. (Eds.), *The theory of peasant economy*. Homewood, Ill.: Published for the American Economic Association, by R.D. Irwin, 1966.

Chiappori, P. (1992). Collective labor supply and welfare. *Journal of Political Economy, 100*(3), 437.

Chiappori, P. (1997). Introducing household production in collective models of labor supply. *Journal of Political Economy, 105*(1), 191-209.

Deaton, A., & Muellbauer, J. (1980). *Economics and consumer behavior*. Cambridge; New York: Cambridge University Press.

Dinkelman, T. (2008). The Effects of Rural Electrification on Employment: New Evidence from South Africa. Working Paper. Princeton University.

Ehui, S. K., Hertel, T. W., & Preckel, P. V. (1990). Forest resource depletion, soil dynamics, and agricultural productivity in the tropics. *Journal of Environmental Economics and Management, 18*(2), 136.

Ehui, S. K., & Hertel, T. W. (1992). Testing the impact of deforestation on aggregate agricultural productivity. *Agriculture, Ecosystems & Environment, 38*(3), 205-218.

FAO. (2003). *Commodity market review: 2003-2004*. Rome: Food and Agriculture Organization.

FAO. (2007). *State of the world's forests, 2007*. Rome, Italy: Food and Agriculture Organization of the United Nations.

Ferreira, S. (2004). Deforestation, Property Rights, and International Trade. *Land Economics, 80*(2), 174-193.

Findeis, J. L., Lass, D. A., & Hallberg, M. C. (1991). Effects of location on off-farm employment decisions. In M. C. Hallberg, J. L. Findeis & D. A. Lass (Eds.), *Multiple job-holding among farm families* (1st ed., pp. 263-276). Ames: Iowa State University Press.

Foster, A. D., & Rosenzweig, M. R. (2003). Economic growth and the rise of forests. *Quarterly Journal of Economics, 118*(2), 601-637.

Geist, H. J., & Lambin, E. F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *Bioscience, 52*(2), 143-150.

Godoy, R., O'Neill, K., Groff, S., Kostishack, P., Cubas, A., Demmer, J., et al. (1997). Household determinants of deforestation by Amerindians in Honduras. *World Development, 25*(6), 977-987.

Goeschl, T., & Camargo Igliori, D. (2006). Property Rights for Biodiversity Conservation and Development: Extractive Reserves in the Brazilian Amazon. *Development and Change, 37*(2), 427-451.

Gronau, R. (2006). *Home production and the macro economy-some lessons from Pollak and Wachter and from transition Russia.* National Bureau of Economic Research, Inc, NBER Working Papers: 12287.

Hart, G. (1986). *Power, Labor and Livelihood: Processes of Change in rural Java*. Berkeley: University of California Press.

Heckman, J. J. (1974). Shadow prices, market wages, and labor supply. *Econometrica, 42*(4), 679-694.

Hiraoka, M., & Yamamoto, S. (1980). Agricultural development in the upper Amazon of Ecuador. *Geographical Review, 70*(4), 423-445.

Hite, K. (2004) Back to the Basics: Improved Property Rights can Help Save Ecuador's Rainforests. *Georgetown International Environmental Law Review, 16*(4), 763-794.

Huffman, W. E. (1991). Agricultural household models: Survey and critique. In M. C. Hallberg, J. L. Findeis & D. A. Lass (Eds.), *Multiple job-holding among farm families* (1st ed., pp. 350). Ames: Iowa State University Press.

INEC. (1992). *V censo de población y IV de vivienda; resultados definitivos*. Quito: INEC (Instituto Nacional de Estadística y Censos).

INEC. (2001). *IVI censo de población y I de vivienda, 2001: Resultados preliminares*. Quito: INEC (Instituto Nacional de Estadística y Censos).

International Labour Organization. (2007). *Key Indicators of the Labour Market, 5th Ed.* Geneva: International Labour Office.

International Monetary Fund. (2001). *World Economic Outlook December 2001*. Washington D.C.: International Monetary Fund.

International Monetary Fund. (2008). *World Economic Outlook October 2008*. Washington D.C.: International Monetary Fund.

Kanwar, S. (1999). Does risk matter? The case of wage-labour allocation by owner-cultivators. *Applied Economics, 31*(3), 307-317.

Key, N., Roberts, M. J., & O'Donoghue, E. (2006). Risk and farm operator labour supply. *Applied Economics, 38*(5), 573-586.

Kimhi, A. (2004). Family composition and off-farm participation decisions in Israeli farm households. *American Journal of Agricultural Economics, 86*(2), 502-512.

Kumar, S., & Hotchkiss, D. (1988). *Consequences of deforestation for women's time allocation, agricultural production, and nutrition in hill areas of Nepal*. Washington DC: International Food Policy Research Institute.

Malthus, T. R. (1999). *An essay on the principle of population*. New York: Oxford University Press.

Mena, C. F., Bilsborrow, R. E., & McClain, M. E. (2006). Socioeconomic drivers of deforestation in the northern Ecuadorian Amazon. *Environmental Management, 37*(6), 802-815.

Mendelsohn, R. (1994). Property Rights and Tropical Deforestation. *Oxford Economic Papers, New Series, 46*, 750-756.

Mishra, A. K., & Goodwin, B. K. (1997). Farm income variability and the supply of off-farm labor. *American Journal of Agricultural Economics, 79*(3), 880-887.

Mitchell, A. W., Secoy, K., & Mardas, N. (2007). *Forests first in the fight against climate change: The VivoCarbon initiative*. Oxford: Global Canopy Programme.

Myers, N. (1986). Tropical deforestation and a mega-extinction spasm. In M. E. Soulé (Ed.), *Conservation biology : The science of scarcity and diversity*. Sunderland, Mass.: Sinauer Associates.

Myers, N. (1988). Threatened Biotas: “Hot Spots” in Tropical Forests. *The Environmentalist*, *8*(3), 187-208.

Pan, W. K. Y. (2007). Forest clearing in the Ecuadorian Amazon: A study of patterns over space and time. *Population Research and Policy Review, 26*(5-6), 635-659.

Pan, W. K. Y., Carr, D. L., & Bilsborrow, R. E. (2004). Causes and consequences of farm fragmentation in Ecuador’s Amazon. Aberdeen Scotland. 90-95.

Pan, W. K. Y., Walsh, S. J., Bilsborrow, R. E., Frizzelle, B. G., Erlien, C. M., & Baquero, F. (2004). Farm-level models of spatial patterns of land use and land cover dynamics in the Ecuadorian Amazon. *Agriculture Ecosystems & Environment*, *101*(2-3), 117-134.

Pichón, F. J. (1993). Agricultural settlement, land use, and deforestation in the Ecuadorian Amazon frontier: A micro-level analysis of colonists’ land-allocation behavior. (Ph.D., University of North Carolina at Chapel Hill).

Pichón, F. J. (1997a). Colonist land-allocation decisions, land use and deforestation in the Ecuadorian Amazon frontier. *Economic Development & Cultural Change, 45*(4), 707.

Pichón, F. J. (1997b). Settler households and land-use patterns in the Amazon frontier: Farm-level evidence from Ecuador. *World Development, 25*(1), 67.

Pitt, M. M., & Rosenzweig, M. R. (1986). Agricultural prices, food consumption, and the health and productivity of Indonesian farmers. In I. Singh, L. Squire & J. Strauss (Eds.), *Agricultural household models: Extensions, applications, and policy* (pp. 153-182) Baltimore and London: Johns Hopkins University Press for the World Bank.

Rose, E. (2001). Ex ante and ex post labor supply response to risk in a low-income area. *Journal of Development Economics, 64*(2), 371-388.

Rosenzweig, M. R. (1980). Neoclassical theory and the optimizing peasant: An econometric analysis of market family labor supply in a developing country. *Quarterly Journal of Economics, 94*(1), 31-55.

Sadoulet, E., de Janvry, A., & Benjamin, C. (1998). Household behavior with imperfect labor markets. *Industrial Relations, 37*(1), 85-108.

Samuelson, P. A. (1956). Social indifference curves. *The Quarterly Journal of Economics, 70*(1), 1-22.

Singh, I., Squire, L., & Strauss, J. (1986). A survey of agricultural household models - recent findings and policy implications. *World Bank Economic Review, 1*(1), 149-179.

Singh, I., Squire, L., Strauss, J. (1986). *Agricultural household models: Extensions, applications, and policy*. Baltimore: Johns Hopkins University Press for the World Bank.

Thapa, K. K., Bilsborrow, R. E., & Murphy, L. L. (1996). Deforestation, land use, and women's agricultural activities in the Ecuadorian Amazon. *World Development, 24*(8), 1317-1332.

Trujillo, J. (1987). Los Pueblos Indígenas y la Colonización en la Amazonía Ecuatoriana. In CIPA and INANDEP (eds.), *Desarrollo Amazónico: Una Perspectiva Latinoamericana*. Centro de Investigación y Promoción Amazónica (CIPA) and the Instituto Andino de Estudios en Población (INANDEP), Lima Peru.

Udry, C. (1996). Gender, agricultural production, and the theory of the household. *Journal of Political Economy, 104*(5), 1010-1046.

United Nations. (2007). *World Population Prospects: The 2006 Revision*. New York: United Nations.

United Nations Development Programme. (2001). *Human development report, 2001: Making new technologies work for human development*. New York, N.Y.: Oxford University Press.

Walker, R. (2004). Theorizing land-cover and land-use change: The case of tropical deforestation. *International Regional Science Review, 27*(3), 247-270.

White, H., J. Leavy, and A. Masters (2003) “Comparative Perspectives on Child Poverty: a review of poverty measures” *Journal of Human Development*, Vol. 4, No. 3, pp. 371-396.

Wood, C. H. (2002). Land Use and Deforestation in the Amazon. In Wood, C. H. & Porro, R. (Eds.), *Deforestation and Land Use in the Amazon*. Gainesville, FL: University Press of Florida.