People, Land, and Context: Multilevel Determinants of Off-farm Employment in the Ecuadorian Amazon

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Abstract. This paper investigates factors affecting decisions of settler colonists to engage in off-farm employment (OFE) in rural or urban areas in the Northern Ecuadorian Amazon (NEA). While OFE decisions are ultimately a matter of individual choice, factors associated with the farm household and the local community also play key roles in this decision-making. Little empirical research, however, has been done on the simultaneous identification of such factors and their effects on labor mobility, and consequently on deforestation and urbanization in frontier areas. This research develops a multilevel conceptual framework and uses a multinomial, multilevel statistical model to study OFE in the NEA in 1999 as a result of factors at the individual, farm household, and community levels. The results show differences between movers and nonmovers in personal characteristics, human capital, farm household life cycle, land use, land management, farm environmental conditions, transportation accessibility, community size, and structure of local labor markets.

INTRODUCTION

Rural population mobility for economic reasons – namely, the search for off-farm employment (OFE)- is regarded as one of the most important catalysts of regional change and implies important demographic and economic consequences for movers and their households, changes in communities of origin and destination, and the spatial distribution of labor in a region. This is the case of the Northern Ecuadorian Amazon (NEA), one of the richest reserves of biodiversity in the world, which has faced profound changes due to population redistribution and mobility. Since the 1990s, population mobility due to OFE - broadly defined here to include diverse forms of temporary movement such as commuting or seasonal mobility, which do not imply a permanent change of residence – has been greatly adopted as a strategy of risk diversification and income maximization within the NEA. However, OFE has not been sufficient to alleviate poverty, environmental degradation and underemployment in the frontier nor in the areas of origin. Thus, in fragile tropical environments such as the NEA, an assessment of the causes of population mobility is particularly important to understand the underlying

causes of increasing deforestation, urbanization, and changes in income and welfare in the population.

More empirical research is necessary to address the implications of OFE in frontier areas, such as the NEA, and to clarify key associations between rural livelihoods, mobility strategies, deforestation, and urbanization. Pichón and Bilsborrow (1999), for example, found that the effect of OFE on deforestation in the NEA can be dubious. On one hand, OFE is likely to relax economic pressures underlying farmers' decisions to deforest their lands as well as to improve household income and capacity to invest in agricultural intensification; on the other hand, higher income from OFE can generate more investment in cattle and pastureland and increase the demand for, and consumption of, agricultural products and beef, thus engendering further deforestation. Research is also needed to assess if OFE to urban areas or other rural areas can substitute in many situations for out-migration and thus alleviate problems of crowding, pressures on urban infra-structure (Bilsborrow, 1998), or deforestation in the original farm plots.

Increasing urbanization in the Ecuadorian Amazon frontier involves recent rapid growth of some long-settled river towns, the formation of new pioneer urban areas, and the incipient transformation of many rural communities, which are acquiring urban characteristics through population growth and acquisition of basic infrastructure. Increasing economic and social articulation is also evolving between larger and smaller urban communities, constituting an incipient but increasingly complex network of urban places. Urbanization due to rural-urban mobility motivated by OFE seems to be facilitated by governmental policies and the dynamics of international markets, which affected the economic sustainability of agricultural activities, especially by negatively impacting the price of cash crops such as coffee, and originating a boom in the oil industry and urban-based economic activities. Furthermore, there is an increasing availability of non-agricultural jobs in the Amazon, especially in oil-related activities, urban services and public employment, and even short-term employment in larger farms in the Amazon.

Continuing rural-urban movements within the Ecuadorian Amazon tend to increase pressures on public facilities and services in local towns. Nonetheless, while in many cases population redistribution can be regarded as an "equilibrating mechanism"

which engenders a more efficient distribution of human capital and facilitating economies of scale in the provision of public services and infrastructure, it may also imply, given the selective nature of migration with the more educated and younger individuals moving more (in general, but not necessarily in the Amazon), that rural production is importantly affected by loss of educated manpower.

While OFE decisions are ultimately a matter of individual choice, it is very likely that factors associated with characteristics of the farm household and the local community also play key roles in decision-making. Little empirical research, however, has been done on the *simultaneous* identification of such factors and their effects on shaping decisions to move. This paper suggests a multilevel approach to OFE which articulates three distinct analytical levels: individuals, farm households, and communities. The literature on population mobility shows a paucity of this type of approach and has relied on single-level approaches, which only scratch the complexity involved in population mobility. This limitation is, to a great extent, the result of disciplinary biases and fragmentation of theoretical perspectives in the empirical literature Bettrel and Hollifield, 2000), scarcity of data at multiple scales, and until a decade ago or so, lack of adequate statistical methodologies to measure population mobility in a multinomial, multilevel approach.

PREVIOUS LITERATURE

The empirical literature on determinants of population mobility can be roughly subdivided between a focus on "micro-level factors" (individual and household) and "macro- or meso-level factors" (measured at the level of communities, municipalities, or higher spatial levels). These approaches are useful to identify key elements affecting population mobility, particularly due to off-farm employment strategies, in rural settings such as the NEA.

Ravenstein (1889) and Lee (1966) are considered two of the first migration theoreticians and, although inspired by some elements of Classical Economics, are usually not associated with a major theoretical body. Pioneer classical economists such as Malthus and Ricardo had only marginally discussed mobility as part of the mechanisms

determining wage levels (as proxy of subsistence levels) and labor supply. On the other hand, "dual economy models" (Lewis, 1954; Ranis and Fei, 1961) are a landmark in macroeconomic approaches to population mobility. In these models, mobility is the mechanism through which balance is restored in the distribution of factors of production such as land, capital, and labor; population mobility occurring from places of low productivity to high productivity.

The Human Capital approach focuses on individual decision-making processes based on individual factors such as age, sex, education, marital status, and occupational background (Sjaastad, 1962; Becker, 1964; Vanderkamp, 1971; Levy and Wadycki, 1974; Mincer, 1978; DeJong *et al.*, 1981; Da Vanzo, 1981; Massey, 1990; Milne, 1991). Following its neoclassical economic orientation, the basic assumption of the Human Capital approach applied to population mobility is that people are rational actors looking for maximization of the returns they can earn from moving or not moving. Labor mobility is considered a form of investment to increase income and involves a calculus of all the expected monetary costs and benefits over a certain range of time, which affects income based on the decision to move (Wood, 1982). Labor mobility decisions respond primarily to wage rate differentials both in the present, as well as expected in the future (Sjaastad, 1962; Todaro, 1969). Assuming that individuals have perfect information on income differentials between places, mobility decisions in the human capital framework are an individual utility-maximization problem, based on the comparison of the utility or personal satisfaction of staying or moving (Milne, 1991). While empirical applications of the human capital approach have mostly considered rural-urban labor mobility, rural-rural mobility may also be taken into account if assumptions about rationality and maximization of the returns are held.[1]

[1] As a contrast to this microlevel approach which considers mobility as an ahistorical decision-making processes, "structural approaches" such as "dependency" and "world-systems" theories discuss mobility in developing countries as a result, to a large extent, of the position of a country in the world economy (e.g., developing countries specializing as suppliers of raw materials and their urbanization associated with the growing of a large informal tertiary sector and a secondary sector) and the historical processes and political factors which led to their economic position (Wallerstein, 1974; Piore, 1979; Balán, 1983). Strategies of capital accumulation in core countries ultimately determine the forms of organization of production and the structure of labor markets in developing countries. Overall, dependency and world-systems theorists share the common assumption that underdevelopment is a consequence of the structural characteristics and of capitalism, and thus can be included in the broader definition of "structural approaches". Brown and Lawson (1985), for example, show that population mobility among cantons in Costa Rica is consistent with development-dependency models, while Wood (1982) and Radcliffe (1991) discuss structural approaches as a way to

An important change in the theoretical and empirical approaches to population mobility was the shift from an atomistic microeconomic perspective, or from a macroeconomic (country or regional) perspective, to a focus on households as the main unit of analysis. Household-level theories have been particularly useful to understand strategies and motivations regarding mobility taking into account not only individual aspirations in terms of income and welfare, but also collective needs of familiar group(s), especially in rural settings (see, e.g., Wood, 1982). The New Economics of Labor Migration, or NELM (Stark and Bloom, 1985; Katz and Stark, 1986; Stark and Lucas, 1988; Stark and Taylor, 1989, 1991) "bridges" the microeconomic orientation to the household level perspective by assuming not only some of the pillars of microeconomic theory (e.g., the "rationality" of income maximization, which drives mobility), but also mobility as a strategy of risk diversification, which can eventually lead households to a "suboptimal" decision to allocate their resources. In other words, households "trade" absolute income maximization strategies for strategies towards a safer, smaller income level that assures less risk to household income and welfare levels.

Two additional approaches focusing on the household level have been used to explain how demographic changes including population mobility are associated with changes in land use and living standards in rural areas: (1) "household life cycle" and (2) "Theory of the Multiphasic Response". While not directly being part of a theory on population mobility, "household life cycle" approaches may provide a link between household demographic factors and land use, which can ultimately affect OFE decisions. This approach draws upon Chayanov's theory of the peasant household (Thorner *et al.* 1986; Ellis 1988; Leinbach and Smith, 1994) and has been adapted by several authors to the Amazonian context (e.g., Walker and Homma 1996; Marquette 1998; Perz 2001; McCracken et al. 2002; Walker *et al*. 2002; Moran *et al*. 2003; Barbieri et al., 2005). Household life cycle approaches discuss how demographic and land use processes at the household level are intertwined and determine a particular demand and supply of labor, which can eventually create excess supply of labor to be allocated in some form of mobility.

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understand the complex nature of population movements, especially their dependence on broader socioeconomic and political change in national or international contexts.

Household motivations to adopt land extensification or intensification, as well as mobility or some type of fertility control, are addressed by a comprehensive model suggested by Bilsborrow et al. (1987), built upon Davis' (1963) "Theory of the Multiphasic Response". In the original formulation by Davis (1963), the "Theory of the Multiphasic Response" explains how family decisions to migrate or change fertility behavior are alternative responses to population pressures on limited resources. Based on the experience of the industrializing of Japan and Europe in the 1940s and 1950s, Davis suggested that the decline in mortality, sustained natural increase, and the consequent population pressures on land are a powerful stimulus for families to control fertility through demographic responses, such as marriage postponement, contraception, sterilization, abortion, and as a last resource, migration outward (if the other responses proved inadequate). Motivations to adopt one response, or a combination of responses, are linked to the fact that families associate population growth with the loss of opportunities to maximize status and welfare. Responses are concurrent (or "multiphasic") in the sense that households can adopt responses simultaneously as a result of population pressures (i.e., the higher the prevalence of one type of response and the higher its effectiveness in relieving negative pressures on living standards, the less likely other responses will occur) (Bilsborrow et al., 1987).

Bilsborrow et al. (1987), Bilsborrow and Okoth-Ogendo (1992), and Bilsborrow and Geores (1994) suggest that the Theory of the Multiphasic Response as proposed by Davis (1963) is not adequate to consider the effects of nondemographic responses in the face of threats to living standards in rural areas, which include the application of a new technology in the agricultural system and the extension of the land area under cultivation. The incorporation of economic and economic-demographic responses proposed by Bilsborrow and colleagues is an important step to expand the range of responses and to explicitly incorporate labor mobility as a response to population pressures on farm resources, together with land management strategies (extensification and extensification) and fertility regulation. These are the four concurrent strategies to diversify risk and achieve desirable income and welfare levels.

The NELM, household life cycle, and the Theory of the Multiphasic Response implicitly assume an important association between mobility and search for OFE as a

way to minimize risk and the selective nature of migration, since the chosen mover in a household is most likely the one with better "human capital" endowments (e.g., higher education and OFE experience) or certain personal attributes (e.g., being younger, or women moving proportionately more to urban areas compared with men). Mobility is expected to generate more benefits to the household, especially in terms of remittances (Stark and Levhari, 1982).

The empirical literature on population mobility on frontier areas has also traditionally given attention to factors at aggregate levels immediately above individuals and households (i.e., communities and villages) as important determinants of population mobility. Socioeconomic and institutional factors mediating mobility decisions can include, for example, the segmentation of labor markets; policies fostering the opening of roads; inadequate credit or titling policies; and other social, cultural, and political-institutional factors. In particular, policies fostering the opening of roads in frontier areas have reduced physical and economic barriers to population mobility into, or within, rural areas in the Amazon (e.g., Burt *et al.,* 1960; Moran, 1983; Rudel, 1983; Schmink and Wood, 1984; Southgate *et al.,* 1991; Almeida, 1992; Pichón, 1996; Nelson and Hellerstein, 1997; Pichón, 1997a; Pichón, 1997b; Rudel and Roper, 1997; Laurian *et al.*, 1998; Pender, 2004). Da Vanzo (1981, p. 111) observes that "one of the most consistent findings in empirical migration analysis for both developed and developing countries is a strong negative relationship between the distance separating two places and the relative size of the migration flow between them, other things being the same". Road accessibility in frontier areas allows the expansion of consumer markets for agricultural and other types of products in a region, as well as facilitates the mobility of labor within and outside the region. Road accessibility also facilitates policies on property rights, subsidizing lands, or open (or cheap) access to land (e.g., Lisansky, 1990; Almeida, 1992; Angelsen, 1999).

Environmental characteristics at the farm also have an important impact on household and individual decisions to move. It is usually difficult, however, to define how such factors can be operationalized. Factors such as soil quality or environmental contamination can be conceptualized at both farm household and community levels. These conceptualizations can also be made at even larger levels, such as countries, if

certain effects are considered: (a) exogenous consumption patterns (e.g., demand for wood or oil in developed countries) on the organization of production in developing countries and (b) their effects on engendering population mobility. These factors must be understood, however, as interacting with a plethora of other socioeconomic and institutional factors involving, for example, permissive environmental laws, urban markets, or international out-migration.

THE NORTHERN ECUADORIAN AMAZON

The Ecuadorian Amazon, a region also known in Ecuador as the "Oriente", is located in the western Amazon Rain Forest and together with the Coastal region and the Highlands ("Sierra") represents three distinct landscapes in the country (Figure 1). The study area in the Northern Ecuadorian Amazon (NEA) encompasses the provinces of Sucumbios (which includes the towns of Lago Agrio and Shushufindi) and Orellana (which includes the towns of Coca and La Joya de Los Sachas).

[Figure 1 – about here]

While oil exploration in the NEA dates from 1940, the study area only began to be occupied by agricultural settler families after the discovery of extensive and commercially viable reserves of oil in 1967. This was followed by the laying of pipelines and a road network for the exploitation of oil and the establishment of the town of Lago Agrio. A consortium led by Texaco was responsible for constructing trunk roads from Quito east to Lago Agrio and Coca, in the NEA (Bromley, 1981; Murphy, 1998). From the mid-1970s to the present, the oil exploited in the NEA has generally been responsible for producing half or more of both foreign exchange earnings and government revenues in Ecuador (Bilsborrow *et al.,* 2004).

Virtually all of the colonization in the NEA has been spontaneous. Most of the colonists were poor, arrived without capital to invest in their plots, and faced a lack of infrastructure or governmental assistance. Two of the main drivers of colonization were a) the opening of roads by oil companies which greatly improved physical accessibility, and b) the concentrated agrarian pressures in the Sierra. (In fact, even though it is intensively occupied by agricultural settlers, the region still attracts migrants from the Sierra).

KEY CONCEPTS

"Scale" and "level". Issues about appropriate space and time of analysis of population mobility reflect the broader discussion of the importance of "scale" in studies involving natural and social processes (Gibson *et al.*, 2000; Wood, 2002). Gibson *et al.* (2000, p. 291) define scale as the "spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon". While the concept of a "multi-scale approach*"* may be more adequate to refer to multiple levels along spatial *and* temporal scales, the concept "multilevel*"* has been used mostly in the literature to describe regions on *spatial* scales. This paper also uses this approach, and defines the concept of "level*"* to describe a "region" along a spatial scale. Following the empirical literature on population mobility (Zhu, 1998; Yang and Guo, 1999; Ezra, 2003; Henry *et al.,* 2003), three regions along a spatial scale are defined in this study: (1) individuals, (2) farm households, and (3) communities.

Farm households and communities. A farm household in the NEA constitutes a place of residence for one or a few families, usually linked by kinship ties. It is also the place of work and basic income generation for all, or almost all, household members. All farm households in the Northern Ecuadorian Amazon can be associated with a reference community consisting of a population center (*centro poblado*) where some basic infrastructure and services can be found. Farm households are usually located near the *centro poblado* and secondary roads crossing the community, though most are dispersed given the large size of plots and the fact that farmers usually live on their plots, not in the *centro poblado*. There is a high variability in community size and characteristics, with some presenting only minimal infrastructure and services while others have diversified infrastructure and services, such as Lago Agrio—the largest town in the region.

Off-farm employment (OFE). The definition of off-farm employment (OFE) refers to those individuals declaring the farm household as a *permanent* place of residence at the time of the survey interview in 1999, but who left the household temporarily to engage in off-farm work for at least one month (in total) in the twelve months preceding the survey. This OFE definition emphasizes a type of mobility mainly

for household income generation and includes a broad range of definitions of *temporary mobility* according to time, destination, and purpose for moving. For example, this OFE definition coincides with the concept of *circulation* proposed by Zelinsky (1971): a sporadic and seasonal movement for employment and income generation reasons in which the migrant has no intention of a permanent or long-lasting change in residence. Other definitions found in the literature which could apply to OFE as proposed in this research are "turnover migrants", "pendular migrants", "target migrants", "seasonal migrants", "temporary migrants", and "compensatory migrants" (Bilsborrow *et al.*, 1984). The definition of OFE also includes the concept of *commuting*, which can involve daily movement, or moves for a few days between work place and residence. While most common in industrialized countries, *commuting* can also occur in areas of increasing urbanization and labor specialization (e.g., oil industry workers). *Commuting* is an important form of mobility in the NEA, where larger farms, oil companies, and urban areas might hire temporary labor.

HYPOTHESES ON DETERMINANTS OF OFF-FARM EMPLOYMENT

Determinant Levels

This paper defines key factors, based upon a review of the literature, which constitute important determinants of OFE at three levels: individuals, farm households, and communities.

Individual level. At the individual level, a group of variables measures the effects of *personal attributes* on OFE. Following virtually all studies since Ravenstein (1889) and Lee (1966), OFE is associated with stages in individual life cycles characterized by *younger ages*. *Gender* also tends to be a significant personal characteristic affecting mobility, with women moving proportionately more to urban areas compared with men. Closely related to age and gender but measuring a distinct concept, *marital status* is expected to be a significant predictor of mobility. Singles tend to move proportionally more than married couples; singles also move more to urban areas, while married couples move proportionally more to rural areas.

Another group of variables measures the effects of *human capital* on OFE. Individuals with *farm work experience only* tend to move more to rural areas or do not move; those without farm work experience tend to move to urban areas. Finally, it can be expected that farm households, particularly in urban areas, tend to select individuals with *higher education* and previous off-farm experience for OFE, since expected income returns are higher.

Farm household level. At the farm household level, some hypotheses measure the effects of *household composition and life cycle* on OFE. *Age of household head* indicates how a particular living experience in the settled area influences household decisions to allocate a member on OFE or not. The older the age of the household head, the less the mobility because it implies a position in the life cycle where older individuals usually have a smaller insertion in off-farm labor markets. *Number of adults and adolescents at working ages* and n*umber of children* test the relationship between producers and consumers and OFE from the farm households. It is hypothesized that a higher number of producers (adults or working-age adolescents) reduces returns to labor at the farm and thus incentivizes mobility, while a larger number of children can imply a situation of labor scarcity and thus higher returns to labor, which decreases incentives to move.

Among *land use* hypotheses, a high proportion of *land in crops or perennials* demands more labor, thus negatively impacting mobility; a higher proportion of *land on pasture* also has a negative impact on OFE but to a smaller extent compared with crops and perennials, since it usually demands less labor.

Among *land management hypotheses,* land extensification as indicated by a *larger farm area* tends to reduce OFE; land intensification as indicated by the use of *chemical inputs,* tends to reduce OFE, due to higher farm yields and productivity (reducing the necessity of supplemental off-farm income). *Hired farm labor* can be regarded as an indication of either land intensification, since it can reflect a higher labor input for a fixed amount of land, or land extensification, if the hired labor is for activities such as land clearing. Hired labor's effect on OFE is dubious. It can reflect labor shortages at the farm household level (e.g., a small household size with a scarcity of adult or adolescent labor, or a large household size but a high proportion of non-working

children) or even a more complex household strategy in which household labor is allocated for more profitable off-farm activities and cheap labor is hired in substitution. *Land title* suggests a degree of land security and consequently a settler's commitment to live, invest, and produce on their land, thus being negatively associated with OFE. Finally, *credit or technical assistance* indicates the accessibility to resources that allows improvements in farm production and living conditions and an investment in land intensification or extensification, with a corresponding reduction in OFE.

Two additional hypotheses are tested at the farm household level. *Environmental contamination* measures if the farm had any form of environmental contamination (soil, air or water). It is expected that environmental contamination degrades farm resources and human health and thus impacts OFE positively. *Walking distance* indicates the distance, in kilometers, from the farm household to the nearest road. It is expected that the greater the walking distance, the less the mobility from farm households, especially for types of OFE which imply higher mobility—such as commuting.

Community level2. Among community-level hypotheses, *distance to the nearest town* measures the distance, in kilometers, from a reference point in the community (e.g., a school) to the closest town. It is assumed that a closer proximity to a town facilitates circulation of people and goods, increasing OFE, and decreasing out-migration. *Community size* refers to the population of the four towns and rural communities in the study area. These may have basic infrastructure such as electricity; local markets (complementary to town markets); health, educational, religious and educational services; and roads linking to larger towns. Furthermore, they might increasingly acquire urban features as they grow, creating new employment opportunities, opportunities for social interaction, economies of scale for investments in infrastructure, political force, or facilitating labor fluxes between community residents and other places. Larger communities, in particular the four main towns, are associated with urban features and a pattern of social organization that can facilitate the retention of potential movers. This relationship between population size and mobility refers to the effect of population

[2] Other community variables tested but which did not show significance in the models of OFE (equations 1 and 2) include: electricity, presence of credit/agricultural development/technical assistance agencies, and presence of a church.

growth and size at the *place of origin*. Finally, two hypotheses test the effects of *labor markets* on OFE: communities with a larger *secondary sector*, and communities with a larger *tertiary sector* absorb surpluses of rural labor force in the community, increasing local mobility due to local OFE opportunities[3].

DATA

This study uses a sample of 611 farm households in the NEA which were surveyed by researchers from the University of North Carolina at Chapel Hill in 1999. These farms were selected from a two-stage PPS (Probabilities Proportional to Size) sampling strategy (see detailed description in Bilsborrow *et al.,* 2004). The total population living on the 611 farm households was 3,746, from which 2,216 were aged 12–59 y. A separate community-level survey was undertaken in 2000 and obtained information on 43 rural communities linked to the 611 sample farms. A farm household is considered to be associated with a specific community if the road distance (in Km) between the farm household and the central point in the community (such as the community center or school) is the shortest one, compared with other communities in the sample region. The community dataset is complemented by information provided by the 2001 Ecuadorian Census on the community population and labor force by the sector of economic activity (primary, secondary, and tertiary sectors).

A MULTILEVEL MODEL OF OFF-FARM EMPLOYMENT

Consider a three-level model, with Y_{ijk} defined as a binary response, indicating if individual i in farm household j and community k moved (=1) or not (=0); and let $E(y_{ijk}) = p_{ijk}$. Let $\pi_{ijk} = \left(\frac{p_{ijk}}{1 - p_{ijk}} \right)$ represent the odds that the individual will move. The binomial multilevel model is:

[3]The tertiary sector included low paid, formal, and semi-informal activities in retail, transportation, commercialization, etc., as well as informal activities such as domestic service, which may constitute a broad source of employment for community population, and an alternative for the allocation of farm labor during some part of the year. The secondary sector refers mostly oil extraction, but also agricultural processing, such as coffee roasters, rice huskers and sawmills

$$\log \pi_{ijk} = \gamma_{000} + \sum_{i=1}^{n}(\gamma_{\mathrm{i}} \mathrm{a}_{\mathrm{ijk}}) + \sum_{j=1}^{p}(\gamma_j x_{jk}) + \sum_{k=1}^{q}(\gamma_k w_k) + (u_{0jk} + u_{00k}), \quad (1)$$

where γ_{000} represents the intercept; $\sum_{i=1}^{n}(\gamma_{\mathrm{i}} \mathrm{a}_{\mathrm{ijk}}) + \sum_{j=1}^{p}(\gamma_j x_{jk}) + \sum_{k=1}^{q}(\gamma_k w_k)$ represents a) a vector of i=1,2,…,n independent variables at the individual level (a), a vector of j=1,2,…,p independent variables at the farm household level (*x*), and a vector of k=1,2,…,q independent variables at the community level (*w*); b) γ_i, γ_j and γ_k represent a vector of the effects of an independent variable at the individual, household or community levels, respectively, that is, the *ceteris paribus* changes in the log-odds of OFE for a given variable. The terms *u* are the random effects representing unobserved factors operating at the farm household and community levels. The random effects are assumed to be normally distributed [$u \sim N(0, \sigma^2_u)$].

The multinomial multilevel model can be derived from equation (1). Denote the categories of response as r: r =1, if the choice of destination is the local community, r=2 if the destination is another rural area, r=3 if the destination is other urban area, and s=0 if the individual chooses not to move (s = r = 0). In this situation, the fitted multilevel multinomial model can be written as:

$$\log\left(\frac{{}_r\pi_{\mathrm{ijk}}}{{}_s\pi_{\mathrm{ijk}}}\right) = {}_{\mathrm{r}}\gamma_{000} + \sum_{i=1}^{n}({}_{\mathrm{r}}\gamma_i \; {}_{\mathrm{r}}\mathrm{a}_{\mathrm{ijk}}) + \sum_{j=1}^{p}({}_r\gamma_j \; {}_r x_{jk}) + \sum_{k=1}^{q}({}_r\gamma_k \; {}_r w_k) + ({}_r u_{0jk} + {}_r u_{00k}), \quad (2)$$

where $\log\left(\frac{{}_r\pi_{\mathrm{ijk}}}{{}_s\pi_{\mathrm{ijk}}}\right)$ represents the log-odds of having an event of type r rather than an event of type s, the reference category (the decision of not moving). The coefficients ${}_{\mathrm{r}}\gamma_i$, ${}_r\gamma_j$, ${}_r\gamma_k$ represent the log-odds of OFE in location r versus not moving (the baseline, s). The interpretation of the random terms is similar to the binary multilevel model. The model can be considered an extension of the binary models, since it estimates simultaneously binary logits for all possible comparisons among the outcome categories (Long, 1997). The model includes the same assumptions of the binomial model in terms of conditional dependence and normally distributed random effects.

Overall, the great advantage of multilevel statistical models is to fully specify the distribution of the population by introducing a random coefficient which measures the extent to which the mobility of individuals in the same farm household or community

resembles each other as compared with the mobility of individuals in different farm households and communities. The consequence is usually better estimates of fixed effects.

The models described in Eqs. (1) and (2) are *random intercept models* in which the only variation between households and communities is in their intercepts, given by the random terms. The risk of OFE is estimated for individuals aged 12–59 y, thus assuring age limits that deal only with persons old enough to be directly involved in OFE, but not so old as to not move due to declining health or retirement.

RESULTS

Descriptive results

Off-farm employment by location and type of work. Table 1 shows the number and distribution of persons engaged in OFE, by location of work and type of employment. It shows that 23% of the entire sample population was engaged in OFE in the twelve months preceding the survey interview in 1999 (507 individuals of the 2,216 at risk population). Agricultural labor was by far the most common type of OFE in the study area, involving 13% of the total sample population and 57% of all OFE. Nonetheless, most of the agricultural OFE labor was in the community (78%). "Services" were the second most common type of OFE, especially in urban areas (44% of workers in this type of employment) and in the community (30%). "Professional/technical" and "Other" employment opportunities were mostly concentrated in urban areas (54% and 56%, respectively), while manual work in oil companies was mostly in rural areas (71%). "Self-employment" occurred mostly in urban areas or within the community.

[Table 1 about here]

Factors at the individual level. Table 2 shows the means and standard deviations for individual-level explanatory variables included in the model of the determinants of OFE, according to place of destination (1998–1999). Individuals engaged in OFE were mostly in the older age groups (> 24 y). Considering the young age pattern of marriage, common in frontier areas, may suggest that OFE was predominantly a household strategy

of income generation and risk diversification involving older farm household members, especially the head, his wife or older sons or daughters—probably in periods when demand for farm labor was low (e.g., between planting and harvesting seasons). Finally, the results showed a younger age composition of the farm labor force (i.e., those not engaged in OFE).

[Table 2 about here]

Among variables measuring *personal attributes,* women were mostly associated with urban OFE (a mobility corresponding to their great out-migration especially to urban areas), or remaining in the farm and having little insertion in the local community or rural OFE. Table 2 also shows virtually no difference between movers regarding marital status; the majority of those looking for community, rural, or urban employment were married or in other forms of consensual union, with equal numbers of singles and married not engaged in off-farm work.

Among *human capital variables,* there was little difference between education level of those involved in short-range employment mobility (OFE in the local community) and those not engaged in OFE. However, the difference was much greater for those working in other urban or rural areas (longer range mobility) that had considerably higher educational attainment. In particular, those engaged in urban OFE had more education, which was expected, given the requirements of higher education for many urban jobs. Overall, the results suggest that those with more education were more likely to take advantage of employment opportunities farther from their farms, due for example, to more access to information as well as access to labor markets where higher education was required.

Table 2 shows little difference across groups engaged in farm work except for those working in urban areas. In this case, engagement in farm work and urban employment had a smaller association. There was a higher association between those engaged in farm work and those involved in OFE in the community. Obviously this reflects, as expected, the fact that being a short distance from employment opportunities in the community facilitated commuting.

Factors at the farm household level. Table 3 shows the means and standard deviations for farm household-level explanatory variables included in the model of the

determinants of OFE, according to place of destination (1998–1999). Among *farm household composition and life cycle* variables, there are small differences between the ages of the household head across places of OFE. The slightly lower mean age for those choosing urban destinations could indicate an association between earlier positions at the farm household life cycle and urban employment, but also the effects of weighting household variables by person-weight (see footnote in Table 3). Those not engaged in OFE had the oldest age of household head, indicating that older cohorts of colonists may have had less access, or desire, to engage in OFE.

[Table 3 about here]

The results show an association between large household size (numbers of adults and children) and OFE outside the local community—specifically in the case for other rural areas—and non-engagement in off-farm work. This suggests that larger households may allocate family labor in traditional rural activities within the farm or elsewhere, with the largest also having enough members to allocate to rural work. On the other hand, those in which someone engaged in urban work were much smaller in terms of both numbers of adults and children in the household.

Urban OFE was associated with a smaller number of children. The smaller number of children and a smaller farm size may facilitate urban work; urban work is the most incompatible with child care and a small farm size (see farm area below) means that there is less need for farm labor, freeing up labor. However, the most important factor in urban OFE was probably the much higher education of this group, as discussed previously.

Among *land use* variables, Table 3 shows that that most land in the NEA farms was in pasture rather than crops/perennials. Farms with less land in crops/perennials and in pasture were more likely to have people involved in OFE. Considering places of OFE, farms with more land in pasture were more likely to have people working in other urban areas. This may indicate an important association with strategies of allocating labor to urban areas and investment in pasture and cattle. Individuals not engaged in OFE usually had more land in crops/perennials and pasture (as well as larger farms), suggesting, other things equal, a strategy of income generation based on farm production using household labor.

Among *land management* variables, as expected, having more land was associated with a less likely engagement in OFE. Among those in OFE, farms with more land were associated with people involved in rural off-farm work. Smaller farms tended to be associated with OFE in the community or in urban areas. Table 3 also shows that lack of land security was more associated with OFE, especially within the local community (that is, short-range mobility). Thus, land insecurity may have limited job search to the immediate community. Farm households with less use of credit and technical assistance were more likely to have members engaged in OFE, especially in urban areas, perhaps because they did not seek such assistance, or lacking it, were not as successful in their farm work, so they sought urban work.

Two variables measured land intensification: chemical inputs and hired labor. Less use of chemical inputs was linked to people more likely to be engaged in OFE, especially in the community or other urban areas. The higher land productivity, if associated with land intensification, may have helped retain farm labor. The other relevant variable available was hired labor, which may refer mainly to land intensification. Hired labor was much higher for farm households with individuals engaged in either rural or urban employment away from the local community, as expected. This may suggest a substitution of farm labor for hired labor; in particular, since women tended to be proportionally more engaged in urban employment than men; this may reflect farm labor allocation decisions in which female farm labor was replaced by hired (usually male) farm labor.

Table 3 shows that a higher proportion of individuals living in farms with *environmental contamination* (particularly oil spills) were associated with OFE in other rural areas. This may indicate limitations in farm production due to the contamination of natural resources, with farm households looking more for off-farm supplemental sources of income. Finally, shorter walking distances to the nearest road seemed to be a facilitator of urban OFE. There evidently was a powerful effect of walking access to the farms on the ability to engage in urban employment. This was particularly relevant for women, due to their proportionally higher insertion in urban labor markets.

Factors at the community level. Table 4 shows the means and standard deviations for community-level explanatory variables included in the model of the

determinants of OFE, according to place of destination (1998–1999). *Distance from the community* center (more specifically, from a geo-referenced landmark in the center of the community, such as a local school, a road intersection, or community center) to the nearest town shows small differences between urban off-farm work, other places of OFE, or no engagement in OFE. Again, it shows that farms closer to towns were more likely to have people in OFE overall, especially in urban areas.

[Table 4 here]

Farm households located in *larger communities* were more likely to have individuals working in urban markets. Larger communities had infrastructure and other characteristics, such as higher education and an "urban-like life style", and offered more possibilities for urban employment. At the other extreme, smaller communities were more associated with local community OFE. Finally, there were virtually no differences between those engaging in OFE and those not moving, in terms of the proportion of labor force in the *secondary sector*. This was because employment in the secondary sector was low, and tended to be similar between smaller and larger towns. On the other hand, farms near communities with a larger *tertiary sector* were more likely to have people engaged in urban areas OFE. This may be explained by the broad composition of activities in the tertiary sector.

Results of the multilevel model

Four models are estimated. Model 1 estimates the determinants of OFE vs. not OFE, without taking into places of destination, while Models 2a, 2b, and 2c distinguish, respectively, between OFE in the local community vs. not OFE, in other rural areas vs. not OFE, and in other urban areas vs. not OFE. For easy of presentation, the results are divided in three parts, each one with a table showing the coefficient estimates followed by a table showing the estimates of percent chage in the odds rato: a) the results for individual effects, b) the results for household effects, and c) the results for community effects. Albeit presented separately, all the regression results for individual, household and community effects are from a single model (that is, simultaneously estimated using the multivele approach described in the preceding section).

Individual level. Tables 5 and 6 show, respectively, coefficient estimates and the percent change in the odds ratio of individual-level variables in the multilevel models of OFE. An individual in the intermediate age groups (18–24 and 25–34) in Model 1, had lower odds to be engaged in OFE than an individual in the age group 12–17. In fact, for an individual between 18 and 24, the odds of working away were almost 100% less compared with an individual in the age group 12–17 (Models 2a, 2b and 2c); and an individual aged 25–34 was also less likely to move away, albeit the odds were less. The youngest were most likely to engage in temporary (rather than permanent mobility such as out-migration) forms of mobility due to their age, lack of experience in working for pay, and higher bonds to the farm household (e.g., cultural or social norms which made it difficult to move away from the farm at a young age) (Barbieri and Carr, 2005). The only exception in Tables 5 and 6 was for those in the age group 35–59 engaged in urban work; the odds of OFE were 20.5% *higher* than in the reference group (12–17). A person in this age group who engaged in urban OFE was probably the household head or his spouse.

[Table 5 about here]

[Table 6 about here]

The coefficient estimates and odds ratios show that women were much less likely to engage in OFE than men. Women tended to be more engaged in urban activities, as shown in Table 2; even though, the odds of OFE were still considerably higher for males (122%), contrary to expectations. It is likely here that gendered characteristics of OFE were different from out-migration (permanent change of residence), in which case women had higher odds to move to urban areas when compared with men (Laurian *et al.,* 1998; Barbieri and Carr, 2005). The effect of being single was significant only for community OFE; the odds of being in OFE decreased by 36% when compared with a married individual. However, the statistical significance is low ($5\% < p < 10\%$). This is probably related to the older age pattern involved in this type of mobility, with movers usually being the head of household, as suggested in Table 2.

Education was not significant in the overall model of OFE (vs. not in the OFE; Model 1), but had a distinct effect when community or urban OFE was considered. Regarding urban work destinations, the results confirmed the hypothesis, showing a highly significant effect of human capital on urban employment; having at least some

secondary education increased the odds that an individual would engage in urban OFE—by almost 300%. Individuals with higher education were more likely to work in urban areas for at least some time during the year, both as a strategy to maximize income, but perhaps also due to the motivation of engagement in an "urban life style". On the other hand, having more education implied 40% less odds of being engaged in local community off-farm work. This explains the small expected returns, both in terms of income and personal satisfaction offered by employment in the local community.

An individual with previous experience in farm work had only 36% lower odds of engagement in OFE in general (Model 1). This shows that previous farm work contributed to farm labor retention. The effects of previous farm work on OFE had, however, a distinct direction when considering OFE by place of work. While engagement in farm work increased the odds of community OFE by 70%, it decreased the odds of urban OFE by 66%. In the first case, it suggests that temporary work, for example, helped in land clearing in other farms of the community, may have been compatible with the labor demands on the farm household. In the second case, the "opportunity cost" of urban OFE might have been high for those also involved in farm work, for example, due to transportation time costs to urban areas or the demands of specific tasks in the farm household, such as women nurturing small children. Perhaps most important, however, was the lack of occupational backgrounds in other activities since farming offers few skills useful for urban activities.

Farm household level. Tables 7 and 8 show that one additional adult living in the farm household slightly increased the odds that an individual would engage in overall OFE (Model 1), but the result was only marginally significant. Among destinations, the data showed that the main significant effect was on increasing the local community OFE; one additional adult increased the odds by almost half. As expected, given decreasing returns to farm labor, households with larger numbers of adults appeared more likely to allocate adult labor in the local community OFE during some part of the year.

[Table 7 about here]

[Table 8 about here]

An additional child in the farm household had no effects on overall OFE (Model 1) but did significantly increase the odds of OFE in each locus of work or OFE, contrary

to expectations. The highest effect was for rural OFE, with the odds increasing 38% for each additional child. The smaller percent changes in odds ratios occurred for urban OFE (20%) and in community OFE (28%). These results showed that, rather than an incentive to retain farm labor, households allocated farm labor more to a variety of off-farm activities to meet the higher subsistence or welfare needs of an increasing number of consumers.

Finally, the age of the household head was significant and had an inverse relationship in all models in Table 7, as expected. The largest effects occurred for work in the local community or urban employment; one additional year in the age of the household head decreased the odds of OFE by 6%. The age effect on rural OFE (2%) was smaller than on urban OFE.

Tables 7 and 8 show that land use variables had an inverse relationship with OFE in all models. Overall, the results suggested a strong association between land and labor use on the farm[4]. Model 1, for example, showed that one additional hectare of land in crop or perennials was associated with 12% smaller odds that an individual would engage in OFE, while the association is only 2.5% in the case of land used as pasture. (Remembering that since land size is controlled for, the variables reflected land use share). These are strong results, totally consistent with theoretical expectations. When considering the place of off-farm work, the effects of land use that were significant for a specific land use were not always significant for the other; thus, one additional hectare of land in pasture was associated with a decrease in the odds that an individual would engage in community OFE by 8%, but one additional hectare in crops or perennials was associated with a decrease in the odds by twice as much for rural OFE (16%), and by 14% for urban OFE.

As expected, more farmland reduces OFE overall, but the effect was marginal except for decreasing the odds of work in the local community. These results were expected since they implied higher resources available to support the household, other

[4]Problems of endogeneity between land use variables and OFE is possible. Land use in crops/perennials and pasture, which were assumed to cause OFE, may also have been a consequence, for example, of OFE which generates income to invest in cattle, or even be jointly determined. Some control of this problem was assured in this paper by the use of lagged variables (land in pasture and crops/perennials in the year preceding the survey in 1999). Nevertheless, the analysis here avoids strong causal statements involving land use variables and OFE, focusing instead on the *associations* between land use and OFE.

things being equal. One additional hectare of farmland decreased the odds of community and urban OFE by, 4.4% and 2%, respectively.

Having a land title had little effect, only slightly increasing urban OFE, in a direction contrary to expectations; a farm with land title increased the odds that one of its members would engage in OFE by 81%. If farm households in a better socioeconomic position were more likely to have land titles and if urban employment was associated with higher human capital (and probably higher wages), it was reasonable to observe a significant but not causal association between urban OFE and farm land title.

There was no overall effect of credit or technical assistance on overall OFE (Model 1). However, farms which received credit or technical assistance were more likely to have someone engaged in local community or rural OFE, contrary to expectations; it increased the odds by 153% in the first case and by 134% in the second case. It may be that in these cases farm households saw OFE as a way to acquire income to amortize or pay off credit or loans, while still working closer to the farm.

The use of chemical inputs had no overall effect, but farms where they were used were much less likely to have someone working away, especially in either community or urban OFE, as expected. In both cases, the odds that an individual worked away were negative and approximately 50%. It can thus be inferred that land intensification tends to increase returns to farm labor, reducing the necessity of seeking supplemental sources of income via OFE. Farms where labor was hired tended to have someone working away in urban areas. Farms which hired labor had 136% higher odds of having someone engaging in urban OFE. It is likely here that some "substitution" of hired labor was used for on-farm household labor.

The results in Tables 7 and 8 provide some support for the hypothesis that environmental contamination increased population mobility in the form of OFE. The results are marginally significant for Model 1. Environmental contamination increased the odds that an individual would engage in local community and rural OFE by 172% and 188%, respectively. Given that it increased local OFE, the results imply that the contamination was not a widespread local phenomenon, and the effects might be on reducing farm production and productivity. Thus, OFE appears to be a way to supplement farm income when it is impacted by pollution.

As expected, the walking distance from the farm to the nearest road reduced OFE in general. Each additional kilometer decreased the odds of local community OFE by 13%, and urban OFE by 32%. The much higher effect for urban OFE was fully expected since distance complicated commuting to work. This result confirmed the orthodoxy in the migration literature about the negative effects of physical barriers on the movement of people in general (see, e.g., Ravenstein, 1889; Lee, 1966).

Community level. Road distance from the local community to the nearest town was generally linked to less OFE, as expected. The results in Tables 9 and 10 thus show that longer distances tended to decrease OFE. One additional kilometer decreased the odds that an individual would engage in local community OFE or in rural OFE by 4–5%. This is reasonable, since larger distances increased the costs of temporary labor mobility, especially commuting, and increased the viability of a definitive residential change (see Barbieri, 2005; Barbieri and Carr, 2005). Due to better transportation access to urban areas (e.g., regular bus services linking communities to nearest towns), road distance was not a significant factor decreasing OFE to urban areas.

[Table 9 about here]

[Table 10 about here]

The coefficient estimate for community size is scaled in 100s (that is, the percent change in the odds of OFE refers to the effect of an additional 100 persons in the community). After controlling by community size in the multilevel model, there were no significant additional effects of variables measuring the presence of health facilities or secondary schools (which were tested, but not included in the model due to high correlation with community size). Community size was, in this case, a broad proxy for the availability of services in the community, but added the desirability of analyzing the effects of "urbanization" (in a strict sense of population growth) on OFE. The effects were marginally significant and negative, as expected, for all models of OFE, suggesting that the larger the community, the lower the probability of OFE. Considering Model 1 for example, if a community had about 100 inhabitants more, the odds that farms would have someone engaged in OFE decreased by about 2%. As communities grew, they acquired more infrastructure, services, and sources of support for settler colonists (e.g., social contacts, consumer markets) that reduced OFE.

More employment in the secondary sector in the community decreased the odds that a farm had anyone engaging in rural or urban OFE. The effects were small but in the direction expected. Thus, a larger secondary sector had some effect on retaining the labor which otherwise would have looked for employment in the secondary sector or elsewhere. On the other hand, a 10% increase in tertiary sector employment increased rural OFE by 175%, and urban OFE by 525%. Considering that an important proportion of this sector corresponded to transportation and commercialization activities, a higher articulation with urban areas was likely to increase urban OFE. Since the effects on local community OFE were not significant (though one would expect them to be significant and negative, thus offering local jobs), it is likely that the tertiary sector in local towns rarely reached a stage typical of countries at more advanced urbanization and "modernization" processes, in which the tertiary sector is a significant "pull factor" in retaining rural labor.

Random effects. Table 11 shows the coefficient estimates for the random effects at the farm household level and community level. The random effects at the farm household level were statistically significant in all models except Model 2c (urban OFE). The statistically significant effects indicated that, after controlling for all fixed effects (independent variables) at the farm household-level, there was still unexplained farm household variation in the models. An implication is that, in Models 1, 2a and 2b, individuals within the same farm households had mobility behavior more alike than that of individuals in other farm households because they shared unmeasured characteristics. On the other hand, the fixed effects variables were sufficient to explain OFE in urban areas, as shown by the non-significant random effect. There was not a significant unexplained variance in the model for urban OFE.

The community-level random effects were not significant in any model; they were, in fact, close to zero in all models except Model 2a (where the effect was still too small to be significant). This suggests that the community variables in the fixed parts of the model— community size, distance to the nearest town, labor force in secondary and tertiary sectors—were sufficient to explain the community effects on OFE.

CONCLUSIONS AND POLICY IMPLICATIONS

This paper contributes to the empirical literature on population mobility by relying on multilevel data which allows investigating the effects of individual, farm household, and community characteristics on OFE decisions. Population mobility and redistribution may increasingly become the dominant demographic factor in frontier regions over the next decades, considering that fertility and mortality levels tend to be reduced (Bilsborrow *et al.*, 2004). The second generation of settlers will continue to reach adulthood and seek more land or jobs; this will be combined with declining agricultural yields (due to decreasing soil quality with use over time) and therefore will decline the capacity of farms to sustain members. There has been little research on the determinants of OFE within frontier areas of developing countries, and that which exists does not incorporate intergenerational characteristics associated with family succession nor the effects of context on population mobility. This reflects, at least in part, the theoretical complexity and fragmentation in studies on population mobility.

At the individual level, the results show how personal attributes have strong impacts on mobility decisions. Younger individuals are much more likely to move than older ones; men tend to predominate in OFE; and married people tend to engage in OFE locally. These results provide support for previous research on the preponderance of individual factors on decisions to move in Latin America, contrasted with Africa and Asia, where mobility seems more related to family or household strategies. Cultural factors may be critical in this case, substantiating mobility as a "rite de passage" (Piore, 1979) of individuals in particular life stages.

While corroborating the importance of individual factors on decisions to move, the multi-level conceptual framework discussed here finds that farm household and community factors have important effects on OFE decisions. Farm household factors indicate that more adults in the household stimulate OFE in local communities; OFE is higher as the number of children in the household increases; and the age of the household head effects indicate that older farm households (assuming an association between age of the head and age of the farm household) engage less in OFE. Thus, it is likely that farm household life cycle factors are key determinants of the mobility of younger household members, which will increase (a) pressure on natural resources of the region and (b)

demands on urban infrastructure and budgets. However, the former can be ameliorated by appropriate settlement and agricultural policies, and the latter by appropriate urban planning. It is important for planners and policymakers to understand the implications of population momentum that results from past (and present) high fertility, which has major implications for the future labor supply and consumption demands in urban and rural areas.

Overall, policies to promote socioeconomic development and environmental sustainability in the Amazon will be influenced to a major degree by how governments react to the increasingly important labor mobility dynamics. An important policy implication is the need to adopt a long-term planning perspective, incorporating policies such as family planning to reduce unwanted births and therefore high population growth. This would reduce second-generation effects of past high fertility on patterns of land fragmentation, land use, and living standards. Another policy implication is the desirability of promoting land intensification to improve farm productivity and returns to labor, which would tend to retain more rural labor.

Other farm household-level variables suggest an important association with OFE. Higher shares of land in crops and perennials are an important factor because of their effects on farm labor needs. Among so-called land management variables, having more land decreases OFE, whether in the local community or urban employment. Two land intensification variables were measured, and showed distinct effects: (1) the use of chemical inputs is linked to less OFE, while (2) having hired labor is associated with urban OFE (probably indicating a substitution of farm labor by hired labor). Land titles have little effect, and farms receiving credit and technical assistance are more likely to have members involved in OFE in the local areas. This suggests that the search for off-farm income may be complementary to farm investments, or that the same households engage in both to increase their welfare. The variable measuring environmental contamination shows a negative effect on the farm natural resource base and stimulates a search for off-farm income via community or rural OFE. Walking distance is negatively associated with OFE in all models except rural-rural mobility, and is negatively associated with rural-rural migration from new cohorts (with an opposite effect for new cohorts).

In conclusion and perhaps more importantly, the multilevel approach is useful to isolate the effects of policy-relevant contextual variables from individual and household factors. Community factors may reflect policies at the local level (or formulated at higher levels and "filtered down" to the local level) and indicate the context of individual and farm household mobility decisions. Theories about population mobility can help inform regional development policies about transportation, housing, energy distribution, agricultural extension, urban infrastructure, regulation of labor markets, environmental protection, and information on population growth and redistribution over space. This research suggests some important policy implications from community effects (the most relevant for policies) on OFE, albeit the results are generally weaker than those for farm household and individual variables. Nonetheless, the results on the effects of contextual or community-level effects must be considered provisional. There has been almost no empirical multivariate multi-level research on this important topic in frontier areas.

Among community factors, the size of the community is negatively associated with OFE, which may indicate that characteristics of larger urban agglomerations (e.g., better infrastructure, services, and consumer markets for farm products) seem to facilitate farm labor retention. While this paper focuses on community size as a determinant of OFE *at the origin,* it may be speculated that larger communities at places of *destination* are also a powerful mechanism to attract rural labor. This is based on the literature which suggests that the typical "urban bias" in policies in developing countries acts as a major mechanism to attract population to leave rural areas and move to urban ones (Lipton, 1977; Bilsborrow, 1998, 2002). The existing practice therefore—including in Ecuador—of channeling most public investments to urban areas in the forms of better infrastructure, public sector employment, new factories, etc, induces population mobility to urban areas (Bilsborrow, 2002).

Policies to increase the proportion of the labor force in the secondary sector in the communities of the NEA (e.g., expand oil activities and mining, small-scale industries such as food processing, etc) would seem likely to help retain rural population and reduce urban growth or land extensification and deforestation. A larger secondary sector in the community means not only more employment opportunities, but also a larger consumer market for farm products. Policies to improve farm income and reduce population

mobility (particularly to urban areas) could involve incentives to invest in facilities such as coffee driers and rice huskers. On the other hand, the results indicate that policies to increase the tertiary sector will have little effect on retaining rural labor, since a large tertiary sector in the local community may be more articulated with other larger communities, improving information flows and hence leading to more OFE.

Another key issue is better planning of investments in "social overhead" of frontier areas, particularly road openings. Due to the role of oil companies in opening roads, and the indirect effect on spontaneous colonization (without previous investments in socioeconomic infrastructure), the occupation of the Ecuadorian Amazon did not involve significant public investment. While some policies fostering urban employment or the expansion of oil activities may induce rural-urban mobility, rural-rural migration to other areas of the Amazon can also be influenced by *where* new oil extraction is permitted and (not unrelated) where new roads and colonization are permitted. Apart from the macroeconomic issue (i.e., whether new roads should be allowed for oil extraction in national parks and indigenous lands) our results indicate that better road access to towns from rural communities favors OFE. Policymakers should promote technologies and methods of oil exploitation which do not imply opening roads in the middle of the Amazon forest in order to limit the extension of the road network in the NEA to areas with ongoing processes of colonization and to forbid, or at least to limit, its extension into areas of high cultural and species biodiversity, such as protected areas and indigenous lands.

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Table 1. Number and Distribution of Persons Engaged in Off-farm Employment, by Locations and Type of Employment – Northern Ecuadorian Amazon, 1999[a]

Type of off-farm employment	Total	% of Total Population (N=2216)	Place of Off-farm Employment					
			Local Community		Other Rural		Other Urban	
			N	%	N	%	N	%
Agricultural labor	289	13.0	225	77.9	63	21.8	1	0.3
Manual work for oil company	21	0.9	4	19.0	15	71.4	2	9.5
Professional/technical	50	2.3	6	12.0	17	34.0	27	54.0
Services[b]	70	3.2	21	30.0	18	25.7	31	44.3
Self-employment	43	1.9	17	39.5	7	16.3	19	44.2
Other	34	1.5	3	8.8	12	35.3	19	55.9
Total	507	22.9	276	54.4	132	26.0	99	19.5

[a] For individuas 12-59 years of age

[b]Includes employment in restaurants, shops, hotels, banks, government, commercial establishments and others; taxi and transportation service

Table 2. Means and standard deviations of independent variables, according to off-farm employment status and individual-level independent variables – Northern Ecuadorian Amazon, 1999[a]

Independent variable	Place of Off-farm Employment						Not in off-farm employment	
	Local Community		Other Rural		Other Urban			
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Personal attributes								
Age group 12-17	0.11	0.31	0.05	0.21	0.07	0.26	0.32	0.47
Age group 18-24	0.28	0.45	0.23	0.42	0.28	0.45	0.21	0.40
Age group 25-34	0.26	0.44	0.43	0.50	0.33	0.47	0.17	0.37
Age group 35-59	0.35	0.48	0.30	0.46	0.31	0.47	0.30	0.46
Gender (0=female, 1=male)+	0.88	0.32	0.92	0.27	0.62	0.49	0.48	0.50
Marital status (0=married/in union, 1=single/not in union)	0.39	0.49	0.39	0.49	0.37	0.49	0.50	0.50
Human capital								
Education (1=at least some secondary)	0.49	0.50	0.58	0.49	0.74	0.44	0.52	0.50
Engagement in farm work (1=yes, 0=no)+	0.90	0.30	0.84	0.37	0.68	0.47	0.84	0.37

[a]For persons in the ages 12-59

Table 3. Means and standard deviations of independent variables according to off-farm employment status and farm household-level independent variables – Northern Ecuadorian Amazon, 1999[a]

Independent variable	Place of Off-farm Employment						Not in off-farm employment	
	Local Community		Other Rural		Other Urban			
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Household life cycle								
Age of household head	43.21	13.50	43.83	13.43	42.02	12.78	45.99	12.14
Number of adults	4.57	2.97	4.92	2.61	4.09	2.07	4.68	2.48
Number of children	2.63	2.14	2.70	2.03	2.14	1.54	2.72	2.13
L*and use*								
Land in crops/perennials (ha)	2.87	2.52	3.12	3.51	2.56	3.18	4.00	3.67
Land in pasture (ha)	4.13	6.82	4.54	8.28	6.23	9.84	6.66	9.56
Environmental conditions								
Environmental contamination (0=no, 1=yes)	0.42	0.50	0.51	0.50	0.43	0.50	0.43	0.49
Land management								
Farm area (ha)	21.32	18.22	28.45	25.64	24.44	20.56	30.47	26.07
Land title (1=has title)	0.33	0.47	0.41	0.49	0.41	0.50	0.44	0.50
Use of inputs (0=no, 1=yes)	0.29	0.45	0.37	0.48	0.28	0.45	0.34	0.47
Hired farm labor (0=no, 1=yes)	0.35	0.48	0.55	0.50	0.57	0.50	0.44	0.50
Credit or technical assistance (0=no, 1=yes)	0.23	0.42	0.25	0.43	0.20	0.40	0.26	0.44
Transportation accessibility	0.27	0.44	0.30	0.46	0.57	0.50	0.26	0.44
Walking distance to nearest road (Km)	1.03	1.58	1.18	1.76	0.55	1.06	1.12	1.75
Road distance to nearest town (Km)	17.47	12.51	18.66	15.38	14.77	12.84	17.89	13.47

[a]For persons in the ages 12-59

Means and standard deviations are weighted by person-weights, that is, the number of individuals exposed to the risk of out-migration in the farm household in 1999. For example, a farm household with 5 individuals will have a weight 5 (and consequently household-level characeristics for this household are multiplied by five), while another household with two members will have weight two. Weightng by person-weights allows distinguishing farm household variables according to the housheold's composition (those engaged in community, rural or urban off-farm employment, and those not engaged in off-farm employment).

Table 4. Means and standard deviations of independent variables according to off-farm employment status and community-level independent variables – Northern Ecuadorian Amazon, 1999[a]

Independent variable	Place of Off-farm Employment						Not in off-farm employment	
	Local Community		Other Rural		Other Urban			
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Transportation accessibility								
Distance to nearest town (Km)	18.55	16.00	21.02	18.01	18.54	15.82	20.60	16.14
Community size								
Population size	2064.11	4950.77	2816.02	5933.34	4578.59	85.14	2692.00	5506.35
Labor market								
Proportion of labor force in secondary sector	0.08	0.08	0.07	0.07	0.08	0.07	0.08	0.07
Proportion of labor force in tertiary sector	0.29	0.26	0.35	0.28	0.42	0.31	0.34	0.27

[a]For persons in the ages 12-59

Means and standard deviations are weighted by person-weights, that is, the number of individuals exposed to the risk of off-farm employment in a community in 1999.

Table 5. Coefficient estimates of independent variables at the individual level, multilevel model of off-farm employment – Northern Ecuadorian Amazon, 1999

Independent variable	Model 1: Engaged in off-farm employment vs. not in off-farm employment		Place of Off-farm Employment (versus not in off-farm employment)					
			Model 2a: Local Community		Model 2b: Other Rural		Model 2c: Other Urban	
	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]
Constant	-1.416	0.407**	-1.286	0.641	-3.147	0.749***	0.708	0.804
Personal attributes								
Age group 18-24 (ref.:age group 12-17)	-0.303	0.176**	-3.834	0.351***	-3.511	0.460***	-3.727	0.481***
Age group 25-34 (ref.:age group 12-17)	-2.410	0.256***	-0.632	0.254**	-0.272	0.297	-1.147	0.351***
Age group above 35 (ref.:age group 12-17)	-0.393	0.190**	0.218	0.232	1.25	0.278***	0.186	0.323
Gender (ref.: 0 = female)	2.316	0.158***	2.417	0.211	2.522	0.332***	0.799	0.252***
Marital status (ref.: 0 = married/in union)	0.075	0.188	-0.449	0.239*	-	-	-	-
Human capital								
Education (ref.: 0 = less than secondary education)	0.256	0.165	-0.513	0.232**	-	-	1.381	0.288***
Engagement in farm work (ref.: 0 = not engaged)	-0.450	0.196**	0.531	0.284*	-	-	-1.093	0.301***

[a]significance level: *p<0.10, **p<0.05, ***p<0.01 (two-tailed test)

Table 6. Percent change in the odds-ratio of being engaged in off-farm employment in 1999, for significant individual-level variables, multilevel model of off-farm employment - Northern Ecuadorian Amazon, 1999

Independent variable	Model 1: Engaged in off-farm employment vs. not in off-farm employment	Place of Off-farm Employment (versus not in off-farm employment)		
		Model 2a: Local Community	Model 2b: Other Rural	Model 2c Other Urban
	% Change Odds Ratio	% Change Odds Ratio	% Change Odds Ratio	% Change Odds Ratio
Personal attributes				
Age group 18-24 (ref.:age group 12-17)	-26,14	-97,84	-97,01	-97,59
Age group 25-34 (ref.:age group 12-17)	-91,02	-46,85	-23,81	-68,24
Age group above 35 (ref.:age group 12-17)	-32,50	-	-	20,44
Gender (ref.: 0 = female)	913,51	-	1145,35	122,33
Marital status (ref.: 0 = married/in union)	-	-36,17	-	-
Human capital				
Education (ref.: 0 = less than secondary education)	-	-40,13	-	297,89
Engagement in farm work (ref.: 0 = not engaged)	-36,24	70,06	-	-66,48

Table 7. Coefficient estimates of independent variables at the farm household level, multilevel model of off-farm employment – Northern Ecuadorian Amazon, 1999

Independent variable	Model 1: Engaged in off-farm employment vs. not in off-farm employment		Place of Off-farm Employment (versus not in off-farm employment)					
			Model 2a: Local Community		Model 2b: Other Rural		Model 2c: Other Urban	
	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]
Household life cycle								
Age of household head	-0.018	0.008**	-0.061	0.012***	-0.024	0.012**	-0.060	0.013***
Number of adults	0.078	0.042*	0.389	0.066***	-	-	-	-
Number of children	-0.027	0.040	0.246	0.060***	0.325	0.074***	0.165	0.081**
Land use								
Land in crops/perennials (ha)	-0.124	0.027***	-	-	-0.172	0.050***	-0.149	0.055***
Land in pasture (ha)	-0.026	0.011**	-0.081	0.019***	-	-	-	-
Environmental conditions								
Environmental contamination (ref.: 0 = no contamination)	0.274	0.155*	1.002	0.235***	1.057	0.293***	-	-
Land management								
Farm area (ha)	-0.007	0.004*	-0.045	0.007***	-	-	-0.020	0.009*
Land title (ref,: 0 = no title)	-0.155	0.187	-	-	-	-	0.591	0.351*
Use of inputs (ref.: 0 = no use)	-0.160	0.165	-0.740	0.245***	-	-	-0.703	0.324**
Hired farm labor (ref.: 0 = did not hire)	0.223	0.162	-	-	-	-	0.861	0.312***
Credit or technical assistance (ref.:0=no credit or assistance)	0.019	0.191	0.927	0.281***	0.851	0.345**	-	-
Transportation accessibility								
Walking distance to nearest road (Km)	-0.087	0.048*	-0.144	0.072**	-	-	-0.379	0.133***

[a]significance level: *p<0.10, **p<0.05, ***p<0.01 (two-tailed test)

Table 8. Percent change in the odds-ratio of being engaged in off-farm employment in 1999, for significant farm household-level variables in the multilevel model of off-farm employment - Northern Ecuadorian Amazon, 1999

Independent variable	Model 1: Engaged in off-farm employment vs. not in off-farm employment	Place of Off-farm Employment (versus not in off-farm employment)		
		Model 2a: Local Community	Model 2b: Other Rural	Model 2c Other Urban
	% Change Odds Ratio	% Change Odds Ratio	% Change Odds Ratio	% Change Odds Ratio
Household life cycle				
Age of household head	-1,78	-5,92	-2,37	-5,82
Number of adults	8,11	47,55	-	-
Number of children	-	27,89	38,40	17,94
L*and use*				
Land in crops/perennials (ha)	-11,66	-	-15,80	-13,84
Land in pasture (ha)	-2,57	-7,78	-	-
Environmental conditions				
Environmental contamination (ref.: 0 = no contamination)	31,52	172,37	187,77	-
Land management				
Farm area (ha)	-0,70	-4,40	-	-1,98
Land title (ref.: 0 = no title)	-	-	-	80,58
Use of inputs (ref.: 0 = no use)		-52,29	-	-50,49
Hired farm labor (ref.: 0 = did not hire)	-	-	-	136,55
Credit or technical assistance (ref.:0=no credit or assistance)	-	152,69	134,20	-
Transportation accessibility				
Walking distance to nearest road (Km)	-8,33	-13,41	-	-31,55

Table 9. Coefficient estimates of independent variables at the community level, multilevel model of off-farm employment – Northern Ecuadorian Amazon, 1999

Independent variable	Model 1: Engaged in off-farm employment vs. not in off-farm employment		Place of Off-farm Employment (versus not in off-farm employment)					
			Model 2a: Local Community		Model 2b: Other Rural		Model 2c: Other Urban	
	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]
Transportation accessibility								
Distance to nearest town (Km)	-0.028	0.017*	-0.048	0.023**	-0.043	0.026**	-	-
Squared distance to nearest town	0.000	0.000*	0.001	0.000*	0.001	0.000*	-	-
Community size								
Population size	-0.018	0.011*	-0.006	0.003**	-0.007	0.003**	-0.004	0.002*
Squared population size	0.000	0.000	-	-	-	-	-	-
Cubic population size	0.000	0.000	-	-	-	-	-	-
Labor market								
Proportion of labor force in secondary sector	-0.365	1.073	-	-	-3.585	2.134*	-2.483	2.062
Proportion of labor force in tertiary sector	0.077	0.418	-	-	1.013	0.615*	1.832	0.582***

[a]significance level: *p<0.10, **p<0.05, ***p<0.01 (two-tailed test)

Table 10. Percent change in the odds-ratio of being engaged in off-farm employment in 1999, for significant community-level variables, multilevel model of off-farm employment - Northern Ecuadorian Amazon, 1999

Independent variable	Model 1: Engaged in off-farm employment vs. not in off-farm employment	Place of Off-farm Employment (versus not in off-farm employment)		
		Model 2a: Local Community	Model 2b: Other Rural	Model 2c Other Urban
	% Change Odds Ratio	% Change Odds Ratio	% Change Odds Ratio	% Change Odds Ratio
Transportation accessibility				
Distance to nearest town (Km)	-2,76	-4,69	-4,21	-
Community size				
Population size	-1,78	-0,60	-0,70	-0,40
Labor market				
Proportion of labor force in secondary sector	-	-	-97,23	-
Proportion of labor force in tertiary sector	-	-	175,39	524,64

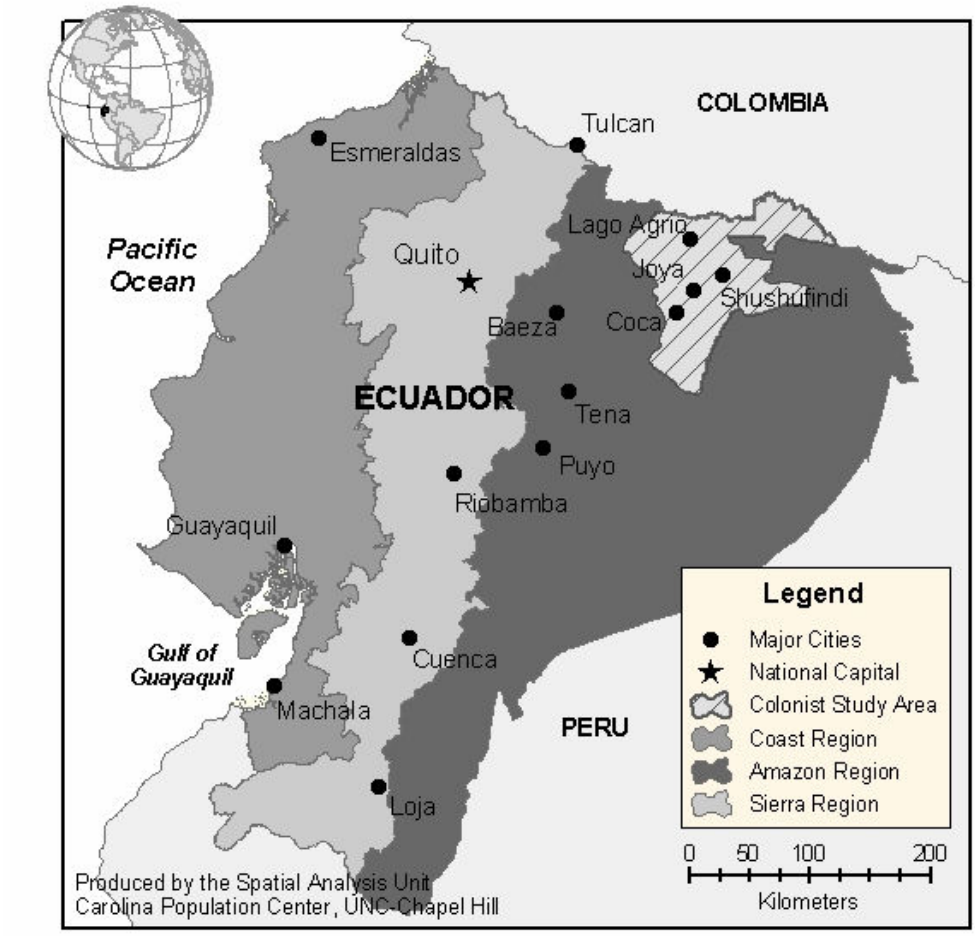
Table 11. Farm household-level and community-level random effects for models of off-farm employment - Northern Ecuadorian Amazon, 1999

Independent variable	Model 1: Engaged in off-farm employment vs. not in off-farm employment		Place of Off-farm Employment (versus not in off-farm employment)					
			Model 2a: Local Community		Model 2b: Other Rural		Model 2c: Other Urban	
	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]	Coefficient	St. error[a]
Farm household level								
Farm household-level random effect	0.770	0.169***	3.360	2.000*	5.469	2.000**	3.000	3.464
Community level								
Community-level random effect	0.000	0.000	0.117	4.472	0.000	0.000	0.000	0.000

[a]significance level: *p<0.10, **p<0.05, ***p<0.01 (two-tailed test)

Illustrations

Figure 1. Study area in the Northern Ecuadorian Amazon (NEA)


COLOMBIA
Tulcan
Esmeraldas
Lago Agrio
Pacific
Ocean
Quito
Joya
Shushufindi
Baeza
Coca
ECUADOR
Tena
Puyo
Riobamba
Guayaquil
Legend
Major Cities
National Capital
Colonist Study Area
Coast Region
Amazon Region
Sierra Region
Gulf of
Guayaquil
Cuenca
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