Ideal Type Theories and Concrete Cases in Land Science:
A Multi-step Appraisal of the Evolutionary Theory of Land Rights in Madre de Dios, Peru

Stephen G. Perz ^{a,*}, Johanna Espin ^a, Jorge Castillo ^b, Andrea Chavez ^{b,c}, Rafael O. Rojas ^d,
and Grenville Barnes ^e

^a Department of Sociology and Criminology & Law, 3219 Turlington Hall, University of Florida, PO Box 117330, Gainesville, FL 32611-7330 USA

^b Universidad Nacional Amazónica de Madre de Dios, Puerto Maldonado, Madre de Dios, Peru

^c Center for Latin American Studies, University of Florida, Gainesville, Florida, USA

^d School of Natural Resources and Environment, University of Florida, Gainesville, Florida, USA

^e School of Forest Resources and Conservation, University of Florida, Gainesville, Florida, USA

* Corresponding author. E-mail: sperz@ufl.edu. Phone: +01-352-294-7186. Fax: +01-352-392-6568

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Abstract.

The relationships of regional integration, land tenure and land use have all received substantial previous attention. Nonetheless, existing theoretical frameworks tend to presume ideal types of land tenure in understanding the impacts of regional integration on change in institutions and land use. We therefore evaluate the evolutionary theory of land rights (ETLR) for the case of Madre de Dios, Peru. This is a useful case since tenure for agricultural lands is private individual as the ETLR theorizes, but other characteristics, such as the presence of forest extractivism, depart from the assumptions of the ETLR. We pursue a multi-step analysis of key relationships of the ETLR, focusing particularly on the linkages between highway paving as an indicator of regional integration, titling as a measure of tenure formality, multiple indicators of land market engagement, and land uses with diverse ramifications for ecological sustainability. Findings for the different steps partially support the ETLR for the case of Madre de Dios. Disconfirmation however sometime occurs due to geographic accidents rather than due to truly contrasting findings. We conclude by discussing the need to identify characteristics of empirical cases that do and do not fit the expectations of theories in order to better evaluate the applicability of theory for analysis and policy.

Keywords: infrastructure, land tenure, land use, Amazon, Peru

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1. Introduction

Theoretical frameworks for the evaluation of land tenure models are based on ideal types, notably private individual tenure in the property rights school (Demsetz 1967; Alchian and Demsetz 1973) and community lands in the common pool resources literature (Berkes 1989; Ostrom 1990). A key issue in using such frameworks is to evaluate how well they fit concrete empirical cases. While land tenure models do come with boundary conditions, there remains a need to manage tensions pertaining to scope of applicability between universalism and context-specificity. In that endeavor, analysis should identify factors that explain where general frameworks do and do not fit, in order to better delineate boundary conditions.

Theories of land tenure are increasingly theories of change (Feder and Feeny 1991; Sjaastad and Cousins 2008). In such work, population growth, structural changes in regional economies, and market integration are frequently enumerated as key factors that impel shifts in land tenure arrangements. At the same time, work on development has increasingly centered on processes of regional integration into global commodity networks (Bourguignon and Pleskovic 2008; Bulmer-Thomas 2001). Integration initiatives to facilitate cross-border exchange constitute significant drivers of change in land tenure (Barnes 2009; Perz, et al. 2014a). However, there remains a need for systematic analysis of the ramifications of regional integration for land tenure change and its consequences.

In this paper, we take up a pre-eminent theoretical framework for the analysis of land tenure change, the evolutionary theory of land rights (ETLR; Feder, et al. 1988; Feder and Feeny 1991; Deininger and Feder 2001). The ETLR stemmed from the property rights school and highlights the advantages of formalizing property rights in terms of private individual tenure. We apply the ETLR to

Madre de Dios, Peru, which is a useful case since it is the site of a major infrastructure project for regional integration, and private individual tenure prevails. Madre de Dios thus offers as study case where the ETLR ought to apply. At the same time, other characteristics of land tenure in Madre de Dios depart from the assumptions of the ETLR.

We draw on data from a survey of roadside farms, conducted when highway paving was partially complete. This permits comparisons of farms in areas with and without highway paving as a proxy for regional integration. Our analysis encompasses a systematic evaluation of three key assertions of the ETLR. The first concerns the importance of highway paving as a determinant of tenure formalization, a focal element of the evolution of land rights. The second takes up the consequences of integration and formalization in terms of institutional advantages such as market transactions (notably access to credit) and avoidance of agrarian conflicts. The third concerns the effect of integration, formalization and institutional advantages for the sustainability of natural resource management.

1.1. The Evolutionary Theory of Land Rights (ETLR)

According to the ETLR, as resources become scarcer and thus more valuable, it becomes more worthwhile to gain formal property rights. Such rights come in bundles and refer to rights of access, rights of use, and rights of transfer. Whereas rights of access ensure control over a resource and thereby avoid overexploitation, rights of use motivate investments to make the resource more productive, and rights of transfer permit sales to realize gains.

The property rights argument drove theoretical elaboration on land titling and related policy proposals falling under the banner of tenure security (Feder, et al. 1988). Tenure security is a crucial precondition for reaping the benefits of property rights. Whether by formal land titling or other means, tenure security provides the basis for investing in resource productivity. Also crucial is that in many

countries, titles are necessary to substantiate property rights to land as collateral for obtaining credit from banks in order to make investments in productivity.

Work on tenure security and titling in developing regions motivated articulations of the ETLR in the context of regional economic development (Feder and Feeny 1991; Deininger and Feder 2001).

Figure 1 outlines the key expectations of the ETLR, in terms of a series of relationships among change processes entrained by regional integration, resulting in the evolution of land tenure. Exogenous factors such as new infrastructure can stimulate regional population growth, the emergence of markets, and the introduction of new technologies, which tend to raise land values. Where property rights are not precisely defined, rising land values motivate formalization of property rights for tenure security, as via demarcation of clear property boundaries, clarification of access and use rights, and titling of land. Consequently, property values appreciate, land markets emerge, and land sales and other market transactions become more viable. At the same time, formal sources of credit emerge in the form of banks, and formalization of property rights becomes more important for securing credit. Synergistically, the state finds it increasingly worthwhile to make public investments in the recognition and enforcement of property rights, which reduce agrarian conflicts. Formalization, tenure security and credit in turn motivate greater investments in long-term resource productivity, contributing not only to increased yields but also sustainable land use and thus regional development.

(Figure 1 about here)

This synergistic dynamic is the “evolution” to which the ETLR refers: during the course of regional development, property rights change by shifting from traditional rights shared by communities toward formalized private individual rights (Platteau 1996; Deininger and Feder 2001). There have been similar arguments to formalize property rights in urban areas to encourage investments and liquidity for

economic growth and poverty alleviation (De Soto 2000). The property rights school, ETLR and formalization arguments have supportive empirical research in various countries (e.g., Feder, et al. 1988; Otsuka, et al. 2001; Alston, et al. 1999; Sills and Caviglia-Harris 2008).

Nonetheless, empirical testing has also prompted criticisms. There has been dispute about several key arguments in the ETLR (e.g., Platteau 1996; Sjaastad and Cousins 2008). Two noteworthy criticisms for present purposes are: 1) whether credit is necessarily available, and 2) whether resource use among titled properties is ecologically sustainable. With regard to the first, the ETLR recognizes that if informal credit is available, the benefits of titling for productivity may be reduced. Concerning the second, there are questions concerning the content of the term “sustainable” in resource use. While sustainability is often invoked with regard to ecological sustainability, the ETLR’s emphasis on economic efficiency leads to a focus on investments in resource productivity. Hence it becomes important to specify the forms of natural resource management, including particular types of land use, as to their implications for sustainability.

1.3. Trans-boundary Integration in Latin America: The Case of the Inter-Oceanic Highway

The ETLR account highlights regional integration as a key catalyst for tenure formalization and its consequences. Integration initiatives include trade agreements and trans-boundary infrastructure projects. We focus on Latin America, which has no shortage of both types of initiatives. In this paper, our inquiry centers on the latter. In Latin America, no infrastructure program is more significant than the Initiative for the Integration of Regional Infrastructure in South America (IIRSA).

IIRSA was constituted by a meeting of presidents from 12 South American countries in 2000 (IIRSA 2008). IIRSA was conceptualized as an explicitly spatial strategy organized around “axes of integration” targeted for infrastructure investments. Such axes constitute strategic growth corridors for

international commerce. Subsequent IIRSA meetings included multilateral development banks and led to agreements to fund 350 projects at a total projected cost of \$38 billion (CEPEI 2002; IIRSA 2008).

During the first 5-year implementation phase of IIRSA, in 2006-2010, a pre-eminent project was to pave the Inter-Oceanic Highway (IOH) through Madre de Dios, Peru (Dourojeanni, et al. 2010). As the name suggests, the strategic purpose of the IOH was to link Atlantic ports in southern Brazil to Pacific ports in Peru.

Madre de Dios is located in the southwestern Amazon, where the rainy season from November to May hampers overland transit on unpaved roads. Paving the IOH was thus a longstanding dream realized, upgrading the main road through the department to a year-round highway for cross-border commerce. What began as a horse path in the 1930s and was widened with government investments in colonization after the 1960s had finally by 2010 permitted regional integration between Brazil and Peru.

1.4. Madre de Dios, Peru

As a part of the Amazonian lowlands, Madre de Dios was historically somewhat isolated from the rest of Peru. Peruvian public policies have on the whole historically tended toward centralism, with some notable exceptions (Chavez and Perz 2012). Under the Garcia administration of the 1980s, the Government of Peru supported Amazonian colonization, opened an Agrarian Bank that offered credit to colonists, and promulgated other policies to encourage development in Madre de Dios. Peru's economic crisis in the 1990s put an end to such programs, slowing land settlement and investment. After 2000, the Toledo administration took up new policy incentives and in particular supported the IOH.

Consequently, Madre de Dios has seen major changes in land occupation and resource use in recent years (Chavez, et al. 2013). The 1980s colonization program under Garcia led to roadside land settlements and incipient pasture formation due to credit incentives for cattle. The Agrarian Bank constituted a key early source of formal credit for landowners in Madre de Dios. The 1990s crisis

however removed the governmental credit lines and prompted land abandonment in some areas. Where colonists held on, they formed associations to protest government withdrawal, which led to provision of technical support for planting and marketing (Rojas 2012). Formal credit however remained a precious commodity, forcing many landowners to rely on informal credit, notably the *habilito* arrangement used for the castaña (“Brazil nut”) harvest (cf. García Morcillo 1982). Under *habilito*, castaña buyers would advance cash to families with forest concessions on the condition that they in turn would sell their harvest to the buyers for a set price. While the *habilito* supports forest extractivism, income from castaña may in turn be invested in agriculture (Rojas 2012).

By the 2000s, several economic and political shifts were underway in Madre de Dios. Prices for forest products such as castaña rose, prompting agricultural households to pursue forest extractivism. By the late 2000s, paving of the IOH raised roadside land values and stimulated a new wave of migration from the Andean highlands. This prompted agrarian conflicts in many areas without clearly demarcated property boundaries. In the late 2000s, the global financial crisis pushed up prices on commodities, including precious metals such as gold. In that context, paving of the IOH from relatively poor regions of Peru to areas in Madre de Dios with alluvial gold deposits catalyzed a gold boom (Asner, et al. 2013; Swenson, et al. 2011).

1.5. Land Tenure in Madre de Dios

Rapid changes in land use have complicated tenure in landscapes along the IOH, due to a combination of land abandonment, unclear tenure, and informal (illegal) economic activity. Madre de Dios has a history of complicated land reform processes (McKechnie 2005). Colonization followed by abandonment and shifts in land use prompted initiatives for *saneamiento*, the clarification of property boundaries and ownership. To that end, the Special Land Titling and Cadaster Project (PETT) was created in the early 1990s under Peru’s Ministry of Agriculture. During the mid-1990s, Peru’s land-titling agency,

the Organization for Formalization of Informal Property (COFOPRI) was constituted to pursue rural and urban land titling. Both aimed to develop a cadaster based on cartographic data and field verification.

However, land tenure formalization via *saneamiento* and titling were undermined in Madre de Dios for several reasons. The overlapping functions of PETT and COFOPRI led to duplication of efforts when both agencies worked in the same areas at different times (Giugale et al. 2007). Details in demarcation and determinations of ownership often differed in PETT and COFOPRI documents. Discrepancies in geographic information and titling data led to conflicts among landowners. Whereas the point of *saneamiento* under PETT and titling by COFOPRI was to advance formalization, the rise in agrarian tensions was precisely the opposite of the intended outcome.

Agrarian problems worsened due to rapid economic shifts in the late 2000s. The Government of Madre de Dios completed its macro-level Ecological-Economic zoning plan (IIAP 2002), which identified appropriate areas for particular economic activities. While the plan was in many ways technically sound, it proved hard to implement. Paving of the IOH stimulated migration into Madre de Dios. Migrants coming for agricultural land found many unresolved tenure situations apt for exploitation by seizing lands with vague claims. Further, overlaps in some land claims, including between agricultural properties and forest concessions, led to conflicts, even in light of the zoning plan (Chavez, et al. 2012). Also common was migration by highlanders seeking mining claims. Peruvian law distinguishes between surface and subsoil rights, which permits overlapping tenure claims by claimants pursuing surface and subsurface resource exploitation. However, alluvial gold mining is very destructive of surface habitat and soil structure, so mining claims overlapping agricultural properties, usually established first, led to serious tenure conflicts.

Given these considerations, Madre de Dios exhibits characteristics of tenure arrangements that comply with expectations of the ETLR. Agricultural lands are demarcated as private individual parcels, regional integration initiatives such as paving the IOH provide the impetus to orient production for

markets, and state-led formalization efforts have sought to clarify tenure claims and title lands. This leads to the expectation that in Madre de Dios, households with private land claims will seek formalization for the sake of market engagement in order to support investments in sustainable land use. That said, Madre de Dios also has specific characteristics that depart from the assumptions of the ETLR. In addition to private land parcels, some landholders also have access to forest concessions; bank credit is limited and informal credit mechanisms are common; land titling initiatives have only partially resolved tenure informality; and rapid economic change has undermined tenure security.

These circumstances make an analysis of tenure formalization in Madre de Dios especially useful for an evaluation of the ETLR. We draw on the causal sequence presented in Figure 1 to pursue an analysis of three key linkages highlighted in the ETLR. We therefore organize our analysis in three steps, shown in Figure 2 (cf. Perz, et al. 2014b). The first step concerns the linkage of regional integration (via highway paving) with tenure formalization. This step evaluates whether infrastructure as a key driver of land change encourages formalization. The second step is to evaluate the linkage of integration and formalization with access to credit and other forms of market participation, such as land rentals, as well as land conflict. This step examines several key consequences of tenure formalization, while also considering the independent effects of regional integration. The third and final step assesses the ramifications of integration, formalization and its consequences on natural resource management. Whereas some forms of resource management are more ecologically sustainable than others, we consider multiple land uses in order to evaluate the relevance of integration and formalization for sustainability in terms of specific uses. Organizing the analysis in this fashion thus allows a systematic evaluation of key linkages in the causation posited by the ETLR.

(Figure 2 about here)

2. Methods and Materials

2.1. Field Data Collection

We drew on information from surveys of rural communities and households conducted in 2007 and 2008 along the IOH in Madre de Dios. Faculty and students at the University of Florida (UF) coordinated the data collection effort via partnerships with counterparts at the National Amazonian University of Madre de Dios (UNAMAD). Fieldwork proceeded in two phases. The first phase involved a survey of 88 leaders of 41 communities in Madre de Dios in 2007 (Perz, et al. 2012). We define “communities” in Madre de Dios as local associations constituted by neighboring families with private individual land parcels. Associations emerged in Madre de Dios in the 1990s and hold regular meetings to discuss shared problems (Rojas 2012). We selected communities geographically, sampling at more or less regular distance intervals along the IOH in Madre de Dios. Our sample includes communities with a broad range of characteristics in terms of their paving status, land tenure, and livelihoods.

For the second phase of the data collection, we revisited a representative subset of communities in order to conduct more detailed household interviews. In 2008, personnel from UF and UNAMAD visited 12 communities in Madre de Dios and conducted interviews with 312 households. We sampled communities for revisits geographically, based on their location and thus their paving status. Figure 3 shows the locations of the communities and households we revisited for household interviews in Madre de Dios. Within each community, we pursued random sampling of households, which was viable insofar as current lists of association member families were available. We worked from population estimates provided by community leaders in the first phase to establish sampling ratios such that smaller communities had larger ratios to ensure adequate representation.

(Figure 3 about here)

For the interviews, we developed a questionnaire based on similar instruments applied previously in the study region. We ensured that the questionnaire was culturally appropriate in local argot and institutionally relevant for the Peruvian land tenure regime. The questionnaire was translated and/or reviewed by Peruvian collaborators in Madre de Dios prior to application.

The questionnaire included sections with questions on concepts related to regional integration, land tenure, market participation, and resource management. Sections included items on household location (including GPS coordinates and information on the paving status of roads traveled to reach markets), migration history, family labor, household assets, social capital (via organizational memberships), capital inputs (including formal sources of credit), resource tenure (including the private lands and forest concessions, land sales and rentals, and access to other lands via third parties), health and well-being, and future plans. The section on location and paving status provided information to identify households with and without highway paving as an indicator of regional integration. The sections on migration, labor, and various capitals permit measurement of household productive capabilities. The section on resource tenure affords evaluation of land assets, titling status and related aspects of formalization, including incidence of agrarian conflicts. In addition, the questionnaire featured items on agricultural activities (annual and perennial crops, livestock and related products such as milk), forest extractive activities (including NTFPs), and off-farm income sources (such as wage jobs, retirement pensions, and others), which permit analysis of natural resource management.

2.2. Methods of Analysis

We drew on these data to pursue multivariate statistical models of household characteristics in order to evaluate specific tenets of the ETLR for the case of Madre de Dios. We begin by focusing on determinants of formalization. Analyses of formalization in the context of ETLR focus on land titling and presume private individual rights. For the case of Madre de Dios, this is eminently appropriate.

However, many households had not yet received titles for various reasons. We therefore differentiate among degrees of tenure formalization by distinguishing households by titling status, among landowners with a definitive title, those with a preliminary title or other document indicating processing of a title application, and those without any tenure document.

The first part of the multivariate analysis therefore evaluates the importance of various determinants of tenure formality. We focus on factors highlighted by the ETLR as affecting formalization, notably regional integration and population growth. For regional integration, we highlight new infrastructure as a catalyst of integration processes. Key to infrastructure in Madre de Dios has been the paving of the IOH. At the time of our household survey, households in some communities had received paving while others had not. Further, we know when the households without paving eventually received it. We therefore considered several measures of highway paving and market accessibility in preliminary models before settling on time since paving, which exhibited similar but stronger effects in the models than the alternatives. For population growth, we observe community net migration in the 5 years prior to the community survey. If the ETLR is applied to Madre de Dios, these variables should correspond to formalization via titling, especially definitive titles.

While we feature the integration and population variables, we also control for the effects of other factors. We draw on Bebbington's (1999) capitals and capabilities framework, which highlights the importance of land, labor and various capitals (cultural, human, social) as assets which influence rural livelihoods. For land we consider hectares claimed (in both agricultural properties and forest concessions); for labor, we account for household composition (labor availability via the number of adults, and dependency via the number of children and elderly); for cultural capital we include region of birth (Madre de Dios or elsewhere in Peru, to reflect distinct regional identities) and time on the first agricultural property (in years); for human capital, we account for place of birth (rural or urban) and respondent education (years of school completed); and for social capital we consider absent family

members (who reside in towns) and the number of types of organizational memberships. More details on these control variables are available elsewhere (Perz, et al. 2014b). Per the ETLR, households with greater assets will invest more in formalization in order to secure their assets and thereby make them more productive.

In the second part of the analysis, we focus on the consequences of formalization, highlighting market transactions and land conflicts. Following the ETLR, formalization begets tenure security; while that is difficult to observe directly, the ETLR asserts that tenure security as via titling should result in more market engagement as via land transactions and credit, as well as fewer land conflicts. We therefore focus on three outcomes of formalization with regard to market transactions: 1) formal bank credit obtained in the past year, 2) land rentals from others, and 3) plans to sell.¹ We consider formal credit because it is central to the ETLR account as a means to increase the productivity of land use. We also evaluate land rentals and plans for land sales as distinct market transactions related to tenure formality. While renting land from others suggests the expansion of productive activity, plans to sell instead imply transitions from on-farm production, whether to off-farm activities or retirement. We evaluate land conflicts as tenure security should result in fewer conflicts according to the ETLR. Per Figure 2, we feature the effects of integration via infrastructure, population growth and the formalization variables, net of the effects of the control variables, on each of these outcomes.

In the third and final step of the analysis, we evaluate the ramifications of integration, formalization, market-based transactions and conflict for natural resource management. We consider three indicators of natural resource management with regard to sustainability in the Amazonian context: castaña nut harvesting, cattle pasture, and tree crops. Each requires distinct investments and

¹ We also modeled land rentals to others, but we encountered problems with perfect prediction. Households without second properties, those with forest concessions, those with other access to concessions and household heads born in rural areas never rented out. Because many cases fell into these categories, many households were excluded from the analysis. This finding results from the rarity of renting land out to others in the study region. We therefore only present results for households renting from.

has very different environmental ramifications. Castaña (“Brazil nut”) is an important non-timber forest product (NTFP) in the southwestern Amazon (e.g., Cronkleton and Pacheco 2010). Castaña harvesting requires fewer capital investments but permits retention of standing forest, and thus affords sustainability in the sense of retaining forest cover. By contrast, cattle pasture requires investments for clearing of forest and pasture maintenance against weeds and soil degradation. Ranching has frequently been vilified for causing forest destruction and land degradation in the Amazon, though practices are changing (e.g., Walker, et al. 2009). Tree crops constitute long-term investments and provide forest cover that secures soil against erosion. Given these contrasts, one would expect that integration, formalization and its consequences would better account for pasture and tree crops than castaña harvesting.

In all steps of the analysis, we employ multivariate statistical models, developed in Stata version 12.1 (StataCorp 2011). Model development involved incrementally adding groups of independent variables, beginning with indicators of integration, then adding the controls. In later steps of the analysis, we incorporated dependent variables from earlier models as additional controls (cf. Perz, et al. 2014b). Hence we model credit, and later use credit to model resource management. Given the focus of the ETLR on land rights, we only included valid cases of households that possessed their own land ($n=227$), as opposed to households without land or only having access to concessions or via third parties. We also weighted cases based on the size of the community and the sampling ratio. This was important to ensure accurate inferential tests based on how representative each household was of the population from which we sampled. We used robust standard errors that adjust for heteroscedasticity in the data.

3. Results

3.1. Univariate Analysis

Table 1 presents descriptive statistics of our dependent and independent variables. The dependent variables are the key foci of the ETLR framework, notably tenure formalization (land titles), market transactions (credit, land rentals, and plans to sell) and land conflicts, and natural resource management (forest extractivism, cattle ranching and tree crops). Table 1 also presents the independent variables, namely indicators of regional integration (time since highway paving and population growth via migration) along with the household capabilities variables (land, labor, and various capitals).

(Table 1 about here)

Statistics for the dependent variables indicate considerable variability among households. Roughly two-thirds of the households had a definitive title, and many others had preliminary titles. This reflects the work of PETT and COFOPRI in titling land in the study region. That said, Table 1 also suggests limited market engagement, whether in terms of households with credit (16%), renting from others (4%), or plans to sell (7%). Many more households reported land conflicts (26%). Measures of resource management also indicate variability. The standard deviation for the castaña harvest substantially exceeds the mean, which indicates that a minority of households had access to castaña concessions. The same phenomenon occurs for both cattle pasture and tree crops; minorities of households pursued these activities, but among those households, those activities were important. Because distributions for castaña and the other resource indicators were skewed, we took natural logs to normalize their distributions for purposes of modeling.

Descriptive statistics for the independent variables in Table 1 provide additional information about the households sampled. At the time of surveys, most households still lacked paving, which is why the mean for “time since paving” is negative, though the value is not far from zero. We defined the migration variable based on community leader interviews as the number of in-migrant families to the

community in the past 5 years minus the number of out-migrant families during the same time period divided by the families present at the time of interviews. A positive value indicates a net gain in population due to migration, and Table 1 indicates a positive mean value, though there was variation among communities.

Beyond the regional integration measures, Table 1 shows that households held agricultural properties with around 40 ha each, with a few households (8%) reporting second properties. Somewhat more households (17%) indicated access to a forest concession, though it was rare (3%) for households to report access to a concession via a third party. Households averaged almost 3 adults each, with 1 or 2 children present and occasionally an elderly family member. Only a minority of household heads interviewed were born in Madre de Dios, a reflection of strong migration from the Peruvian highlands over several decades. That said, respondents had resided for an average of 15 years on their agricultural property. Most were of rural origin, and they averaged roughly 6 years of school completed. As a reflection of the limited number of children present, households reported a mean of more than one person absent, and other analysis indicated that absent family members were often older children sent to towns for secondary education or work. Households reported limited membership in various types of organizations. All of these measures exhibit variation among households.

3.2. Multivariate Analysis

We pursued multivariate analysis to evaluate the statistical importance of regional integration for tenure formalization and its consequences. For the first step, Table 2 presents results from an ordinal logistic regression model of tenure formality, where titling status may be untitled, preliminary or definitive. Here positive coefficients indicate that an increase in the value of an independent variable increases the chances of a household having a definitive title and thus formal land tenure. The key question is whether the indicators of regional integration increase the chance of more formal tenure.

Table 2 indicates the land titling model is highly significant ($p < 0.001$). However, years since paving exhibits a negative coefficient for tenure formalization. That is, households with paving were less likely to have definitive titles. The effect of population growth was insignificant. Other findings in the formalization model do accord with expectations: household with larger properties, older households (with fewer children), households on site for longer durations, and households with more organizational memberships were all more likely to have definitive titles. The inverse relationship observed for time since paving reflects the geography of paving and titling in Madre de Dios: whereas titling activities by PETT and COFOPRI occurred primarily in the Province of Tambopata in central Madre de Dios, at the time of fieldwork, paving had largely transpired in the Province of Tahuamanu in northern Madre de Dios. Hence the inverse finding is not a disconfirmation of the ETLR, but instead an accident of geography.

(Table 2 about here)

Table 2 continues to the second step of the analysis, and considers the first indicator of market transactions, namely whether households had received formal bank credit in the previous year. Here we ran two models, a “base” model with the regional integration and household capability variables, and then a “formalization” model that added the titling variables. We present the second of the two models since findings from the base and formalization model are substantively the same for the base model variables. Here titling becomes an independent variable that should exert a positive effect on obtaining credit. The credit model is a binary logistic regression since the outcome variable for credit is dichotomous. We report odds ratios which rise above 1.0 if an increment in the value of an independent variable increases the probability of a household receiving credit. The credit model is only weakly significant overall ($p < 0.15$). Having a definitive title increases the probability of receiving credit, but the

effect is not highly statistically significant ($p < .15$). The explanation for this finding does not reside with geographic accident. Instead, the positive but weak effect of titling on credit in the study region is likely due to the availability of alternative forms of credit such as the *habilito*.

Table 3 presents models of other market transactions as well as agrarian conflicts. For the sake of brevity in our presentation, Table 3 only shows coefficients for variables of primary theoretical interest in light of the ETLR, though we make note of other significant findings (and can make the full findings available upon request). For land rentals, plans to sell, and agrarian conflicts, we present results for regional integration from the base models and integration and formalization from the formalization models. The first model in Table 3 reports findings from a binary logit model of land rentals from others. Models were statistically significant ($p < .001$), but in both the base and formalization model, regional integration exerted no significant effect on land rentals from. Further, in the formalization model, titling had no significant effect. Instead, household capabilities determined land rentals from others. Households with concessions were much more likely to rent land ($p < .001$), and households on site longer were much less likely to rent land ($p < 0.01$). The finding for concessions may reflect investments by forest concessionaires in rentals for pasture (Rojas 2012); the finding for residence duration suggests a reduced need to rent once a household is more established on their property.

(Table 3 about here)

The second column in Table 3 presents findings from a binary logit model of plans to sell an agricultural property. The model is significant overall ($p < 0.001$), and this time, there are findings that confirm the ETLR. Years since highway paving increases the probability of a household having plans to sell their agricultural property. This finding is strong ($p < 0.01$) and holds when accounting for land titling. Paving in Tahuamanu Province of Madre de Dios indeed stimulated new land settlement and plans for

land sales, likely due to increased land prices. In this regard, regional integration stimulates land markets.

The final column in Table 3 presents models of land conflicts. The conflict model is significant ($p < 0.01$), and there are negative effects of integration in terms of years since highway paving and community population growth (as the odds ratios are less than 1.0). Similarly, both titling variables exhibit negative effects on conflict. That said, all of these coefficients are insignificant. These findings are a surprising failure to confirm expectations from the ETLR given the prevalence of land conflicts around Madre de Dios. Several control variables also exerted weak effects on conflict ($p < 0.15$). Only the presence of elderly household members had a strong positive effect ($p < 0.05$), which might suggest targeting of older households for land invasions.

Table 4 takes the third and final step in the analysis, by presenting models of natural resource management. We considered multiple estimators for models of castaña, cattle pasture and tree crops, and present results from approaches that were most appropriate given the properties of the dependent variable; these also returned stronger results.² The question is whether integration fosters forest-based extractive activities that are more ecologically sustainable or land-based agricultural activities featured in the ETLR. The complication in the case of Madre de Dios is that the ETLR focuses on agricultural activities, whereas forest extractivism is considered more sustainable in ecological terms. For each resource management activity, we present the base model featuring indicators of regional integration, and then add the titling measures in the formalization model, and finally the variables for market transactions and conflict. With this modeling strategy, we are interested in seeing which of the ETLR variables influences each activity, and whether more indirect (distant) determinants such as regional

² Castaña harvested, pasture area and tree crop area are all continuous measures, hence we employ linear models with various estimators. We considered OLS before moving on to other estimators which were more appropriate, such as WLS to account for sampling weights and Tobit to account for the many zeros in the distribution for castaña.

integration remain important when accounting for more direct (proximate) determinants such as market transactions and conflicts.

(Table 4 about here)

The castaña models appear in the first column of Table 4. We modeled the castaña harvest using the Tobit estimator since many households lacked access to forest concessions, resulting in a distribution with many zeros ($n=78$ out of valid $n=227$). Since the distribution of castaña harvested was skewed, we model the natural log of harvest values.³ The base model for castaña is very strong ($p<0.001$), and shows a positive but insignificant effect of highway paving, and a strong negative effect of community population growth due to migration. Households in more stable communities with smaller increments of population reported larger castaña harvests. Several household capabilities variables explain a considerable portion of the variance, especially whether a household had a forest concession, other concession access, birth in Madre de Dios, and membership in more local organizations. None of these findings is surprising; access to forests and stronger local ties are all important for participation in the castaña harvest. The formalization model leads one to the same interpretation about regional integration and castaña. The land title variables add little to explanation and exhibit negative coefficients, especially for definitive titles. This could indirectly suggest that households with definitive titles rely less on castaña and more on agriculture. But the findings are weak, and as we will see for tree crops, that interpretation is overdrawn. The addition of market transactions and conflict contributes little to explanation, and the strong negative effect of community population growth and the weak effect of definitive titles both remain. The castaña harvest thus has little to do with highway paving and occurs primarily in demographically stable communities. These findings are not

³ To avoid losing valid cases, we added one to all castaña harvest values before transforming raw values into natural logs.

surprising in light of the ETLR, which highlights investments in land improvements for agriculture, which is very different from forest extractivism that relies on extant natural capital. Nonetheless, the case of castaña confirms that the ETLR does not account for harvesting of an NTFP.

The second column in Table 4 presents models of pasture for cattle. The natural log of pasture area was approximately normal, so we present WLS results that account for sampling weights. The base pasture model was strong and significant ($p < 0.001$), and regional integration in terms of years since highway paving exerts a strong, positive effect on pasture area. Satellite imagery of Madre de Dios show substantial pasture areas in Tahuamanu Province where the IOH was paved by the time of our fieldwork (Chavez, et al. 2013). This finding could also reflect the influence of Brazilians just across the border from Tahuamanu Province (Perz, et al. 2014a). For Brazilians, cattle ranching is a very important activity, including in the southwestern Amazon (Hoelle 2015). The formalization model shows insignificant effects of land titling, which was surprising, though the strong positive effect of highway paving remains. The market transactions model reveals two additional significant effects among the ETLR variables, namely a positive effect of rentals from others and a negative effect of plans to sell. The first is a commonplace among landowners focusing on cattle: they often need additional land for grazing, even if they have considerable pasture area. The result for plans to sell is intriguing given the insignificant effects of titling, but implies that households with plans to remain where they are also have more pasture. Household capability variables also contribute to understanding of pasture area: households with larger agricultural properties, those with longer durations on properties, and those with heads of urban origin all had significantly more pasture ($p < 0.01$). The pasture models thus align well with expectations of the ETLR: regional integration does expand pasture investments, as do certain forms of market transactions that increase access to land for this land-extensive activity. However, there remain questions about the ecological wisdom of ranching in the Amazon, though improved pasture management practices can in principle permit sustainable management (Walker, et al. 2009).

The final column presents the models for area under tree crops. Here the base model is statistically insignificant, though there is a significant but negative effect of years since paving on tree crop area. This is a surprising result, but likely reflects the geography of market demand vis-à-vis highway paving up to the time of our fieldwork. As noted earlier, paving began in Tahuamanu Province, which is far from the regional capital of Puerto Maldonado. At the time, most tree crops were planted close to the regional capital. Hence the negative effect of time since paving is unlikely to indicate that paving somehow suppresses tree crop planting. The formalization model adds little to explanation, but the market transactions and conflict model is significant overall. This is due precisely to the addition of the ETLR variables involving land rentals from others, plans to sell, and conflict. All three exert significant negative effects on tree crops. The land rental effect likely reflects the intensive nature of tree crops, such that households involved in tree crops focus on their agricultural properties and, unlike ranchers, do not need extra land. The negative effect of plans to sell suggests that established households have more tree crops, which require long-term investments from planting to harvesting. The negative effect of conflict suggests that de facto tenure security (as opposed to de jure security via land titles) is also important for tree crops, for the same reason: they require long-term investments and stability to be profitable. Overall the importance of the ETLR variables for tree crops in Madre de Dios largely stems from the more proximate variables tied to market transactions and avoidance of conflict. Insofar as tenure security fosters investments in tree crops, the ETLR would seem consonant with ecologically sustainable land use.

4. Discussion and Conclusion

Given the characteristics of the study region, the results for Madre de Dios are of interest not only for the ways in which they confirm the ETLR but also for the ways in which they do not. Madre de Dios is a region that is changing rapidly in part due to the recent paving of the IOH, as well as state

efforts to clarify and secure land tenure, which highlights private individual tenure geared for agricultural production. Under conditions of regional integration and state-led titling, one would expect tenure formalization to proceed along with its various consequences.

The results confirm several expectations of the ETLR. Most private individual landholdings had definitive titles and most of the rest had some type of provisional document. Hence under conditions of regional integration via highway paving, there are also indications of efforts to formalize tenure and thereby ensure tenure security. The process of integration in terms of highway paving also influenced at least one indicator of market engagement, such that time since receiving paving increased the probability of plans to sell land. This is likely due to rising land prices along paved sections of the IOH and thus reflects the emergence of land markets. Models of castaña harvests showed that integration, formalization and market engagement had little to do with NTFP management. This indirectly confirms the ETLR insofar as it focuses on agricultural land use rather than harvesting of NTFPs. Indeed, weaker population growth and not having a definitive title corresponded with larger castaña harvests; but the main effects on castaña were simply from having access to forest concessions. Conversely, highway paving had a strong positive effect on cattle ranching in terms of pasture area, along with significant effects of market engagement which suggest that land rentals from others and plans not to sell foster more extensive ranching. Further, market engagement was very important for tree crops; while titling itself was not important, some key consequences of tenure security, such as land rentals and lack of conflicts, were important for the long-term investments required in cultivating tree crops.

Beyond findings that are consistent with the ETLR, other findings that would seem to run contrary can in fact be explained by intervening third factors that do not undermine the ETLR. For example, integration in terms of years since highway paving was negatively related to tenure formalization in terms of titling. But that finding reflects the geographic accident that titling efforts started in one end of Madre de Dios (Tambopata Province) whereas highway paving started at the other

(Tahuamanu Province), rather than an inverse relationship per se. Similarly, because of the geography of paving, the negative effect of highway paving on tree crops reflects their proximity to the main regional market (also in Tambopata Province), and not avoidance of paving by tree planters.

Some findings do however disconfirm the expectations of the ETLR. Despite highway paving and extensive land titling, there was nonetheless limited market engagement and more extensive agrarian conflict. Further, the ETLR makes strong assumptions about formal credit, which is limited in our study region. Integration and formalization do not affect formal credit, likely due to the presence of informal credit. Another form of market engagement, namely renting land from others, similarly had little to do with integration or formalization. Moreover, conflict was not significantly affected by integration or formalization (though we return to this issue below).

Beyond negative findings are results that confirm the limits of the scope of the ETLR with regard to land use. The importance of forest concessions and NTFPs presents novel findings in light of property rights theory. Earlier we noted that the lack of relevance of integration, formalization and market engagement for the castaña harvest indirectly support the ETLR, which focuses on agricultural systems. But the other side of the coin is that the same findings confirm the circumscribed scope of the ETLR, as it does not apply to NTFP harvesting in forest concessions.

The findings from this study thus permit refinement of the scope of relevance of the ETLR. The case of Madre de Dios shows that there are contextual factors which make the ETLR relevant (e.g., highway paving, land titling), as well as those which do not. In the latter group are geographic accidents which do not undermine the ETLR (e.g., the distinct geographies of paving and titling and key market centers), as distinct from other factors that limit the ETLR's applicability (e.g., informal credit, NTFP harvesting). Differentiating these types of factors is crucial for adequately evaluating the impacts of key drivers of land use, especially since the same households may practice more than one form, including one which is more relevant to the ETLR (e.g., cattle ranching) than another (e.g., NTFP harvesting).

This conclusion concerning theoretical scope bears additional implications for public policy. Tenure diversity, as between private agricultural parcels and forest concessions, complicates analysis of tenure security and its consequences. The significant titling effort in Madre de Dios is reflected in our sample insofar as most households with agricultural plots had some type of title. But the titling effort by definition did not extend to the case of forest concessions, which fall under a different access and use regime. Hence efforts to ensure tenure security are also limited to specific types of lands, and in broader landscapes with diverse land types, the impacts on tenure security will be constrained. The further implication is that tenure security among households with access to multiple types of lands will be similarly limited, depending on the applicability of titling efforts to different types of lands and their relative importance for household livelihoods. Hence titling of agricultural properties might beget security for agriculture, but if crop prices are high and forest concessions do not permit clearing, the lack of security in forest concessions could result in illegal deforestation there for crop production (Chavez, et al. 2012).

On that note, since the time of our fieldwork in Madre de Dios, major changes have transpired which shifted the circumstances surrounding tenure security and its consequences for land use. Most notable is the boom in gold mining, stimulated by the global financial crisis that led to a rise in prices of precious metals after 2008 and facilitated by the completion of the IOH in 2011. The gold boom stimulated migration into Madre de Dios, where there is alluvial gold in many creeks. This prompted establishment of mining settlements in unclaimed areas as well as land invasions in some agricultural communities. Miners sometimes cite Peruvian law that differentiates surface and subsoil rights, which did nothing to help relations with farmers whose lands were degraded by gold mining. In this regard it is likely that tenure security for farmers, title or no title, has been undermined, legally and literally, by miners seeking to claim subsoil rights.

Another change since our fieldwork is the completion of the Intercontinental Bridge over the Madre de Dios River at the regional capital of Puerto Maldonado in 2011. Along with migration and money from gold, completion of the bridge facilitated urban expansion, constituting new market demand. Not surprisingly, urban growth stimulated the land market and land use intensification around the city. Some agricultural properties were invaded by migrants seeking land, while others were converted to suburban residential lots. Both cases represent trajectories toward urbanization, beyond the tenure evolution contemplated by the ETLR.

A third change since our fieldwork is cultivation of papaya (*Carica papaya*). Madre de Dios is one of the few places left in Peru that is free of key diseases of this important tree crop. The arrival of the IOH helped stimulate a papaya boom, primarily on underused pastures along the IOH. This has also modified the use of labor on small farms such as those in the communities we surveyed, since papaya is established in large plantations and owners require substantial labor to maintain the trees and harvest the crop. How long the papaya boom will last depends on land management, especially once key papaya diseases arrive in Madre de Dios.

These changes – completion of highway paving, commodity booms, and urban population growth – are all impelling alterations in land use in Madre de Dios. In response to land invasions, we have anecdotal evidence of increasing demand for land titles, in the form of roadside property fences posted with large signs indicating the numbers of title petitions in local courts. The commodity booms are abundantly evident from the IOH in the form of the infamous desert landscapes left by gold mining and the long rows of roadside papaya plantations. Some farmers also partake of mining because it is lucrative and complements the agricultural season in the timing of labor demand. Mining in this respect complements forest extractivism as a source of capital for investment in agriculture. But while commodity booms can be seen as impelling land use investments, they nonetheless fall outside of the processes featured by the ETLR in that booms are not generally sustained.

Nevertheless, regional integration and the economic pressures created by commodity booms impel tenure formalization, while continued urban growth stimulates the land economy, resulting in new forms of land use. In that regard, integration, commodity booms and urban expansion catalyze change processes consonant with the expectations of the ETLR, notably tenure formalization, greater market engagement, and more intensive land use. At the same time, the characteristics of Madre de Dios that fall beyond the ETLR beg questions. The surface/subsoil tenure problem catalyzes land conflicts, and the castaña sector operates under a different tenure regime of forest concessions. The broader implication here is that it is crucial to identify which conditions posited by the ETLR (or other theories) do and do not hold, in order to delineate where to expect agreement between the ideal and the empirics, and where to anticipate differences. This in turn bears implications for policy, for differences between theory and empirical cases provide a basis for anticipating different outcomes from those expected in theory, in order to avoid policies that do not yield the anticipated effects.

Acknowledgments

Financial support for this research came from the National Science Foundation, Human and Social Dynamics Program, Grant #0527511, the Coupled Natural and Human Systems Program, Grant #1114924, and from the US Agency for International Development, Latin America and Caribbean program in Environment, Cooperative Agreement RLA-A-00-06-00071-00. Several of the co-authors are coordinators of the socio-economic component of the NSF HSD grant, and they thank the students and other collaborators who contributed to the fieldwork and data entry in Madre de Dios, Peru (Mara Cardenas, Rosmery Chacacanta, Eder Chulla, Wendy Cueva Cueto, Yeni Franco Solano, Mercedes Perales, Rosa Cossio, Aldo Ramirez, and Benjamin Zevallos). For logistical support we thank Gabriel Alarcón.

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Figure 1. The ETLR framework, highlighting causal pathways from regional integration to tenure formalization, market transactions, formal credit, avoided conflict, and resource management. Adapted from Feder and Feeny (1991).

Figure 2. Analytical design with key explanatory variables from the ETLR as incorporated into each of three steps in the analysis: formalization, outcomes, and resource use.

Figure 3. Map of Madre de Dios, Peru, with rural communities visited, households interviewed, and selected regional market towns along the Inter-Oceanic Highway

Table 1. Descriptive Statistics for Determinants and Consequences of Tenure Formalization in Independent Communities, Madre de Dios, Peru, 2008

Indicator	Mean	Standard Deviation
Formalization		
Preliminary Title (0=No, 1=Yes)	0.29	0.46
Definitive Title (0=No, 1=Yes)	0.66	0.48
Market Transactions		
Formal Credit, 2007 (0=No, 1=Yes)	0.16	0.37
Land Rentals from Others (0=No, 1=Yes)	0.04	0.20
Plans to Sell (0=No, 1=Yes)	0.07	0.26
Conflict		
Conflicts over Agricultural Land, Last 12 Months (0=No, 1=Yes)	0.26	0.44
Natural Resource Management		
Kg Castaña Nut Harvest, 2007	979.19	3279.73
Ln Kg Castaña Nut Harvest, 2007	2.20	3.35
Ha under Cattle Pasture	6.68	11.08
Ln Ha under Cattle Pasture	1.32	1.21
Ha under Tree Crops	2.53	18.54
Ln Ha under Tree Crops	0.63	0.65
ETLR Variables		
Years since Highway Paving	-2.00	1.14
Community Net Migration ((In-Out)/Families*100)	15.73	16.42
Capitals and Capabilities		
Land		
Ha of Agricultural Property	37.05	30.09
Ln Ha of Agricultural Property	3.35	0.83
Second Agricultural Property (0=No, 1=Yes)	0.08	0.27
Forest Concession (0=No, 1=Yes)	0.17	0.37
Other Concession Access (0=No, 1=Yes)	0.03	0.16
Labor/Dependency		
Adults in Household	2.89	1.54
Children in Household	1.43	1.26
Elderly in Household	0.15	0.45
Cultural Capital		
Region of Birth (0=Other, 1=Madre de Dios)	0.28	0.45
Years on Agricultural Property	15.11	11.69
Human Capital		
Place of Birth (0=Rural, 1=Urban)	0.36	0.48
Respondent Years of School Completed	6.27	3.01
Social Capital		
Absent Family Members	1.26	1.70
Types of Organizational Memberships	0.69	0.69

Table 2. Determinants of Formalization (Titling) and Credit, Households with Land in Rural Communities, Madre de Dios, Peru, 2008

Determinants	Land Titling (Ordinal Logit)	Formal Credit, 2007 (Logit)
Pseudo-R ²		
Chi-square	52.00 **	26.76 +
df	15	17
<u>Drivers of Tenure Evolution:</u>		
Years since Highway Paving	-0.483 **	1.111
Community Pctg. Net Migration	0.008	0.991
<u>Control Variables:</u>		
Ln Ha of Agricultural Property	0.644 *	0.952
Second Agricultural Property (0=No, 1=Yes)	0.429	2.305
Forest Concession (0=No, 1=Yes)	-0.446	4.349 *
Other Concession Access (0=No, 1=Yes)	0.398	1.805
Adults in Household	0.073	1.448 *
Children in Household	-0.303 *	1.197
Elderly in Household	0.212	1.251
Region of Birth (0=Other, 1=MDD)	0.183	0.649
Years on Agricultural Property	0.091 **	0.962 +
Place of Birth (0=Rural, 1=Urban)	-0.005	1.015
Respondent Years of School Completed	-0.019 *	0.985
Absent Family Members	-0.039	1.080
Types of Organizational Memberships	0.493 *	0.974
Provisional Title (0=No, 1=Yes)		3.568
Definitive Title (0=No, 1=Yes)		5.500 +

1. After listwise deletion of cases with missing data, n=227.

2. + p<0.15, * p<0.05, ** p<0.01.

Table 3. Effects of Formalization on Market-based Transactions and Conflicts, Households with Land in Rural Communities, Madre de Dios, Peru, 2008

Determinants	Land Rentals from Others (Logit)	Plans to Sell (Logit)	Conflicts over Agricultural Land, Last 12 Months (Logit)
Base Model			
Pseudo-R ²			
Chi-square (df=15)	49.97 **	36.56 **	29.46 *
Years since Highway Paving	0.625	2.472 **	0.795
Community Pctg. Net Migration	1.020	0.977	0.978 +
Formalization (Land Title) Model			
Pseudo-R ²			
Chi-square (df=17)	50.63 **	40.82 **	33.17 *
Years since Highway Paving	0.566	2.934 **	0.761
Community Pctg. Net Migration	1.022	0.975	0.978 +
Provisional Title (0=No, 1=Yes)	0.422	0.426	0.577
Definitive Title (0=No, 1=Yes)	0.374	3.158	0.401

1. After listwise deletion of cases with missing data, n=221.

2. + p<0.15, * p<0.05, ** p<0.01.

Table 4. Formalization and Resource Management, Households with Land in Rural Communities, Madre de Dios, Peru, 2008

Determinants	Ln Castaña Nut Harvest (Tobit)	Ln Ha under Cattle Pasture (WLS)	Ln Ha under Tree Crops (WLS)
Base Model			
(Pseudo) R ²	0.250	0.443	0.055
Chi-square/F-test (df=15)	182.12 **	38.56 **	1.34
Years since Highway Paving	0.603	0.210 **	-0.092 *
Community Pctg. Net Migration	-0.168 **	-0.004	0.001
Formalization (Land Title) Model			
(Pseudo) R ²	0.254	0.443	0.069
Chi-square/F-test (df=17)	184.86 **	33.82 **	1.14
Years since Highway Paving	0.494	0.207 **	-0.074 +
Community Pctg. Net Migration	-0.171 **	-0.004	0.000
Provisional Title (0=No, 1=Yes)	-1.982	-0.030	0.297
Definitive Title (0=No, 1=Yes)	-2.941 +	-0.050	0.395
Market Transactions and Conflict			
(Pseudo) R ²	0.256	0.488	0.114
Chi-square/F-test (df=22)	186.09 **	60.30 **	13.67 **
Years since Highway Paving	0.572	0.219 **	-0.084 *
Community Pctg. Net Migration	-0.170 **	-0.004	0.000
Provisional Title (0=No, 1=Yes)	-2.128	-0.006	0.264
Definitive Title (0=No, 1=Yes)	-2.944 +	0.007	0.393
Formal Credit, 2007 (0=No, 1=Yes)	-0.781	0.035	-0.053
Land Rentals to Others (0=No, 1=Yes)	-0.595	0.217	-0.146
Land Rentals from Others (0=No, 1=Yes)	0.326	1.156 **	-0.444 **
Plans to Sell (0=No, 1=Yes)	-0.679	-0.010 **	-0.008 **
Conflicts Over Agricultural Land, Last 12 Months (0=No, 1=Yes)	0.000	0.004	-0.007 **

Notes.

1. After listwise deletion of cases with missing data, n=227.
2. + p<0.15, * p<0.05, ** p<0.01.
3. Inferential statistics for Tobit models are Chi square tests.
4. Inferential statistics for WLS models are F-tests.