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Titling, Credit Constraints, and Rental Markets in Rural Peru: Exploring Channels and Conditioned Impacts

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Abstract

This paper constructs a baseline and pursues an overall impact evaluation of the PETT (*Programa Especial de Titulación de Tierras*), an ambitious rural titling program created in Peru in 1992. The general evaluation of impacts on farmers shows a picture of not many positive effects, at least in the short period of the evaluation (2004-2006) and for a limited sample of farmers located in the Coast and Sierra regions. On average, most income variables (and income composition) do not seem to be impacted by titling, and there are no detectable effects on investments (except for permanent pasture in the Sierra) or other outcome variables, such as credit, land markets, or land conflicts. However, this general picture hides important impacts that may occur for some groups of farmers, or for farmers facing different constraints in the pre-intervention stage. Given the limitations, we investigated in more detail two important channels that are behind the potential impacts of rural titling programs: credit access and use of land rental markets.

Keywords: Land titling, Rural areas, Agricultural economics, Peru
JEL classification: O13, Q15, R14

1. Introduction

Peru has been implementing an ambitious rural titling program during the past decade. With financial support from the Inter-American Development Bank (IDB), an agency of the Ministry of Agriculture, called PETT (*Programa Especial de Titulación de Tierras*, created in 1992), began increasing its titling operations in the mid-1990s. In its first stage (1996-2001), the titling effort was oriented mainly toward modern areas along the Coast that had been affected by Agrarian Reform in the 1970s; in 2002, the emphasis of the program switched toward titling the more traditional Andean (or Sierra) region. The Peruvian rural land titling program is considered one of the largest in South America, given the massive number of plots and farmers it aims to reach.[1]

Notwithstanding its importance and maturity, the impact of the Peruvian rural land program has not been rigorously evaluated because it lacked a proper baseline.[2] For the second phase of the IDB-financed titling program (2002-2006), it was considered necessary to construct a baseline and pursue an overall impact evaluation for the program. A baseline survey of a representative sample of rural households was conducted at the end of 2004 by the GRADE-Cuanto consortium (Zegarra *et al*., 2005). In October 2006, a final impact survey was conducted for the same sample (Zegarra *et al*, 2006). This evaluation was based on difference-in-difference estimators for treated and matched comparison groups; it is the main source of data for this study.[3]

The results obtained in the impact evaluation were not very impressive (regarding the impact of titling) because few impact variables could be identified as moving in a positive way due to the PETT titling process between 2004 and 2006. For instance, most variables associated with income (and its composition) did not show any significant effects (at least due to titling).

1 According to the Peruvian Agricultural Census (1994), there are 1.75 million farmers in Peru with about 5.5 million plots. The national cadastre of rural plots developed by PETT accounts for about 2.5 million plots currently (2006), although it does not cover all the agricultural area (for instance, communal lands are not included). Of the area in the rural cadastre, our estimate is that PETT has titled about 40 percent of the plots or about 1 million parcels during the last decade.

2 In an effort to solve this problem and come out with credible impact measures, Torero and Field (2005) used LSMS type household surveys (ENNIVs) from 1994, 1997, and 2000 combined with a new specific survey applied in 2004. Combining these surveys, the authors were able to build a data set at the plot and farmer levels that was used for impact evaluation purposes. This important effort, however, did not produce conclusive results for most impact variables of title on welfare, investments, and credit access, especially when applying difference-in-difference estimators.

3 There was an additional gathering of data at the community level for this study. Data on credit supply, relative price of agricultural factors, and other non-PETT interventions were included in the community questionnaire.

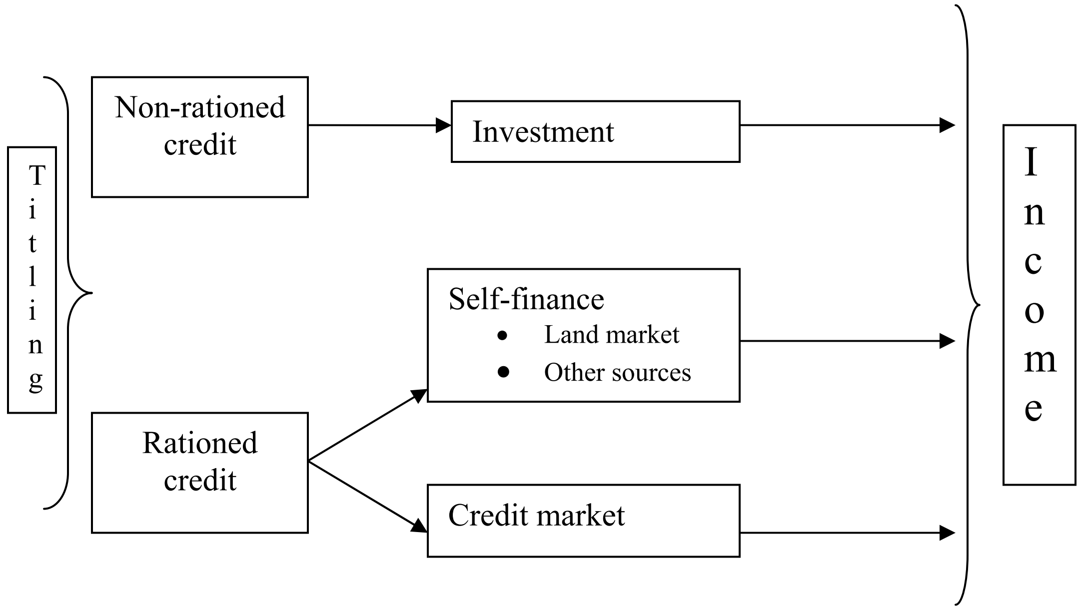
And access to credit did not have a statistically significant impact. For the Sierra, the only variable that titling seemed to affect was installation of permanent crops; but this was mainly in new pastures for cattle. However, on the Coast there were marginally significant effects on agricultural income and the value of livestock. In both regions, it was not possible to find any significant effects on other variables, such as various types of investments, conservation practices, land values, agricultural and non-agricultural assets, and land conflicts.

A limitation of the standard matching methods for impact evaluation that were used in the above-mentioned evaluation is that the estimates, which provide only average effects, offer little information on the potential channels through which any impacts may have affected the decision-making of farmers. An analyst might look at the average impact variables and be able to say something about the relative importance of some channels that may appear to be active. But it could be the case that some channels are only active for some types of farmers or for farmers in particular circumstances or contexts. If this were the case, the analyst may want to cut the sample in a way that would maintain the basic assumptions of the matching method and lead to conclusions about the relevant channels for the observed impacts.

Methodologically, in this study, we do not estimate full structural models of farmer behavior or even reduced forms in which an exogenous variable gives estimates of the impact of titling on behavior.[4] Instead, we keep our main approach inside the paradigm of the impact evaluation literature, using economic theory to identify appropriate variables to condition the estimation of impacts with matching techniques and to shed light on the potential channels. We start by developing a simple diagram that highlights some of the key expected impacts of titling on income, based on the international literature (Figure 1).

[4] A recent example of the approach of using structural equations to estimate the impacts on land markets and income of a titling program like Procede in the Mexican *ejido* land reform is given by Bresciani (2004).

Figure 1.1. Expected Impacts of Titling on Income



We distinguish credit constrained and credit unconstrained households, and look at investment and income generating activities. For unconstrained households, an impact of titling on investment, productivity, and income can be interpreted as a direct effect of more tenure security over land assets, which makes investment more profitable. For credit constrained households, the impact of titling becomes conditioned on increases in liquidity, which may come from credit markets or self-finance alternatives. Households can increase their investment and income due to titling only if the liquidity constraint is relaxed.

In this study, we are particularly interested in exploring the importance – for measuring the effects of titling – of credit constraint regimes, which are unobservable. We develop an empirical strategy to identify credit constrained and unconstrained regimes, and thus have an important dimension to cut our sample when estimating impacts using matching methods. At the same time, we are interested in evaluating the role of the land rental market channel, especially as a potential source of self-finance for credit constrained farmers. We hypothesize that the land rental market becomes more active for titled farmers only under certain circumstances, such as when the density of titling in the community is high enough for transaction costs to go down. This last issue is important for a titling program than operates for an entire community, not isolated or dispersed individuals.

The rest of the paper is organized as follows. In Section 2, we describe the main approach that we use for evaluating impacts using matching methods. Section 3 describes the titling process that characterized PETT in rural Peru during the period under evaluation. This description is important for identifying whether the process may have some features that are amenable to the matching approach, and for identifying some variables that need to be considered when estimating matching scores between treated and control groups. We also explain the sampling process in more detail in Annex 1.

Section 4 describes the conceptual approach and estimation of unobservable credit constraint regimes, which will be used to condition for potential impacts of titling on diverse outcome variables. In Section 5, we develop a model of the land rental market with tenure insecurity and transaction costs associated with titling density. In this case, we re-estimate the impacts using title density (at the community level) as a cutting variable of the sample. Section 6 presents the main conclusions of the study.

2. The Impact Evaluation Approach[5]

The so-called evaluation problem is generally a problem of establishing causality. A public program generates an impact or change on people's lives and we want to know if they improved their welfare due to that intervention. For establishing this potential causality between the intervention and people's welfare, we need to know what would have happened to these people without the intervention (a counterfactual). We then compare what happened with what would have happened on the welfare variable. Obviously, we cannot observe the same people in these two states. Observing people before and after an intervention generally does not solve the problem, because other socio-economic factors—besides the intervention itself—may have affected the impact variable as well.

The solution to this problem in the evaluation literature is to build a counterfactual group (that mimics the behavior of the treated group without the intervention) from those who were not intervened. For this to be a reasonable approach, some conditions must hold. The counterfactual group must be similar to the treated one in some fundamental way, i.e., the people must be equally likely to have participated in the program, but did not participate due to some exogenous factor (i.e., not related to their characteristics). One way to ensure that this condition holds is

[5] See Duflo et al. (2006), Heckman et al. (1997), and Manski (1995).

through randomization of the program among potential beneficiaries, so that both the treated and counterfactual groups come from the same distribution. When randomization is not feasible or was not adopted, another approach is to build the counterfactual from the people who did not participate in the program during the period under evaluation, which is the method we use in this study.[6]

We formalize some of the ideas stated here. We define an impact variable Y, which may take different values according to observed program participation (Y_1 if D=1 and the agent participates, or Y_0 and D=0 and the agent does not participate). The value of Y at any point is:

$$Y = D(Z)*Y_1 + (1-D(Z))*Y_0 \qquad (2.1)$$

We denote D(Z) the observed participation status, depending on a set of variables Z, which determine program participation. The main goal of impact evaluation is to estimate $E(Y_1-Y_0|D=1,Z)$, i.e., the expected value of the change in the impact variable conditional on participation (this is called the mean treatment effect on the treated). This requires knowledge about $E(Y_0|D=1,Z)$, which is the value that Y would have taken for a non-participating agent if that agent had participated in the program (the counterfactual), which is not observable.

Instead, impact evaluation looks for a suitable estimator of $E(Y_0|D=1,Z)$ based on observables, which may be, for instance, $E(Y_0|D=0,Z)$, i.e., the expected value of the impact variable for the non-participating group. If the impact variable Y has the same conditional (on Z) distribution independent of participation status, we can build the counterfactual using observable information. This is a required assumption for using non-experimental data to estimate the impact of treatment on the treated. This assumption is formalized as:

$$E(Y_0|D=1,Z) = E(Y_0|D=0,Z)= E(Y_0|Z) \qquad (2.1A)$$

[6] Programs like rural titling in Peru have some features that are close to the situation in which a reasonable counterfactual can be built. The extent of land formalization in rural Peru prior to the intervention (circa 1994) was so low that the strategy implemented by PETT was one of massive coverage, working entire agricultural areas as titling blocks. Even if there may have been some selection rule or prioritization at the level of these blocks, the process of individual titling was hardly based on demand; it was more a typical exogenous intervention coming from outside the communities. At the same time, all areas were eligible (with the exception of communal and protected areas), and the probability of receiving a title for a farmer depended more on location and the timing of the general process. We explore in more detail the process of titling and potential biases in Section 3.

According to equation 2.1A, $Y_0|Z$ is independent of D, the participation status, and both the participating and non-participating units will have the same conditional distribution of the impact variable regardless of participation status.

Matching methods

When exogenous randomization (or experimental design) on the participation status is made, condition (2.1A) is automatically accomplished as far as the eligible units are randomly extracted and assigned to participation status before the intervention occurs from a known and well defined population. When randomization does not occur (a non-experimental framework such as the one we have for this study), condition (2.1A) must be assumed and is the basis for using matching methods.

The main point of the matching methods is that the researcher is able to observe all relevant variables Z that explain participation in the program and so can observe (and consistently estimate):

$$0 < \Pr(D=1|Z) < 1 \qquad (2.1B)$$

This is the probability of participation in the program as a function of those conditioning (and observable) variables Z. Under (2.1A) and the existence of probability such as (2.1B), the matching estimators of the impact (in a non-experimental framework) will identify the same parameters as the ones in an experimental design.

We now focus on the impact variables and define a set of variables T and U that determine the impact variables according to:

$$Y = g(T) + U \qquad (2.2)$$

where g(.) is a deterministic function of observed T variables and U are unobserved variables to the researcher. The main concern with a non-experimental impact evaluation is the potential relationship between Z and U. If there is dependence or correlation (or variables in common) between Z and U, the unobservables will affect both participation and impacts, and the matching method will not be able to eliminate the bias from selection on unobservables. The most favorable case for the matching method to estimate unbiased impacts is when Z and U are independent, so that any selection on Z will not bias the impact assessments.

Estimation of the impacts requires (2.1A) to be able to condition on variables Z. This is very demanding in terms of data processing because differences in impact variables must be conditioned on multi-dimensional variables. However, the evaluation literature has shown that conditioning only on Pr(Z) is equivalent, and the matching process can be done in the one-dimensional P(Z), which is the probability of program participation. The estimation of P(Z) plays a central role in impact evaluation because matching between treated and comparison units will be based on this function, which is called the p-score variable.

In practice, P(Z) makes the treated and comparison groups comparable on Z, and each treated observation is assigned a comparison (or group of comparisons) to get a measure of the difference in the values of the impact variable. The mean of these values over a well defined support on Z is the estimated impact or average effect of treatment on the treated.

How matching handles potential biases in non-experimental data

Two sources of bias arise with matching procedures. The first is related to the common support on Z. It is only for positive and overlapping values for the treated and comparison groups on P(Z) that the procedure will estimate parameters equivalent to those obtained in an experimental setting with the same support. The second bias is related to the distribution of P(Z) in the common support. Comparing treated observations only with comparison observations weighted according to closeness in P(Z) provides a correct impact estimation, mimicking what would happen in an experimental setting.

Another bias that potentially appears in an impact evaluation is related to non-observable variables U when these, for instance, are not independent of Z. If participation is somewhat based on unobservable variables U as well, which also affect expected impacts Y, the matching method will generate biased estimates of impacts, and we will not know the shape and direction of the biases without experimental data.

However, if the unobservable variables that have these features are permanent, the bias may be eliminated using difference-in-difference estimates, which can be calculated when data on pre-program and post-program variables are available. In our case, this option is available because we have pre-program or baseline data for this study, and the assumption required is that the Z variables are independent of the difference in the U's at the two points in time.

Assessing impact channels

The final idea that we will use in this study is related to the relationship between Y and the conditioning variables in the impact equations. We assume a more complete model for the impact equation:

$$Y = g(T|X) + U \qquad (2.2')$$

in which the impact of T on Y is conditioned on the values of the X variables, which are related to the context or to binding constraints on the agent. In order to be able to condition impacts on X variables, they must be uncorrelated with U (and also with Z), or with differences in the U's over time when we use difference-in-difference methods.

3. The Titling Process and Sampling Design

In principle, we can divide the plots of land in rural Peru at some point in time (for example, 2004) according to their ownership documents in three categories: (a) plots titled and registered before the PETT project, (b) plots titled and registered by the PETT project, and (c) plots with other types of documents not registered in the formal system. The effort of titling by PETT in 2004-2006 formalized property in the last category of plots.

We looked into the details of the PETT titling process in order to detect similarities and departures from an experimental situation for impact evaluation, such as titling for individual farmers as part of a random process (and so, by definition, totally exogenous to farmers). There are four main entities that intervene in the titling process, for example for a plot in Peru:

- Aerophotograph National Service (a public firm called SAN)
- PETT-Central Office
- PETT-Regional Offices
- SUNARP (National Registry)

The program hires SAN to take aerial photos of specific locations. According to our interviews, the locations are required by PETT regional offices according to their annual work plans. SAN is a service that is provided by the Air Force of Peru. The service is limited by climatic conditions and flight plans related to the overall operation of the firm.

After receiving the aerial photos, PETT's central office begins the process of converting the images into digital information, using diverse techniques, such as spatial triangulation models and photogrametric restitution. The (unprocessed) photos are also sent to the requesting regional office, which at that point begins one of the most important parts of the titling process: gathering information in the field. PETT's regional staff uses a complete aerial photo (*vuelo aerofotográfico*) to plan the process of gathering information on all plots in the related area.

PETT's personnel choose one extreme of the image, identify the nearest community, and travel there to cover all the relevant area inside the photo, visiting each involved community to collect information on all their plots. In this process, PETT's personnel fill in a plot-specific document (*ficha*) for each plot, and obtain all the required documentation that can be used to show possession or property of the plot by the farmer making the claim. In general, the entire process is made in blocks of plots, which are divisions of the area covered by the aerial photo.

According to Peruvian legislation, individual farmers can use several alternative documents to show that they have been farming the land peacefully during the past years (which is enough to claim the property). For example, they may use previous titles or acquisition documents, payment of water tariffs, declarations from neighbors, payment of local taxes and other receipts, or any proof of being a farmer working peacefully on the plot. According to PETT's staff, the documents most often used by farmers are declarations by neighbors, followed by *minutas de compra-venta*, a document that is generated by a notary when land is acquired from a third party.

When they go to the field to gather information on the plots, PETT's personnel seek to obtain all the necessary documentation. However, sometimes key documents may be lacking, such as the personal identification of one or both of a married couple. At this point, the marital status of the claiming farmer is also established. In the case of a married or stable couple (for at least two years), it is obligatory to assign any land property to both spouses unless one of them had already established an individualized claim to the property prior to the marriage. A sketch is made of each individual plot. All of the field information is then combined with the data processed by PETT's central office (after processing) to form a legal file or *expediente*, which involves all the documentation related to the titling process of a plot and is sent to the National Registry, SUNARP. All the legal files that are ready and that belong to the same block are sent together.

SUNARP then takes over and evaluates the documentation according to the registration procedures and legal requirements (including the publication of claimed owners in a local paper). After the registration process is completed, a title for each plot is generated and the process of giving the title to each farmer is part of the responsibility of PETT and the Ministry of Agriculture.

The sampling process

During the titling process, PETT also generates a cadastre of rural plots based on the information it has collected. The cadastre is a complete list of plots, containing information such as the aerial photo to which each plot was assigned, the coordinates of the plot, the date when PETT visited it, its shape and area, the current status of the property (according to the most recent update), and whether the owner already had the title. The cadastre also contains information on some of the attributes of the owner or owners – name, identification number, and some information taken from the original *ficha*.[7]

The cadastre is a key element for this study; we used it as the basis for taking the baseline sample of plots (and households) in 2004. The decision to use the cadastre of plots as our sampling framework was based on the fact that a high proportion of non-titled plots in the cadastre qualified as good candidates for receiving a PETT title in the period 2004-2006 (the treatment period) but, due to delays and the long duration of the titling process, did not receive a title in that period. We thus assigned them to the control group of the evaluation. Another important factor was that the PETT cadastre is the only available database of plots that has been built in a systematic way and allows systematic sampling. However, the database has important limitations, which are explained in Annex 1 (see footnote 7).

A sample of districts, areas, and plots was taken from five built-up geographical domains in the rural Coast and Sierra regions, using an adjusted version of the cadastre of 2004 as the sampling framework (see Annex 1 for more details on the sampling design and stratification). The original baseline sample had 2,234 households but only 2,034 households were interviewed. The final evaluation survey in 2006 was able to find about 1,800 of the same baseline households and applied a similar questionnaire to them. Data were collected on income, agricultural and non-agricultural production, land market activity, agricultural and soil conservation practices,

[7] It turned out that some of the fields in the database (especially those related to the title status of plots in 2004) were not updated as the titling process progressed. This adversely affected the sampling design, which is discussed in Annex 1.

investments, access to credit (formal and informal), land conflicts, and other household and dwelling characteristics. No expenditure data were collected. A final visit to all of the involved communities was made for the purposes of this study, in which a community questionnaire was applied to local informants to gather information about the presence of credit institutions over time, land and other factor prices, and the presence of other non-PETT public and private interventions.

Potential biases in the titling process

From the titling process description, we see that titling does not come as an endogenous decision of the farmer; it is more related to decisions taken at a state institution. The methodology implemented by PETT during the titling process is of the universal coverage type and consists in working with all farmers over a small area without exception before continuing in a neighboring area. This method of exogenous titling avoids the typical problem of reverse causality between titling and some impact variables, such as investment.

However, from the description of the titling process, we can also see that there are potential biases that might affect the comparison between treated and comparison groups. In this section, we analyze some of these characteristics. To do so, it is important to distinguish two types of potential biases: area or group-based versus individual-based characteristics. Individual characteristics include attributes that imply that a particular plot or household did not receive the title or that there was a larger delay in receiving it due to attributes that affect the potential impacts of titling. Group or area-based characteristics include characteristics of the area to which the plot belongs. Table 3.1 shows the distribution of households in each group (control and treatment) according to the titling density of the block to which the household belongs. The titling density of the block had been estimated from the 2006 PETT cadastre.

Table 3.1 shows that more than 70 percent of the control group belongs to a block in which there is at least one plot with a PETT title. The table shows that belonging to the treatment or the control group depends on a mix of group and individual characteristics. Group characteristics determine how advanced the titling process is in a particular block; individual characteristics determine when a particular household receives its title, once the titling process has already begun on the block to which the household belongs. These potential biases must be dealt with in our matching process.

Table 3.1

Distribution of households in the sample according to the percentage of plots titled in the block

		Percentage of plots titled in the block						
		0	0-15	15-25	25-50	50-75	75 or more	Total
No PETT	Num households	50	32	13	36	27	30	188
	Percentage	26.6	17.0	6.9	19.1	14.4	16.0	100.0
Titled between 2004 and 2006	Num households	5	14	13	45	63	89	229
	Percentage	2.2	6.1	5.7	19.7	27.5	38.9	100.0
	Total	55	46	26	81	90	119	417

Sources
Titling density: 2006 PETT cadastre
Control and treatment: GRADE-CUANTO Final Households Survey

From the description of the titling process, we think the individual characteristics that might introduce biases in the estimates of titling impacts include the following:

- *Migration levels*. Families whose members present higher migration levels might have a lower likelihood of being titled because the owner of the plot might be absent when PETT personnel arrive in the town.
- *Access to personal identification documents*. Because these documents are a requisite, access to them should be correlated with access to a PETT title.
- *Presence of conflict*. The presence of conflict would be correlated with access to a title because PETT's personnel do not process plots under conflict.
- *Characteristics associated with rejection of the title*. We have been told that some farmers are not willing to cooperate with the titling process because they are afraid of being taxed as a consequence of being titled. Therefore, risk aversion is a characteristic that might be positively associated with rejection.
- *Human capital*. Higher levels of human capital or education might be associated with receiving the title faster because mistakes in the legal file delay the process and are less likely to occur when the farmer has a higher level of education. A common mistake in the legal file is that the name in the file is not exactly the same as the name on the personal identification document.

The group or area characteristics that might differ between the treatment and control groups include the following:

- *Land productivity*. Regions with higher levels of productivity might receive preferential treatment by the PETT office in the titling process. This preferential treatment might lead to higher productivity regions being titled earlier.

- *Land fragmentation*. The impact of land fragmentation on the likelihood of being titled earlier is ambiguous. More-fragmented zones could receive a lower priority because they imply lower levels of profitability for agriculture. At the same time, in more-fragmented zones, the titling office might be able to deliver more titles in less time.
- *Isolation*. More-isolated areas might receive lower priority because of greater logistic costs.

Table 3.2 shows the marginal effects of a probit model, at the plot level, which tries to explain the likelihood of being titled between 2004 and 2006. This probit estimation is the basis for the matching analysis in the next section. The estimation excludes plots that had property conflicts in 2004 as well as plots whose owner said they were not interested in acquiring a PETT title in a follow-up survey in 2005. Besides these two characteristics, which led to a marginal reduction in the size of the sample, the estimation includes almost all of the group and individual characteristics just mentioned with the exception of migration levels.[8]

[8] Migration levels were not included because the baseline survey (2004) did not include information on temporal migration. However, a survey in 2005 showed no relationship between being titled after 2005 and temporal or permanent migration levels on 2005.

Table 3.2

Determinants of receiving a title at the plot level
(Marginal effects of a probit model)

	Between 2004 and 2006			Before 2004		
	Coef	Std Err		Coef	Std Err	
Individual Characteristics						
Area owned (hectares)	-0.0061	0.0020	***	-0.0023	0.0013	*
Age of head (years)	0.0021	0.0015		-0.0008	0.0009	
Years of education of head	0.0039	0.0047		-0.0041	0.0031	
Mother tongue of head is spanish	0.1637	0.0415	***	-0.2787	0.0258	***
Family size	-0.0151	0.0088		0.0237	0.0054	***
Time from plot to farmer house	0.0002	0.0006		0.0008	0.0004	
Plot has high slope	-0.0006	0.0523		0.0474	0.0338	
Plot is in middle altitude area	0.0262	0.0444		0.0983	0.0283	***
Plot is in high altitude area	0.1982	0.0467	***	0.0683	0.0326	**
Percentage of plot with irrigation	0.0012	0.0004	***	0.0018	0.0003	***
Index of erosion in plot	0.0032	0.0235		-0.0234	0.0167	
Index of quality of plot	-0.0657	0.0314		-0.0406	0.0191	**
Index of livestock	0.0000	0.0000		0.0000	0.0000	
Area of the plot	-0.0010	0.0051		-0.0047	0.0038	
Head has ID	0.1235	0.0540		0.0288	0.0366	
Spose has ID	-0.0181	0.0539		-0.0438	0.0332	
Group Characteristics						
Time from plot to province capital	-0.1506	0.0379	***	0.0981	0.0250	***
Time from plot to district capital	-0.0012	0.0002	***	0.0004	0.0002	***
Level of land concentration (district)	-8.2029	1.4688	***	-8.5549	0.9660	***
Value of production per hectare (district)	-0.0050	0.0123		-0.0130	0.0070	
Dummy for Sierra	-0.1636	0.0571	***	0.1517	0.0325	***
Number of obs		991			2317	
LR chi2(20)		175.51			308.89	
Prob> chi2		0			0	
Pseudo R2		0.1278			0.0962	

Source: GRADE-CUANTO Final Households Survey

Table 3.2 also shows the determinants of being titled before 2004, just as a reference. From both estimations, we can see that there has been a change in the characteristics associated with being titled. Distance acquired more relevance after 2004, and mother tongue reversed its relationship with the likelihood of receiving a title. In addition, access to irrigation decreased its correlation with access to a PETT title.

Table 3.3 shows the determinants of being titled, at the household level. These estimations exclude the households that reported a property conflict in 2004 as well as households that were not interested in receiving a title. The estimations for receiving a title after 2004 are the base for the matching analysis, at the household level, that will be used in the next section. The estimations in Table 3.3 show the same features as those at the plot level.

As explained in the previous section, we will use difference-in-difference estimators to identify the impacts of titling. A typical concern with the use of this method is the presence of non-observables that are correlated with receiving the treatment as well as with the *growth rate* of some outcome variables, such as land productivity. A way to assess the presence of this problem is to compare the growth rate of the treated and the control group, before the date at which the treatment was delivered.

Table 3.3

Determinants of Receiving a Title at the household level
(Marginal effects of a probit model)

	Between 2004 and 2006			Before 2004		
	Coef	Std Err		Coef	Stad Err	
Individual Characteristics						
Area owned (hectares)	-0.0073	0.0037	*	-0.0036	0.0017	**
Age of head (years)	0.0052	0.0029	*	0.0017	0.0014	
Years of education of head	0.0229	0.0091	***	0.0090	0.0049	*
Mother tongue of head is spanish	0.3014	0.0871	***	-0.0821	0.0408	**
Family size	-0.0327	0.0167	*	0.0065	0.0081	
% of plots with high slope	-0.1403	0.1308		-0.0488	0.0643	
% of plots in med alt area	0.0123	0.1105		0.0433	0.0520	
% of plots in high alt area	0.2930	0.1237	**	0.1850	0.0688	**
Av of percentage of plot with irrigation	0.0702	0.0330	**	0.0292	0.0184	
Average index of erosion in plots	0.1870	0.0618	***	0.0720	0.0332	**
Average index of quality of plots	0.0574	0.0719		0.0254	0.0309	
Index of livestock	0.0000	0.0000		0.0000	0.0000	
Head has ID	0.0491	0.1095		0.0168	0.0539	
Spose has ID	0.2470	0.0915	**	0.0473	0.0503	
Group Characteristics						
Time from cap distr to prov capital	-0.2481	0.0781	***	-0.0077	0.0354	
Minimum Time from plot to district capital	-0.0009	0.0004	**	-0.0004	0.0003	
Level of land concentration (district)	-11.1209	3.2418	***	-6.5824	1.3816	***
Value of production per hectare (district)	-0.0144	0.0222		-0.0049	0.0094	
Dummy for Sierra	-0.3267	0.0995	***	0.0842	0.0448	*
Number of obs		290			621	
LR chi2(20)		105.5			63.87	
Prob> chi2		0			0	
Pseudo R2		0.2625			0.0957	

Source: GRADE-CUANTO Final Households Survey

Table 3.4 presents the marginal effects of probit models that explain the likelihood of receiving a title after 2004, at the household and plot levels. These estimations include the growth rate, between 1997 and 2004, of the value of production per hectare at the district level (using aggregate data from the Ministry of Agriculture). The table shows that, controlling for observables, the growth rate of land productivity is not significantly correlated with receiving the treatment.

Table 3.4

Determinants of being titled, between 2004 and 2006, at the household and at the plot level.
Marginal effects of a probit model

Plot level			Household level		
Individual Characteristics	Coef	Std Err	**Individual Characteristics**	Coef	Std Err
Area owned (hectares)	-0.0062	0.0020 ***	Area owned (hectares)	-0.0078	0.0037 **
Age of head (years)	0.0025	0.0015	Age of head (years)	0.0051	0.0030 *
Years of education of head	0.0031	0.0048	Years of education of head	0.0245	0.0096 **
Mother tongue of head is spanish	0.1712	0.0417 ***	Mother tongue of head is spanish	0.3120	0.0875 ***
Family size	-0.0152	0.0089	Family size	-0.0376	0.0173 **
Time from plot to farmer house	0.0000	0.0006	% of plots with high slope	-0.1585	0.1328
Plot has high slope	-0.0001	0.0524	% of plots in med alt area	0.0173	0.1117
Plot is in middle altitude area	0.0335	0.0446	% of plots in high alt area	0.3063	0.1256
Plot is in high altitude area	0.2044	0.0467 ***	Av of percentage of plot with irrigation	0.0621	0.0419
Percentage of plot with irrigation	0.0012	0.0005 **	Average index of erosion in plots	0.1985	0.0634 ***
Index of erosion in plot	0.0058	0.0235	Average index of quality of plots	0.0828	0.0784
Index of quality of plot	-0.0608	0.0319	Index of livestock	0.0000	0.0000
Index of livestock	0.0000	0.0000	Head has ID	0.0547	0.1098
Area of the plot	-0.0011	0.0051	Spose has ID	0.2177	0.0975 **
Head has ID	0.1151	0.0542 **			
Spose has ID	-0.0193	0.0540			
Group Characteristics			**Group Characteristics**		
Time from plot to province capital	-0.1569	0.0382 ***	Time from cap distr to prov capital	-0.2499	0.0803 ***
Time from plot to district capital	-0.0012	0.0002 ***	Minimum Time from plot to district capital	-0.0009	0.0004 **
Level of land concentration (district)	-7.3992	1.5001 ***	Level of land concentration (district)	-10.7698	3.3554 ***
Value of production per hectare (district)	-0.0014	0.0125	Value of production per hectare (district)	-0.0157	0.0232
Value of prod per ha (growth rate)	0.0041	0.0048	Value of prod per ha (growth rate)	0.0106	0.0104
Dummy for Sierra	-0.2032	0.0568 ***	Dummy for Sierra	-0.3211	0.1033 ***
Number of obs		982	Number of obs		281
LR chi2(20)		174.75	LR chi2(20)		107.88
Prob> chi2		0	Prob> chi2		0
Pseudo R2		0.1284	Pseudo R2		0.277

Source: GRADE-CUANTO Final Households Survey

4. The Impact of Titling under Credit Constraints

It is expected that producers will behave differently regardless of whether they were credit constrained in the formal market before the titling program was implemented. Furthermore, depending on the type of credit constraint they were facing (associated with risk, transaction costs, or quantity or price rationing), their behavioral response to titling could be different. In this section, we will explore these issues, looking at the titling impacts under different credit constraint regimes, which were constructed using direct elicitation from respondents.

For a group of producers who were not credit constrained ex-ante, it is very unlikely that titling would benefit them through the credit channel. Obviously, impacts through the tenure security channel may still come into play. However, credit-constrained producers may benefit from a titling program through the credit channel if the constraint is eased because of having a land title. Further, titling may affect producers differently depending on the type of credit constraint they may be facing. For example, we may hypothesize that those that are quantity constrained (i.e., those that applied for a loan and were rejected or did not apply because the subjective probability of rejection was high) may be more likely to benefit from titling than those that are risk constrained (i.e., they did not apply for a loan for fear of losing the collateral).

In order to evaluate whether the impact of titling through the credit channel has been obscured by the fact that some producers are not credit constrained in the sample, we decided to further explore this channel. In particular, we re-estimate the difference-in-difference estimators, dividing the sample into those highly credit constrained and those with low credit constraints. To do so, we need to deal with the fact that credit constraint status is not directly observed.

Constructing credit constraint regimes

If we consider a simplified model in which the rural household maximizes its expected utility of the end-of-period consumption, subject to liquidity, labor, and budget constraints, it is possible to show that the utility-maximizing behavior of the household differs depending on the regime (constrained or unconstrained) to which it belongs. Several authors – Foltz (2004), Carter and Olinto (2003), and Guirkinger and Boucher (2005) – develop utility-maximization models that capture such behavior.

The problem with this type of modeling exercise, however, is that we do not observe whether a rural household is credit constrained. The literature offers two different approaches to tackle this situation. The first approach is based on direct elicitation of the credit regime, by asking the household head why he or she did not apply for a formal loan, or why he or she would not apply for one. The second approach is based on the estimation of the likelihood of being credit constrained.

Several authors have estimated the probability of being credit constrained through direct elicitation (see Feder et al. (1990) or Petrick (2004)). Using our baseline survey, we can assign each household to a credit regime. Table 4.1 shows a classification based on the answers we received to the question: “Why did (would) you not apply for a formal loan?” In addition to this question, rural households were asked, in case they asked for credit and were rejected, why they believe their request was rejected. Finally, if they received the credit, they were asked whether they got as much as they needed. Using these questions, it is possible to define being credit constrained as not being able to borrow as much as one wants.

Table 4.1
Constrained Regimes Based on Direct Elicitation
("Why did (would) you not apply for a formal loan?")

Question	Type of Constraint
I do not need a loan The interest rate is too high My land does not give me enough to repay a loan	Unconstrained: Price rationed
I don't want to give my land as a guarantee I fear to loose my land My product is too risky	Constrained: Risk rationed
Applied for a loan and were rejected Did not apply because the subjective probability of rejection was high	Constrained: Quantity
Have no Information Paperwork needed is time consuming and costly	Constrained: Transaction cost rationed

It is important to take with caution the estimated probability of being credit constrained coming from direct elicitation. As Gilligan et al. (2004) state, respondents with little or no recent experience in the credit market may have large errors in judging hypothetical questions regarding access to credit markets. In addition, self-reporting of a constraint in the credit market may hide an unrecognized constraint in another market.

In order to assess the validity of self-reported credit constrained status, this study estimated a probit model to identify factors associated with being credit constrained and compared this estimation with the direct elicitation result. Taking into consideration that credit constraints arise from restrictions to an unobserved excess demand, both demand and supply-side determinants should be included in such a model. The fitted value of this model may provide an indicator of how likely it is that a rural household would be credit constrained.

An alternative way to determine whether a rural household is credit constrained is to model jointly the determinants of being constrained with the behavioral model that is valid in the constrained and unconstrained scenarios. Unknown sample separation estimation is used to attach probabilities to households in the sample as to whether they have behaved according to a credit constrained or non-credit constrained rule. After all individuals are assigned to a certain credit regime, the behavioral model is estimated. The estimations of the joint model can be done in sequence using the EM algorithm (as in Aliou and Zeller (2001)). By maximizing the joint likelihood, we assigned each individual to a constrained or unconstrained credit regime in a way that maximizes the likelihood of the data, given the identification assumptions that are introduced in the model.

As Gilligan et al. (2004) state, this type of model requires the estimation of a structural or reduced-form model in which behavior is clearly affected by the credit constraint status. The kind of behavior that is typically modeled is that of consumption smoothing and/or farm labor demand. In the case of consumption smoothing, credit constraints reduce capacity to smooth consumption in the face of income shocks. In the case of farm labor demand, a credit constraint reduces the capacity to hire wage labor. In any of these cases, an empirical test is constructed to see if the division of the sample between a constrained and unconstrained credit regime is consistent with theory. Taking into consideration that our survey did not collect information on consumption, we will need to assess the validity of self-assessed credit constraints by focusing solely on total labor demand.

For identification purposes, we can introduce credit supply-side variables that enter the first equation (the probit or switching equation) that are excluded in the outcome equation. That is, the existence of a supply of credit affects the total labor demand equation only by affecting the regime in which the household is assigned. Differences in the outcome equations between constrained and unconstrained regimes will also provide insight about the overall validity of the model. For example, we should verify that households that are ex-post classified as non-credit constrained make decisions that are not affected by the number of family members in the labor force, as they are able to hire any excess demand for labor from the market (that is, separability holds).

Formally, we can characterize the sample behavior of credit constrained and unconstrained households in a three-equation model:

$$\begin{aligned} C^* &= z\gamma + \eta \\ y^c &= x\beta_1 + \varepsilon_1 \\ y^u &= x\beta_2 + \varepsilon_2 \end{aligned} \qquad (4.1)$$

Here, some outcome variable (in this case ***y*** is the total labor demand per hectare) behaves differently, depending on whether the household is in the credit constrained regime or in the unconstrained regime. If the household is credit constrained, the exogenous determinants ***x*** affect differently the outcome variable (through β_1) than if the same household does not face the credit constraint. In the latter case, the same determinants affect the outcome variable through β_1. Of course, the determinants may be different in the two regimes, which can be tested by equating to zero some parameters in β_1 or β_2. ε_1 , ε_2, and η are normal iid disturbances with zero means and variances (with $\sigma_\eta = 1$ for identification purposes). As we have mentioned, the regime in which each rural household is assigned is unobserved. However, we know that this unobserved component depends on an array of factors that we denote here as ***z***.

For the purpose of the estimation, ***x*** is a subset of ***z***. ***x*** includes the following: whether the plot owned by the household is titled; some characteristics of the owned plots (size, location, level of erosion, slope of the terrain, quality of the soil, proportion of land irrigated, and altitude); characteristics of the producer (gender, age, education, and maternal language); remoteness (time needed to go from the plot to the district capital); and family labor availability (female and male adults). In addition to this variable, which may also affect the probability of being credit constrained, ***z*** includes some variables that may help to identify the supply side of the credit market. These variables include the existence of formal credit institutions in the locality and the availability of credit in the three years previous to the base-line year. It is believed that these supply shifters may affect the net income per hectare only through releasing the credit constraint and shifting the individual from a constrained regime to an unconstrained one.

Main results

Table 4.2 shows the main determinants of being credit constrained using the self-reported credit constrained status. As expected, having a title reduces the probability of being credit constrained. In addition, more education and having Spanish as one's maternal language also reduce the likelihood of being credit constrained. Finally, having formal credit institutions nearby proves to be an adequate instrument, as their presence also reduces the likelihood of being credit constrained.

To assess the validity of the self-assessed credit constraint regime, we obtained an alternative estimate of the likelihood of being credit constrained (using a switching regression technique also known as a mixture model). The EM algorithm used in the estimation was developed by Dempster et al. (1977). The program was constructed using Stata by Zimmerman (1998). We used self-reported credit constrained status as the starting point of the algorithm.

It is important to stress that the model is not a full model that could help us capture the causal effects of titling. Its purpose is just to provide a consistent estimate of the probability of being credit constrained and compare it with the self-reported results. Figure 4.1 shows the results of both the estimated probability of being credit constrained based on self-assessment and the estimated probabilities estimated from the switcher equation and the determinants of total labor demand per hectare for both constrained and unconstrained regimes.

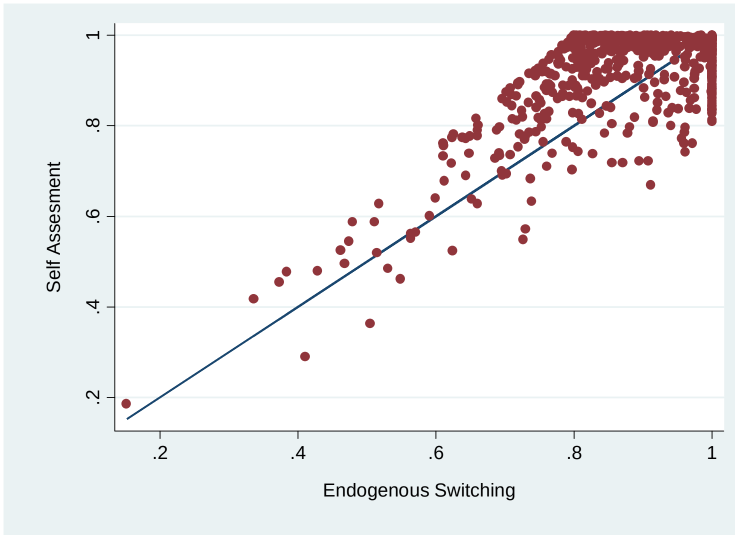
Both estimates are reasonably correlated ($r^2 = 0.7$). Although the assumption of competitive local labor markets (under which the switching regime equation provides a good approximation of the credit constrained regime) is questionable, it seems that both estimates capture the same underlying restrictions. Given this result, we decided to continue the analysis using only the estimates based on the predicted constraint regimes based on direct elicitation.

Table 4.2.
Probability of Being Rationed
(based on self-report)

	Probit	dF/dx
Title	-0.148 *	-0.053 *
	(0.094)	(0.034)
Land Size	-0.003	-0.001
	(0.004)	(0.001)
Fragmentation Index	0.223	0.080
	(0.230)	(0.082)
Maternal Language is Spanish	-0.288 ***	-0.106 ***
	(0.109)	(0.041)
Years of Education	-0.030 *	-0.011 *
	(0.013)	(0.004)
Gender (Head of household is men)	0.010	0.004
	(0.129)	(0.044)
Age of head of household	0.000	0.000
	(0.004)	(0.001)
Remoteness (time to district capital)	0.000	0.000
	(0.001)	(0.000)
Percentage of irrigated land	0.001	0.000
	(0.001)	(0.000)
Cattle Ownership	0.000	0.000
	(0.000)	0.000
Distance from district capital to province capital	-0.027	-0.010
	(0.095)	(0.034)
Erosion Index	-0.042	-0.015
	(0.076)	(0.027)
Percentage of plots in intermediate altitude land	0.019	0.007
	(0.125)	(0.046)
Percentage of plots in high altitude land	0.083	0.030
	(0.165)	(0.059)
Percentage of plots with high slope	0.057	0.020
	(0.166)	(0.060)
Quality Index	0.038	0.013
	(0.042)	(0.015)
Formal Financial Institutions	-0.218 *	-0.075 *
	(0.137)	(0.045)
Number of Male Adults	-0.045	-0.016
	(0.039)	(0.014)
Number of Female Adults	-0.039	-0.014
	(0.038)	(0.014)
Number of Children	-0.063	-0.023
	(0.083)	(0.030)
Title density in district	0.053	0.019
	(0.171)	(0.062)
Constant	-0.023	
	(0.383)	
Observations		894
Adjusted R-squared		0.0281

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Figure 4.1
Probability of being Credit Constrained
Direct Elicitation versus. Endogenous Switching



Next we proceeded to re-estimate the impacts of titling using matching techniques and dividing the sample according to credit constrained and unconstrained regimes. To identify these groups, we divided the sample in three parts and considered those at the top tercile of the estimated probability as having a high probability of being credit constrained. In the case of those having a low probability of being credit constrained, we used the bottom tercile.

The matching estimation was done at the household level,[9] and we used a large set of variables in the probit model for program participation (propensity score calculation). Farmers who said they were not interested in titling as well as those who said they had a conflict with neighbors were eliminated from the control group. These farmers are not likely to obtain a title through the titling process.

Annex 2 presents the probit results and analysis of sample balancing for the households before and after the matching procedure. Important variables in the probit model are head of family attributes (age, education, and mother tongue), and some family land attributes (average plot fragmentation, distance to markets, erosion, quality, etc.). We also incorporated in the probit a variable identifying whether the household head and spouse had identification at the time of the survey. The rationale was that a household head without identification may have

[9] See Annex 1 for the final sample size of households and plots that were used in the matching estimations presented in this and the next section.

more problems in obtaining a title at the end of the process. The only variable we used to attempt to capture the potential preferences of regional PETT offices for areas with more farmers was land fragmentation.

The estimation of impacts by type of credit regime are presented in Table 4.3, which reports average treatment on the treated effects estimates for two sub-samples: those that have a high probability of being credit constrained (upper tercile) and those that have a low probability of being credit constrained (lower tercile).

Our results show that access to credit is not significantly different between the treated and control groups for those having, at the baseline, a similar probability of being credit constrained. This may be an indication that it is unlikely that the results obtained in assessing the impacts of titling in rural Peru come from the credit channel. These results continue to be consistent with previous results in the general evaluation of this program (Zegarra et at., 2006). Considering this result, we may conclude that there is evidence that the investment response to titling documented here more likely comes from the tenure security channel rather than the credit channel.

An interesting point in Table 4.3 is the differentiated effects of land titling on the net supply of labor and income per hectare for those who were highly credit constrained at the baseline. It seems that these farmers may not able to demand labor because of their severe credit constrained status.

Table 4.3
Impact of Titling According to Credit Rationing Regime
(based on endogenous switching model)

	High probability of being Credit Unconstrained		Low probability of being Credit Constrained		
	ATT	Std Dev	ATT	Std Dev	
Access to formal credit	-0.167	0.214	-0.510	0.401	
Non Agricultural Income	181.539	915.237	-304.724	2660.519	
Non Agricultural Income (share)	0.020	0.309	-0.141	0.221	
Net supply of labor	-0.195	0.423	-0.607	0.299	**
Remittances	-317.968	334.018	-42.901	44.637	
Total Income	664.024	2053.050	5090.356	9047.413	
Income per Hectare	-1106.524	1956.083	-2589.125	1157.052	**
Supply of Land (tenancy or rent)	0.320	0.271	0.215	0.223	
Supply of Land (tenancy, rent or loaned)	0.320	0.271	0.215	0.223	
Investment in Installations	0.000	0.000	0.117	0.401	
Investment in Conservation Practices	0.000	0.000	-0.002	0.223	
Investment in Permanent Crops	0.000	0.000	-0.510	0.401	

To pursue our second line of interest, regarding the type of credit constraint farmers are facing, we estimated the likelihood of being credit constrained under different conditions. Using direct elicitation, we divided the sample into the following credit constraint regimes, which are presented in Table 4.1:

1. *Quantity constrained*. Applied for a loan and was rejected or did not apply because the subjective probability of rejection was too high.
2. *Price constrained*. Did not apply for a loan because the interest rate was too high.
3. *Risk constrained*. Did not apply for a loan for fear of losing the collateral.
4. *Transaction cost constrained*. Did not apply for a loan because the transaction costs were too high.
5. *Not credit constrained*. Was non-quantity constrained.

Table 4.4 shows the characteristics (a profile using a multinomial logit estimation) of those who were constrained in each of the above regimes. The baseline category is those who are non-quantity constrained.

Table 4.4
Determinants of Credit Rationing by type (self assessment)

	Risk Rationed		Transaction Cost Rationed		Quantity Rationed		Price Rationed	
Title	-0.742		-1.409	***	-0.486		-0.323	
	(0.483)		(0.502)		(0.412)		(0.413)	
Land Size	-0.020		0.000		-0.019		0.021	
	(0.037)		(0.037)		(0.034)		(0.031)	
Land concentration/fragmentation	-2.209	*	-1.028		-1.329		-1.698	*
	(1.159)		(1.184)		(0.974)		(0.976)	
Maternal Language is Spanish	0.158		-0.246		0.428		1.428	***
	(0.582)		(0.598)		(0.513)		(0.530)	
Years of Education	-0.202	***	-0.224	***	-0.183	***	-0.078	*
	(0.061)		(0.070)		(0.047)		(0.046)	
Gender (Head of household is men)	0.025		0.302		0.003		0.093	
	(0.583)		(0.624)		(0.512)		(0.521)	
Age of head of household	-0.001		0.023		0.012		0.020	
	(0.018)		(0.019)		(0.015)		(0.015)	
Remoteness (time to district capital)	0.007		0.005		0.007		0.005	
	(0.005)		(0.005)		(0.005)		(0.005)	
Percentage of irrigated land	-0.010		-0.016	**	-0.009		-0.010	*
	(0.007)		(0.007)		(0.006)		(0.006)	
Cattle Ownership	0.000		0.000		0.000		0.000	
	(0.000)		(0.000)		(0.000)		(0.000)	
Distance to the province Capital	0.403		0.393		-0.012		-0.024	
	(0.485)		(0.516)		(0.428)		(0.426)	
Erosion Index	-0.446		-0.343		-0.279		0.022	
	(0.375)		(0.395)		(0.313)		(0.305)	
Percentage of plots in intermediate altitude land	0.015		-0.204		-0.169		-0.084	
	(0.674)		(0.725)		(0.576)		(0.577)	
Percentage of plots in high altitude land	1.393		1.292		-0.172		0.323	
	(0.951)		(0.981)		(0.901)		(0.896)	
Percentage of plots with high slope	0.687		0.824		1.014		1.025	
	(1.085)		(1.104)		(1.011)		(1.001)	
Quality Index	-1.244	***	-0.770	*	-1.049	***	-0.635	*
	(0.433)		(0.457)		(0.360)		(0.358)	
Formal Financial Institutions	-0.553		-0.426		-0.078		0.012	
	(0.636)		(0.643)		(0.474)		(0.470)	
Number of Male Adults	-0.090		-0.372	*	-0.121		-0.008	
	(0.174)		(0.196)		(0.146)		(0.142)	
Number of Female Adults	-0.020		0.398	**	-0.189		-0.012	
	(0.182)		(0.183)		(0.156)		(0.154)	
Number of Children	-0.385		-0.064		-0.289		-0.241	
	(0.418)		(0.419)		(0.357)		(0.355)	
Title density in district	-0.198		-1.576	*	0.102		0.857	
	(0.857)		(0.922)		(0.731)		(0.739)	
Constant	7.590	***	5.075	**	7.418	***	2.950	
	(2.287)		(2.406)		(1.928)		(1.917)	
Base Category: Non quantity rationed								
Number of obs	536		Pseudo R2			0.1272		
LR chi2(84)	193.93		Log likelihood			-665.6		
Prob > chi2	0							

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

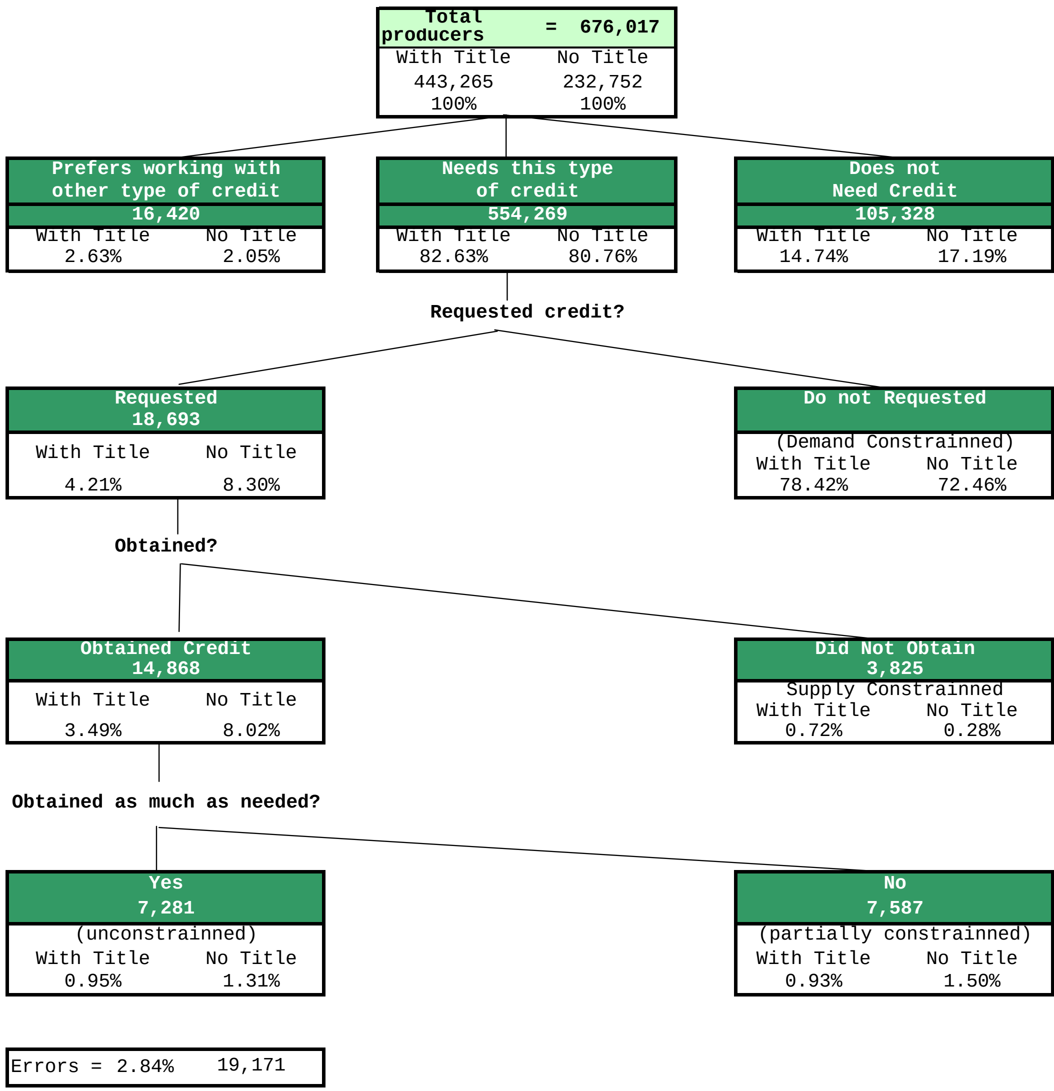
Using the predicted probabilities obtained from the multinomial logit estimation, we divided the sample into each of these regimes. Table 4.5 shows the differentiated effects of land titling for the two most frequent credit constrained regimes: quantity and price constrained. The other two credit constrained regimes (those generated by risk constraints and transaction costs) made up a small fraction of the sample (less than 5 percent of the sample in both cases). Because of this, the average treatment on the treated estimates were highly unreliable.

Table 4.5
Impact of Titling According to Credit Rationing Regime
(based on endogenous switching model)

	Quantity Constrained			Price Constrained	
	ATT	Std Dev		ATT	Std Dev
Access to formal credit	-0.07	0.12		0.18	0.36
Non Agricultural Income	8502.64	2748.97	***	21003.16	20878.38
Non Agricultural Income (share)	0.06	0.19		0.06	0.15
Net supply of labor	0.03	0.23		0.12	0.39
Remittances	82.06	200.86		0.00	0.00
Total Income	8832.61	4734.58	*	-5394.66	4370.30
Income per Hectare	1180.02	775.87	*	-1923.09	1985.46
Supply of Land (tenancy or rent)	0.01	0.12		0.00	0.00
Supply of Land (tenancy, rent or loaned)	0.03	0.13		0.20	0.20
Investment in Installations	-0.04	0.14		-0.18	0.35
Investment in Conservation Practices	-0.31	0.13	***	0.08	0.18
Investment in Permanent Crops	0.38	0.15	***	-0.38	0.27

The main result here is that when we separate those who have a high likelihood of being quantity constrained in the credit market (i.e., high probability of applying for a loan and being rejected or high probability of not applying because the subjective probability of rejection was too high), this group shows positive impacts of land titling that were not present earlier. In fact, this group shows a significant impact of titling on income (including income per hectare and non-agricultural income) as well as a significant impact on investments in permanent crops. Not surprisingly, this same group shows that this investment is associated with a reduction in investments in conservation practices as if the titling generated incentives for crop intensification.

Access to the Formal Credit Market: Self-Reported Credit Market Constraints



	Base-Line
Interest rate is too high	14.71%
Land does not give enough to repay loan	15.89%
Don't want to give land as a guarantee	0.48%
I fear to loose my land	17.71%
Paperwork is time consuming and costly	4.25%
My product is too risky	1.45%
Have no Information	12.24%
Other	5.72%

	Base-Line
Did not hold a title	0.16%
Not enough guarantees	0.00%
Isuficient documentation	0.11%
Insufficient land holding	0.00%
Other/Does not know why	0.00%

5. Titling and the Land Rental Market

In this section, we develop a model to explore the relationship between titling and land rental markets. PETT's titling strategy has an interesting feature in that complete areas are titled at the same time. This opens the possibility that some impacts of titling on land markets (and other outcome variables) are generated due to a sort of externality effect of massive titling. In land markets, for instance, it is more likely that massive titling reduces transaction costs than individualized titling, as many farmers after titling may have increased incentives to enter the land market as demanders or suppliers.

We develop a simple model of a rental market in which there are two effects of titling. In the first, titling increases tenure security at the individual level, and this generates more incentives to offer land in the rental market. In the second, massive titling operates at the community level, and may decrease transaction costs both for suppliers and demanders of rental land.

A model of land rental with transaction costs

This model allows us to analyze the channels through which titling affects the supply of land in the rental market. The model includes some of the elements presented in Carter and Chamorro (2000). We assume that there is only one period, in which the household works in agriculture and makes a decision about the amount of land used in agricultural production. At the end of the period, the household sells the land at the market price. To incorporate the idea of tenure security, we use (as in Carter and Chamorro (2000)) a positive probability of eviction for the land that is rented out.

Algebraically, the household maximizes the following income function:

$$\underset{R^o R^I}{Max} \quad A_i F(T + R^i - R^o) + R^o(r - c(d)) - R^I(r + c(d)) + v(p(t)T + (1 - p(t))(T - R^o)) \qquad (5.1)$$

where A_i is a parameter that represents technology, $F()$ is the agricultural production function, T is the household's endowment of land, R^i is the amount of land rented in, R^o is the amount of land rented out, r is the land rental rate, *c(d)* are the transaction costs in the land rental market (which depend on the titling density, d), v is the sale price of one unit of land, and p(t) is the probability of the land rented out not being evicted and depends on whether the farmer has a property title on the land.

The first term in the income function represents the value of production, the second term is the income derived from renting out land, the third term is the cost associated with renting land in, and the fourth term is the expected value of land at the end of the period, given the probability p(t) of not being evicted. This probability increases when the household has a title on the land it owns.

In this model, we assume that titling density (d) affects the transaction costs of the land rental market. The idea is that, as we will see below, access to a title increases the supply of land in the rental market. If there is a massive delivery of titles (for example, as a consequence of government intervention), there will be an important change in the number of land market transactions. This change will elimínate the high transaction costs that prevail in the presence of thin markets.

The FONC that solve the maximization problem are:

$$\begin{aligned} &A_i F_T(T + R^I - R^O) - (r + c(d)) <= 0 \\ &(A_i F_T(T + R^I - R^O) - (r + c(d)))R^I = 0 \end{aligned} \qquad (5.2)$$

$$\begin{aligned} &- A_i F_T(T + R^I - R^O) + (r - c(d)) - v(1 - p(t)) <= 0 \\ &(-A_i F_T(T + R^I - R^O) + (r - c(d)) - v(1 - p(t)))R^O = 0 \end{aligned} \qquad (5.3)$$

From these FONC, we can deduce that it will be profitable for the household to leave the autarchy regime and rent land out if the following condition holds:

$$(r - c(d)) >= A_i F_T(T) + v(1 - p(t)) \qquad (5.4)$$

This condition means that, in autarchy, the marginal income (equal to the rental price minus the transaction costs) of renting one unit of land out is higher than the marginal cost of renting one unit of land out. The marginal cost is given by the loss in agricultural production plus the expected marginal loss in the value of land at the end of the period. This loss is equal to the probability of eviction of the land that is rented out, multiplied by the price of land.

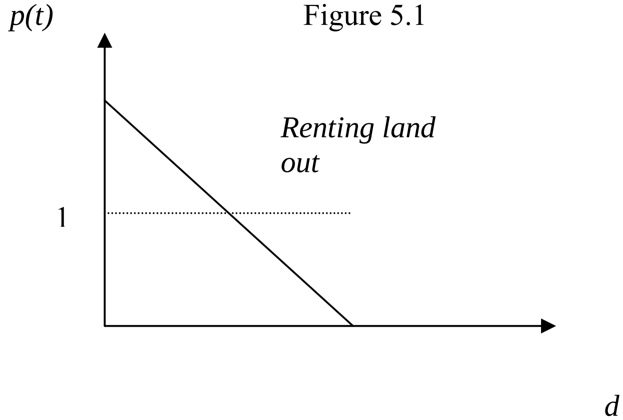
We can see that: $\frac{\partial RHS(3)}{\partial t} < 0$, the right-hand side of equation (5.4) decreases when the household has a title. Access to a title decreases the probability of eviction, decreasing the marginal cost of renting land out. On the other hand, $\frac{\partial LHS(3)}{\partial d} < 0$, the left-hand side of equation (5.4) increases when titling density increases. Because an increase in titling density lowers transaction costs, this change will increase the marginal income associated with renting one unit of land out.

Equation (5.4) defines a threshold that determines whether a household will belong to the regime characterized by a positive amount of land rented out. This threshold depends on the parameters of the model. The figure shows the relationship between *p(t)* and *d* in determining the regime to which the household belongs.

For a given land endowment, the households whose vector (p(t), d) is below the line will not rent land out, while households whose vector (p(t), d) is above the line will rent land out. Because the probability of not being evicted cannot be greater than one, there are values of titling density that create a prohibitive supply of land in the rental market.

In general, for very low values of titling density, access to a title may not be enough in order for the household to change its regime. In that sense, it is possible to state that a household characterized by a higher titling density would be more likely to actually respond to this increase in p(t) with a change in regime, which means that the household would actually pass from autarchy to renting land out. In the next section, we will see how the impact of having a title changes according to the density of the area where the household is located.

Figure 5.1



In order to see this, we re-estimated the impacts of titling (using matching techniques at the plot level) for a sub-population of farmers located in an area with high titling density, defined as more than 60 percent of the sector with titled land by 2006. We estimated the impacts for the overall sample and for the relevant sub-population. The results are presented in Table 5.1.

Table 5.1.
Matching estimations of impacts of titling on renting-out land

Variable	Treated	Controls	Difference	S.E.	T-stat	
Unconditioned impacts						
Land rented out or sharecropped	0.016	0.013	0.002	0.018	0.14	
Land rented out, sharecropped or lent	0.018	-0.029	0.011	0.020	-0.55	
Number of observations with common support					939	
For plots in sectors with high density						
Land rented out or sharecropped	0.047	-0.021	0.068	0.037	1.83	*
Land rented out, sharecropped or lent	0.047	-0.010	0.057	0.044	1.3	
Number of observations with common support					324	

We estimated impacts for all land that was rented out, sharecropped, or lent, and only for rentals and sharecropping. In the unconditioned case, we do not find any significant impact of titling in the land rental market.[10] However, we do find a significant impact (at 90 percent significance) for the supply of rentals in areas with a high density of titling. This suggests that high titling density is indeed an important condition for land market activation. As also shown in the previous section, the titling process in rural Peru does not seem to have activated the financial channel for farmers. In this context, using the land rental market as a way of financing non-agricultural activities may become more attractive. The effect, however, will also be detected in areas with high enough titling density, which are the areas in which transaction costs are more likely to decline with massive titling.

6. Conclusions

The general evaluation of impacts on farmers generated by massive land titling in Peru shows a picture of not many positive effects, at least in the short period of the evaluation (2004-2006) and for a limited sample of farmers located in the Coast and Sierra regions. On average, most income variables (and income composition) do not seem to be impacted by titling, and there are no detectable effects on investments (except for permanent pasture in the Sierra) or other outcome variables, such as credit, land markets, or land conflicts.

However, this general picture hides important impacts that may occur for some groups of farmers, or for farmers facing different constraints in the pre-intervention stage. Moreover, the estimation of average effects does not reveal how a potential impact would

[10] Tables with information on the analysis of the matching results and the quality of matching used here (for plots) are presented in Annex 2.

occur in terms of the decision-making process of farmers. Because of these limitations, we investigated in more detail two important channels that are behind the potential impacts of rural titling programs: credit access and use of land rental markets.

In the case of credit access, we validated the use of self-reported credit access using an endogenous switching regression model and found that elicitation is acceptable for identifying credit access regimes among farmers. Further, only when we distinguished farmers who are quantity constrained (versus risk constrained or transaction cost constrained) did we find that land titling indeed has significant impacts on outcome variables like agricultural income and investment. A negative effect was observed in the use of conservation practices due to more intensive land use.

For the land rental market, we found that density of titling is indeed an important condition for this market to be activated by the titling program. Our theoretical model suggests that there is a threshold for titling density and other exogenous parameters such that farmers are more likely to offer land in the rental market when they are above that threshold. A farmer who is titled but in an area of low density of titling has fewer incentives to supply land than one who is located in an area of high density titling. This result suggests that the strategy of massive titling may be appropriate for generating significant reductions in transaction costs. This effect in the supply of land rentals can be even more important if farmers are credit constrained and will use this market as a way to self-finance their agricultural and non-agricultural activities.

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Annex 1. Use of the Cadastre and the Sampling Procedure

A.1. The cadastre of rural plots: Advantages and limitations

The cadastre is the most complete database that can be used for evaluation purposes of the rural titling project. However, the cadastre has important limitations that are worth mentioning. First, the cadastre is only built in areas that are considered potential sites for individual titling. Extensive areas in the highlands (Sierra) that are under communal domain are excluded from the cadastre, even if plots are operated individually by farmers (*comuneros*). Protected areas are also excluded from any cadastral (and titling) activity in coordination with the national authority (INRENA). These are not important limitations for our study because those areas are not considered subject to private titling by PETT under current legislation, so it would not be appropriate to take samples there to evaluate the impacts of the PETT titling program.

Second, the formation of the PETT cadastre did not follow the same methodology over time. The method for entering and processing data during the first stage of the titling program (1996-2001) was changed in 2002 and afterward. Therefore, the information in the cadastre for the Coast (which was the main focus in the first stage) contains more problems (for instance, regarding current title status) than the more recent cadastral information for the Sierra (which was the main focus in the second phase with the new method).

Adding to the information quality problem, some variables in the cadastre seem particularly out of date, like the variable for the current property status of a plot. It seems that the quality of information that is entered in the cadastre is decreasing along the titling process, which was described in Section 3. For example, we cannot tell whether a plot did not have title in the database because of a problem in the registry (and so the claiming farmer would not receive a title) or because the title was still in some part of the process. Knowing this would have been very useful for constructing a more consistent control group taken only from those whose title was really in progress in the registry.

Notwithstanding these limitations, the cadastre is the most reliable source of information on plots (and households), and can be used for evaluating the potential impacts of the PETT program in rural Peru. In the following, we describe the sampling procedure that was adopted for this purpose.

A.2. The sampling procedure

We received the PETT cadastre database that was updated to June 2004. There were 2,207,199 plots in the national database. The data did not include names or identification numbers of owners of the plots; they did include plot area, date of PETT visit, and current situation in the titling process (the SUNARP registered title). Plots were geo-referenced and coordinates were provided. A distinctive unit in the database was a name for each sector, which was mostly associated with the community in which the plot was located.

Some initial filters were applied to the database:

- Plots with a PETT visit before 1999 were dropped.
- Plots located in the jungle were dropped.
- Sectors with less than 21 plots were dropped.

For the remaining database (1,639,421 plots), we identified whether the plot was titled using the variable on titling status. A total of 9,350 sectors remained and a new cut was established to eliminate districts with less than eight sectors. This was to eliminate districts with very low cadastral coverage. A new total of 1,379,419 plots remained, which was the sampling framework used for this study. In Table A.1, we present the distribution of the sampling framework by geographical domain and titling status (in the cadastre).

Table A.1: Sampling Framework based on 2004 PETT Cadastre

Titulación PETT según Catastro

	No titulado	Titulado	Total	% Pett
DOM1-CN	167,910	35,895	203,805	17.6%
DOM2-CCS	77,772	10,623	88,395	12.0%
DOM3-SN	461,379	83,059	544,438	15.3%
DOM4-SC	133,396	196,332	329,728	59.5%
DOM5-SS	119,400	93,653	213,053	44.0%
Total	959,857	419,562	1,379,419	30.4%

Fuente: Catastro Rural del PETT, marco muestral de ELB

Source: PETT Cadastre, 2004

About 30 percent of the plots appeared with a registered title in the 2004 cadastre. The first two domains (Dom1 and Dom2) corresponded to the Coast, and the titling ratio that appeared in the cadastre was very low (17 and 12 percent), considering that the titling process was already deep in that region by 2004. This situation was related to the lack of update of the titling variable in the cadastre, as was already mentioned. In the case of the highlands (Doms 3 to 5), the titling situation seemed to be more in line with the real situation of that region as the cadastral information was better recorded.

Notwithstanding the limitations of the titling variable in the cadastre, we constructed an indicator of titling density (by PETT) in order to select a sample that would incorporate variation in this key variable. We classified districts as primary sampling units with high-density if more than 50 percent of its sectors were also high-density (more than 70 percent of plots titled). Low-density districts were considered as those with more than 50 percent of sectors of low-density (less than 30 percent plots titled). The remaining districts were medium-density. The framework has 330 districts, distributed in three density categories and five geographical domains, which made up the initial structure of the sample (15 strata), as shown in Table A.2.

Table A.2.: Structure of sampling framework by titling density and domains

Estructura del marco muestral				
dominio	Tit_Baja	Tit_Media	Tit_Alta	Total
DOM1-CN	56	16	3	75
DOM2-CCS	50	3	1	54
DOM3-SN	58	9	5	72
DOM4-SC	10	18	28	56
DOM5-SS	35	31	7	73
Total	209	77	44	330
Estructura de muestra propuesta				
dominio	Tit_Baja	Tit_Media	Tit_Alta	Total
DOM1-CN	10	4	1	15
DOM2-CCS	8	2	1	11
DOM3-SN	10	4	2	16
DOM4-SC	4	4	6	14
DOM5-SS	6	6	2	14
Total	38	20	12	70

Source: PETT Cadastre, 2004

Table A.2 also shows the structure of the proposed sample of districts to be taken in the first stage of the sampling, which has a total of 70 districts, in proportion to the original structure. Random sampling was applied in the first stage of the sampling in each strata.

After selecting 70 primary units, we proceeded to make a second round of sampling in which the sampling units are sectors, or second units of sampling. Sectors were stratified again according to their titling density. A sample of 282 sectors was taken from all strata in this stage, and total information (including names of owners) was requested from PETT in order to proceed to the final sampling stage, in which the sample units are plots (and their owners). In this case, we stratified plots according to their size in order to generate variation in this variable as well. The categories for size were: (i) less than 1 ha; (ii) 1-2 has; (iii) 2-5 has; and (iv) more than 5 has. Table A.3 shows the final structure of the sample of plots by domain and titling density.

Table A.3.: Sample of Plots by domain and density

	TS-Baja	TS-Media	TS-Alta	Total
DOM1-CN	202	216	72	490
DOM2-CCS	280	40	32	352
DOM3-SN	353	90	72	515
DOM4-SC	144	120	192	456
DOM5-SS	209	152	80	441
Total	1188	618	448	2254

Source: PETT Cadastre, 2004

The original sample was selected with a large number of potential substitutes for plots or owners who could not be interviewed. The substituted plots were selected from the same final strata in which the original sampled plot was selected, so it kept the same selection probability.

Final size of the household sample

In the baseline, 2,034 households were surveyed. After a matching process, some households were excluded because of non-comparability, and only 1,855 households were supposed to be visited on 2006. Of these households, 141 were not actually interviewed due to absences or rejections. Of the 1,714 observations, it was possible to derive the titling category of only 1,325 households. It was not possible to derive the category of some households because of missing data on the time they received the title or inconsistencies between surveys. The titling category of these households was distributed according to the frequencies shown in Table A.4.

Table A.4.

Number of households and parcels per titling category

	Households	Parcels
No title	205	788
PETT Title before 2004	728	1,883
PETT Title after 2004	238	832
Title not from PETT	154	308
Total	1325	3,811

Only the households in the "No title" or "PETT Title after 2004" categories were used for the analysis. These two categories sum to 443 observations. Analysis of the 50 percent of the households with the lowest likelihood of being constrained (according to the switching endogenous model) used 107 observations instead of 221, because 11 observations had a conflict in 2004, 5 observations were owners that did not want to title their parcels, and 98 observations were missing outcome or control variables. Analysis of the 20 percent of the households with the highest likelihood of being constrained (according to the switching endogenous model) used 75 observations instead of 88 because of missing control or impact variables.

Final size of the parcels sample

The 1,714 households that were surveyed on 2004 and 2006 had 5,450 parcels. Of these parcels, it was possible to find a titling category only for 3,811 parcels. It was not possible to find the titling category for all the parcels because of missing information on the date the title was delivered or because of inconsistencies between surveys. The titling category of the parcels was distributed according to the frequency in Table A.5..

Analogous to the analysis for households, we only used the parcels that belonged to the "No title" or "PETT Title after 2004" categories. These sum to 1,620 parcels. Of these, only 996 parcels were used in the global analysis. Sixty observations were not used because these parcels had a conflict in 2004, 18 parcels were not used because the owner did not want to title these parcels, and the remaining 546 observations were not used because of missing values.

Justification for the final size of the household sample used for this study

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Annex 2. Matching Quality Analysis

Table A.2.1.

Balancing of samples by matching: Credit Constrained Households

Variable	Sample	Treated	Control	%bias	%reduct |bias|	t	
Area owned (hectares)	Unmatched	6.30	9.95	-30.3		-4.69	***
	Matched	6.48	6.40	0.7	97.6	0.14	
Age of head (years)	Unmatched	51.52	50.65	6.1		0.95	
	Matched	50.91	51.62	-5	18.5	-0.76	
Years of education of head	Unmatched	4.95	4.76	4.5		0.69	
	Matched	4.98	4.62	8.6	-93.8	1.27	
Mother tongue of head is spanish	Unmatched	0.76	0.66	22		3.41	***
	Matched	0.75	0.75	1	95.2	0.16	
Family size	Unmatched	3.91	4.30	-17.9		-2.78	
	Matched	4.02	3.97	2.2	87.5	0.34	
Time from plot to farmer house	Unmatched	20.51	23.93	-11.4		-1.77	
	Matched	21.07	21.70	-2.1	81.6	-0.32	
Plot has high slope	Unmatched	0.12	0.13	-3.8		-0.59	
	Matched	0.12	0.13	-1.5	59.5	-0.23	
Plot is in middle altitude area	Unmatched	0.28	0.28	-0.4		-0.06	
	Matched	0.27	0.27	-0.2	43.1	-0.03	
Plot is in high altitude area	Unmatched	0.26	0.17	22		3.42	***
	Matched	0.24	0.25	-4	81.9	-0.56	
Percentage of plot with irrigation	Unmatched	49.37	43.80	11.5		1.79	
	Matched	49.09	49.03	0.1	98.8	0.02	
Index of erosion in plot	Unmatched	0.40	0.38	3.3		0.51	
	Matched	0.42	0.43	-1.7	49.1	-0.24	
Index of quality of plot	Unmatched	3.12	3.18	-10.3		-1.6	
	Matched	3.13	3.10	4.9	53	0.73	
Index of livestock	Unmatched	2718.30	3490.00	-18		-2.78	
	Matched	2751.30	2610.50	3.3	81.8	0.56	
Area of the plot	Unmatched	1.30	2.20	-20.3		-3.13	***
	Matched	1.35	1.42	-1.7	91.9	-0.36	
Head has ID	Unmatched	0.88	0.85	10.9		1.7	
	Matched	0.88	0.88	0.3	97.2	0.05	
Spose has ID	Unmatched	0.85	0.85	0.5		0.07	
	Matched	0.86	0.84	6	-1170.8	0.88	
Time from plot to province capital	Unmatched	0.52	0.66	-23.5		-3.65	***
	Matched	0.54	0.53	1.4	94.1	0.23	
Time from plot to district capital	Unmatched	56.79	82.36	-30.9		-4.8	***
	Matched	59.05	62.77	-4.5	85.4	-0.72	
Level of land concentration (district)	Unmatched	0.02	0.03	-46.7		-7.25	***
	Matched	0.02	0.02	-3.6	92.3	-0.57	
Value of production per hectare (district)	Unmatched	2.74	2.78	-2.3		-0.35	
	Matched	2.73	2.73	-0.1	95.1	-0.02	
Dummy for Sierra	Unmatched	0.13	0.16	-7.5		-1.16	
	Matched	0.14	0.15	-3.2	57.4	-0.48	

Table A.2.2
Balancing of samples by matching: credit unconstrained households

Variable	Sample	Treated	Control	%bias	%reduct |bias|	t	
Area owned (hectares)	Unmatched	6.6703	14.288	-48.8		-4.62	***
	Matched	6.9918	6.6751	2	95.8	0.31	
Age of head (years)	Unmatched	51.027	52.582	-10.7		-0.98	
	Matched	51.702	48.016	25.4	-137.1	2.36	
Years of education of head	Unmatched	4.7011	4.0065	17.7		1.62	
	Matched	4.3684	4.8903	-13.3	24.9	-1.26	
Mother tongue of head is spanish	Unmatched	0.58696	0.46405	24.7		2.26	**
	Matched	0.55556	0.52124	6.9	72.1	0.63	
Family size	Unmatched	3.5761	4.2222	-28.4		-2.61	***
	Matched	3.6082	4.2365	-27.6	2.8	-2.74	
Time from plot to farmer house	Unmatched	18.467	26.216	-26		-2.41	**
	Matched	18.778	17.93	2.8	89.1	0.31	
Plot has high slope	Unmatched	0.13587	0.18301	-12.9		-1.18	
	Matched	0.1462	0.15746	-3.1	76.1	-0.29	
Plot is in middle altitude area	Unmatched	0.36413	0.33333	6.4		0.59	
	Matched	0.38596	0.4003	-3	53.4	-0.27	
Plot is in high altitude area	Unmatched	0.27717	0.31373	-8		-0.73	
	Matched	0.2924	0.26393	6.2	22.1	0.59	
Percentage of plot with irrigation	Unmatched	47.833	35.454	26.1		2.38	**
	Matched	45.534	46.963	-3	88.5	-0.27	
Index of erosion in plot	Unmatched	0.47826	0.54248	-7.7		-0.7	
	Matched	0.50877	0.57079	-7.4	3.4	-0.67	
Index of quality of plot	Unmatched	3.163	3.1307	5.6		0.51	
	Matched	3.1696	3.1682	0.2	95.7	0.02	
Index of livestock	Unmatched	3163.3	4931.3	-35.4		-3.27	***
	Matched	3365.2	3350.8	0.3	99.2	0.03	
Area of the plot	Unmatched	1.3682	2.5827	-20.2		-1.9	*
	Matched	1.3829	1.4461	-1	94.8	-0.14	
Head has ID	Unmatched	0.86413	0.79739	17.8		1.64	
	Matched	0.8538	0.88385	-8	55	-0.82	
Spose has ID	Unmatched	0.86413	0.87582	-3.5		-0.32	
	Matched	0.8655	0.87151	-1.8	48.6	-0.16	
Time from plot to province capital	Unmatched	0.44897	0.55034	-27.8		-2.56	**
	Matched	0.46272	0.42816	9.5	65.9	0.96	
Time from plot to district capital	Unmatched	64.299	81.144	-17.9		-1.63	
	Matched	67.246	65.833	1.5	91.6	0.14	
Level of land concentration (district)	Unmatched	0.02051	0.02711	-59.1		-5.5	***
	Matched	0.02059	0.02039	1.8	96.9	0.19	
Value of production per hectare (dis	Unmatched	2.4457	2.1105	28.3		2.57	**
	Matched	2.4305	2.3154	9.7	65.7	0.86	
Dummy for Sierra	Unmatched	0.1087	0.01961	36.9		3.27	**
	Matched	0.07018	0.06423	2.5	93.3	0.22	

Table A.2.3
Probit model for program participation: Plots in non-conditioned case

	Coef.	Std. Err.	z	
Area owned (hectares)	-0.015	0.005	-3.09	***
Age of head (years)	0.005	0.004	1.33	
Years of education of head	0.011	0.012	0.91	
Mother tongue of head is spanish	0.359	0.109	3.29	***
Family size	-0.050	0.022	-2.22	**
Time from plot to farmer house	0.000	0.001	0.26	
Plot has high slope	-0.052	0.135	-0.38	
Plot is in middle altitude area	0.065	0.112	0.58	
Plot is in high altitude area	0.496	0.126	3.93	***
Percentage of plot with irrigation	0.003	0.001	2.87	**
Index of erosion in plot	-0.003	0.060	-0.04	
Index of quality of plot	-0.165	0.079	-2.09	**
Index of livestock	0.000	0.000	-0.31	
Area of the plot	-0.001	0.013	-0.08	
Head has ID	0.289	0.141	2.04	**
Spose has ID	0.001	0.139	0.01	
Time from plot to province capital	-0.344	0.096	-3.58	***
Time from plot to district capital	-0.003	0.001	-5.15	***
Level of land concentration (district)	-21.729	3.705	-5.87	***
Value of production per hectare (district)	-0.010	0.031	-0.31	
Dummy for Sierra	-0.328	0.154	-2.13	***
Constant	0.803	0.439	1.83	*
Number of observations			965	
LR			168.11	
Prob > chi2			0	
Pseudo R2			0.1257	

Table A.2.4
Probit model for program participation:
Plots in high density sectors (conditioned)

	Coef.	Std. Err.	z	
Area owned (hectares)	-0.018	0.009	-2.02	**
Age of head (years)	0.003	0.007	0.42	
Years of education of head	0.046	0.026	1.8	*
Mother tongue of head is spanish	0.320	0.178	1.8	*
Family size	-0.087	0.040	-2.18	**
Time from plot to farmer house	0.000	0.003	-0.13	
Plot has high slope	-0.135	0.220	-0.62	
Plot is in middle altitude area	-0.090	0.199	-0.45	
Plot is in high altitude area	0.036	0.214	0.17	
Percentage of plot with irrigation	0.002	0.002	1.16	
Index of erosion in plot	-0.005	0.095	-0.05	
Index of quality of plot	-0.200	0.154	-1.29	
Index of livestock	0.000	0.000	-0.06	
Area of the plot	0.013	0.017	0.76	
Head has ID	0.664	0.262	2.54	**
Spose has ID	-0.641	0.294	-2.18	**
Time from plot to province capital	-0.551	0.253	-2.17	**
Time from plot to district capital	-0.001	0.001	-1.54	
Level of land concentration (district)	-34.184	8.199	-4.17	***
Value of production per hectare (district)	-0.005	0.084	-0.06	
Dummy for Sierra	0.747	0.419	1.78	*
Constant	1.816	0.891	2.04	**
Number of observations			337	
LR			84.12	
Prob > chi2			0	
Pseudo R2			0.1812	

Table A.2.5. Balancing of samples of plots, unconditioned case

	Sample	Treated	Control	%bias	bias	t	
Farm size	Unmatched	7.55	9.98	-13.2		-2.09	**
	Matched	7.74	7.21	2.9	78.2	0.46	
Age of head (years)	Unmatched	51.42	50.81	4.3		0.68	
	Matched	50.71	51.85	-8.1	-86.2	-1.23	
Years of education of head	Unmatched	4.87	4.71	3.7		0.58	
	Matched	4.92	4.65	6.6	-79.3	0.99	
Mother tongue of head is spanish	Unmatched	0.77	0.67	23		3.63	**
	Matched	0.76	0.75	2	91.2	0.32	
Family size	Unmatched	4.00	4.29	-13.2		-2.09	**
	Matched	4.07	3.97	4.7	64.5	0.72	
Time from plot to province capital	Unmatched	0.51	0.65	-24.5		-3.87	**
	Matched	0.53	0.53	0.1	99.4	0.02	
Time from plot to district capital	Unmatched	56.68	80.84	-29.5		-4.65	**
	Matched	58.72	61.75	-3.7	87.4	-0.6	
Time from plot to farmer house	Unmatched	20.44	24.28	-12.6		-1.99	**
	Matched	20.85	22.40	-5.1	59.4	-0.78	
Plot has high slope	Unmatched	0.14	0.13	3.1		0.49	
	Matched	0.14	0.14	-1.3	59.1	-0.19	
Plot is in medium altitude area	Unmatched	0.27	0.27	-0.3		-0.05	
	Matched	0.26	0.26	-0.9	-189.8	-0.13	
Plot is in high altitude area	Unmatched	0.27	0.16	27.1		4.28	**
	Matched	0.26	0.26	-0.3	98.9	-0.04	
Percentage of plot with irrigation	Unmatched	47.65	45.01	5.4		0.86	
	Matched	47.10	49.05	-4	26	-0.61	
Index of erosion in plot	Unmatched	0.43	0.36	11		1.75	*
	Matched	0.44	0.45	-2.2	79.8	-0.32	
Index of quality of plot	Unmatched	3.25	3.19	4.4		0.69	
	Matched	3.25	3.17	5	-14.5	0.75	
Value of cattle (1994)	Unmatched	2811.9	3443.7	-14.8		-2.33	**
	Matched	2845.1	2683.1	3.8	74.3	0.65	
Size of of the plot	Unmatched	2.19	2.26	-0.5		-0.07	
	Matched	2.27	2.04	1.6	-254.8	0.24	
Head has ID (dni)	Unmatched	0.89	0.85	11.5		1.81	*
	Matched	0.88	0.88	0.8	92.8	0.13	
Spouse has ID (dni)	Unmatched	0.84	0.86	-3.9		-0.62	
	Matched	0.85	0.83	6	-52.1	0.89	
Level of land concentration (district)	Unmatched	0.02	0.03	-48.4		-7.63	**
	Matched	0.02	0.02	-2.2	95.5	-0.36	
Sierra dummy	Unmatched	0.13	0.18	-14.5		-2.28	**
	Matched	0.13	0.14	-3	79.3	-0.48	

Table A.2.6. Balancing of samples of plots, conditioned case (high density)

	Sample	Treated	Control	%bias	bias	t	
Farm size	Unmatched	8.1228	13.52	-38.2		-3.9	**
	Matched	8.3093	7.012	9.2	76	1.4	
Farm size (has)	Unmatched	51.209	51.864	-5		-0.46	
	Matched	50.702	49.532	9	-78.7	0.92	
Age of head (years)	Unmatched	4.3543	4.1591	4.8		0.45	
	Matched	4.2851	4.5776	-7.1	-49.8	-0.81	
Years of education of head	Unmatched	0.70079	0.44697	52.9		5.0	**
	Matched	0.68595	0.67818	1.6	96.9	0.18	
Mother tongue of head is spanish	Unmatched	3.752	3.9697	-9.8		-0.91	
	Matched	3.781	3.9073	-5.7	42	-0.66	
Family size	Unmatched	0.55843	0.60191	-12.4		-1.17	
	Matched	0.57626	0.5895	-3.8	69.6	-0.43	
Time from plot to province capital	Unmatched	65.717	71.674	-6.4		-0.6	
	Matched	67.665	72.798	-5.5	13.9	-0.59	
Time from plot to district capital	Unmatched	17.386	23.129	-20		-1.96	**
	Matched	17.541	17.815	-1	95.2	-0.13	
Time from plot to farmer house	Unmatched	0.15508	0.12024	14.3		1.34	
	Matched	0.15761	0.19401	-15	-4.5	-1.42	
Plot has high slope	Unmatched	0.31496	0.38636	-15		-1.41	
	Matched	0.33058	0.34221	-2.4	83.7	-0.27	
Plot is in medium altitude area	Unmatched	0.29921	0.2803	4.2		0.39	
	Matched	0.28512	0.29908	-3.1	26.2	-0.34	
Plot is in high altitude area	Unmatched	37.131	32.761	9.5		0.88	
	Matched	36.348	35.094	2.7	71.3	0.3	
Percentage of plot with irrigation	Unmatched	0.53472	0.66212	-17.4		-1.58	
	Matched	0.54884	0.58776	-5.3	69.4	-0.57	
Index of erosion in plot	Unmatched	3.1044	3.1225	-3.8		-0.34	
	Matched	3.1165	3.1413	-5.2	-37.5	-0.59	
Index of quality of plot	Unmatched	2838.5	4761.6	-37.7		-3.76	**
	Matched	2820	2738.4	1.6	95.8	0.21	
Value of cattle (1994)	Unmatched	1.4987	2.7984	-22.9		-2.4	**
	Matched	1.548	1.3402	3.7	84	0.72	
Size of of the plot	Unmatched	0.90157	0.89394	2.5		0.24	
	Matched	0.90083	0.89702	1.3	50.1	0.14	
Head has ID (dni)	Unmatched	0.87008	0.89394	-7.4		-0.68	
	Matched	0.88017	0.86797	3.8	48.9	0.4	
Spouse has ID (dni)	Unmatched	0.02009	0.02435	-48.1		-4.62	**
	Matched	0.02021	0.02066	-5	89.5	-0.57	
Level of land concentration (district)	Unmatched	0.07087	0.0303	18.5		1.63	
	Matched	0.07438	0.07377	0.3	98.5	0.03	