Impacts of Land Certification on Tenure Security, Investment, and Land Market Participation: Evidence from Ethiopia

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Abstract: While early attempts at land titling in Africa were unsuccessful, factors such as new legislation, low-cost methods, and increasing demand for land have generated renewed interest. A four-period panel allows use of a pipeline and difference-in-difference approach to assess impacts of land registration in Ethiopia. We find that the program increased tenure security, land-related investment, and rental market participation and yielded benefits significantly above the cost of implementation.

***Keywords*:** land certification, land rights, tenure security, investment, rental market, Ethiopia

JEL: *O13*, O17, Q15

1. Introduction

A number of factors have recently led to renewed interest in the formalization of property rights to land in Africa where the majority of land continues to be held under customary tenures. Since the 1990s, many African countries have passed legislation to remedy perceived shortcomings of existing systems, particularly by strengthening customary land rights, recognizing occupancy short of full title, improving female land ownership, and decentralizing land administration. Advances in information technology and remote sensing offer new tools to reduce the cost of land administration. From the demand side, a number of factors are intensifying existing pressures on land and creating a risk of dispossession for traditional landholders. These include increased prices for food, fuel, and fiber; together with new demands for land by outside investors and alternative streams of income from selling environmental services. It is thus widely felt that defining property rights, at the individual or group level, and establishing a well-governed system of land administration will be critical for Africa to make use of these opportunities in a way that contributes to overall growth while at the same time avoiding socially undesirable outcomes and conflict.

However, while there is undeniable potential, the history of land titling in Africa is one of failure rather than success, primarily due to three reasons. First, lack of understanding of the reality of local rights and attempts to replace them in a top-down way with a 'modern' paradigm have generally ended up in failure (Easterly 2008). Second, unless accompanied by broad-based information campaigns, efforts to formalize land tenure can easily cause a race for rights that will favor the powerful. By dispossessing traditional right holders, this process can end up reducing rather than increasing social welfare, especially for those with secondary rights (e.g., to grazing). Finally, the use of high cost approaches that are implemented in

other parts of the world often proved unsustainable because the benefits were much below the cost of establishing and maintaining land titles (Jacoby and Minten 2007)

This paper quantifies the early impact of recent land certification in Ethiopia, a program that is of interest for three reasons. First, although implemented by the Government with minimum outside assistance, it is arguably the largest land administration program carried out over the last decade in Africa, and possibly the world. Second, it departs from the approach of traditional land titling interventions in a number of ways, namely by (i) issuing non-alienable use right certificates rather than full titles; (ii) promoting gender equity with joint land ownership by spouses and inclusion of their pictures on certificates; (iii) using a participatory, decentralized process of field adjudication; and (iv) replacing sophisticated mapping with community identification of boundaries. Third, costs are significantly lower than both those achieved by alternative models and in line with participants' capacity to pay, implying that this could provide a model for responding to new challenges.

To assess program impact, we investigate early effects of issuing certificates at household or individual level on perceived tenure security, land-related investment, and land market participation, using a four-period household panel survey from Amhara region. We use a difference-in-differences strategy combined with a pipeline approach that is justified by the program's gradual roll-out and the fact that outcome variables moved in parallel in treatment and control areas before the program. Results are robust to whether the household or the village is used as the unit of intervention and, as most of the control had already received information about the program or undergone the registration process, constitute a lower bound of true impact. Three main findings stand out. First, the program had significant impact on the variables of interest, i.e. it helped to increase tenure security, investment, and renting out by landlords. Second, a rough estimate of program-induced benefits (based on the net increase in productivity due to program-induced investment) suggests a favorable cost-benefit ratio especially if current investments are maintained. Finally although it has a positive effect, the fact that considerable tenure insecurity remains implies that certification by itself cannot compensate for gaps in the policy environment. To reap certification's full potential, it is necessary to not only honor existing certificates but also to change policies that currently prevent realization of the full impact as needed.

The paper is structured as follows. Section two reviews evidence on impacts of land-related programs as well as characteristics of the Ethiopian effort that are used to formulate hypotheses on program impact. Section three presents descriptive data for the entire sample and for treatment and control groups and discusses the modalities of program implementation and their implications for the estimation strategy. Section four provides estimates of certification impacts on the key variables of interest and section five concludes with a number of implications for Ethiopia and other countries in the region.

2. Background and approach

The literature suggests that, in principle, measures to strengthen land rights or improve their enforcement can affect owners' incentives to make land-related investments, transfer land to more efficient uses through markets, and use land as collateral for credit. Given Ethiopia's policy environment, impacts are expected to be limited to investment and rental market participation, and key aspects of the way in which the program is implemented are used to formulate hypotheses that can be subjected to statistical tests.

2.1 Evidence from the literature and implications for Africa

The literature identifies three channels through which more secure and better enforced property rights could affect economic outcomes. First, well-defined property rights to land and the ability to draw on the state's enforcement capacity lower the risk of eviction, increase incentives for land-related investment (Besley 1995), and reduce the need for land owners to expend resources to stake out or defend their claims. Thus, groups, such as women, who were traditionally discriminated against (Joireman 2008), could benefit even more and security of rights against the state can have broader political ramifications (Boone 2009).

The positive impacts of more secure land tenure on investment and land values in rural areas have been demonstrated in China (Jacoby *et al.* 2002), Thailand (Feder *et al.* 1988), Latin America (Deininger and Chamorro 2004, Field *et al.* 2006, Bandiera 2007, Fort 2007), Eastern Europe (Rozelle and Swinnen 2004), and Africa (Deininger and Jin 2006, Goldstein and Udry 2006, Holden *et al.* 2009). In urban areas, efforts to enhance tenure security have led to increased levels of self-assessed land values (Lanjouw and Levy 2002), greater investment in housing (Galiani and Schargrodsky 2005), and female empowerment (Field 2005). Receipt of titles has allowed former squatters, especially women, to join formal labor markets instead of staying at home to guard their land, thereby increasing their income and reducing child labor (Field 2007). Joint titles helped reduce fertility (Field 2003), increased investment in children's human capital (Galiani and Schargrodsky 2004) and improved educational outcomes (Galiani and Schargrodsky 2005). The way in which property rights to land could be exercised has also affected governance and corruption (Lobo and Balakrishnan 2002) and performance of local institutions (Deininger and Jin 2008).

The size of tenure security and investment benefits depends on the availability of investment opportunities and the reduction in enforcement efforts afforded by formal recognition. Moreover, it will also be critical to design a process that does not generate losses by threatening secondary rights, weakening existing institutions, or setting off speculative clamors for land that increase conflict. Benefits will be larger in settings with potential for land-related investment with high payoff, where tenure has

been insecure or the level of conflict high, and where the certificates generated will be respected and affect behavior by third parties. To assess whether intervention is warranted, these benefits need to be compared to the cost, both of first-time registration and of sustaining the required institutions over time. A combination of limited benefits, inappropriate processes, and failure to account for the cost of maintenance have limited the impact of past efforts to register land in many African contexts (Pinckney and Kimuyu 1994, Bruce and Migot-Adholla 1994, Jacoby and Minten 2007).

A second potential benefit from land registration is that low-cost access to reliable information about individuals' land ownership via a public registry will reduce the cost of exchanging land in rental or sales markets. Rental allows land owners to tap new sources of income while retaining their land as a means of insurance or old-age protection. At the same time, those who remain in farming can consolidate and cultivate larger farm areas. Formal documentation of land rights can allay fears that rented out land will be lost, either to the government through redistribution, or to tenants who do not vacate it at the end of the lease period. This can be useful in contexts where migration requires land owners to be temporarily absent or if the number of transactions increases beyond the capacity of informal, local mechanisms to handle them transparently. In China, rental activity contributed to occupational diversification and was estimated to have increased productivity by about 60% (Deininger and Jin 2008). In Vietnam, awarding certificates is estimated to have prompted not only investment in perennials (by 7.5% compared to no certificates) but also an 11-12 week expansion of the time households spent in non-agricultural activity, an effect that was particularly pronounced for the poor (Do and Iyer 2008).

Finally, in many settings, a key benefit of formal land titles is the ability to sell land to strangers and the associated ability to use land as collateral for credit (de Soto 2000).[1] The reason is that, if a reliable land registry provides a formal and low-cost way to identify land ownership without the need of physical inspection or inquiry with neighbors, land is ideal as collateral. However, for credit effects from formal registration to materialize, households will need to have otherwise bankable projects, be credit-worthy, and willing to take the associated risk (Boucher *et al.* 2008). Moreover, land markets need to be sufficiently liquid to make quick sales feasible. While credit effects of land titling are reported in the literature (Feder *et al.* 1988), positive impacts were often limited to larger owners (Mushinski 1999, Carter and Olinto 2003) or may have failed to materialize even in settings where they were expected (Field *et al.* 2006, Fort 2007). Even if profitable projects exist, legal restrictions on land sales (Sundet 2004), limited commercial value of the land under question (Galiani and Schargrodsky 2005, Payne *et al.* 2008) and social or political considerations that limit foreclosure (Field and Torero 2006) may jeopardize

[1] The large differences in the ratio of credit to GDP across countries is used as a key argument to justify interventions to formalize land rights that could then allow greater use of land as a collateral to access credit (de Soto 2000, Besley and Ghatak 2008).

realization of credit effects. Credit effects of land titling might thus be less readily achieved than originally hoped for.

2.2 Hypotheses on program impact and outcome variables

In one of the largest land registration programs in the world,[2] three of Ethiopia's four main regions have, over the last five years, registered more than 20 million parcels of rural land to some 6 million households.[3] Certification is initiated by a team of experts from the *woreda* that guides the process from a village meeting to the election of an independent village land use and administration committee (LAC).[4] The LAC then assumes responsibility for systematic field-based adjudication of rights through a public process with the presence of neighbors and help from elders to resolve conflicts. The adjudication process produces preliminary registration certificates that identify size and neighbors for each of a holder's plots.[5] Results are then displayed in public and, after a period for raising complaints, entered into registry books, copies of which are to be kept at *kebele* and *woreda* levels. Thereafter, certificates with pictures of the land holders (husband and spouse in case of joint ownership) are issued by the *woreda*. Certificates also include space for maps and spatial information is then expected to be added in a 'second stage'.

Evidence suggests that decentralized and participatory implementation with emphasis on the provision of information, issuance of certificates rather than titles, and a focus on gender equality helped avoid some of the problems raised in the literature on land titling in Africa. A nation-wide survey (Deininger *et al.* 2008a) highlights evidence that access to information and certificates was neither biased against women nor the poor. It also suggests that the process was generally implemented as planned; in particular (i) public meetings were held before and during the certification process; (ii) land use committees (LACs) represented most of the sub-*kebeles*; and (iii) adjudication relied on village elders to resolve disputes and included demarcation in the field with neighbors present. Survey data suggest that the quality of the certification process was high; certificates could be issued in 95% of cases where there were no disputes about ownership, compared to 80% in many titling projects. Case study evidence also points to reductions in conflict when registration involved identification of borders and systematic conflict resolution.[6] Also,

[2] The program is similar in size to the 11 million certificates awarded in Vietnam from 1993 to 2000 and the issuance of 8.7 million titles in Thailand during 1980-2005. Its accomplishments compare favourably to what was achieved by other land administration programs, e.g. the 2.7 million titles (1.2 million urban and 1.5 million rural) issued in Peru from 1992 to 2005 and the 1.8 million titles issued in Indonesia since 1996.

[3] The fourth largest region in Ethiopia, Tigray, had implemented a similar program in 1998 (Holden *et al.* 2008, Holden *et al.* 2009). Although a number of modifications were undertaken, the relative success of this program was one of the reasons for other regions to initiate certification programs. This low-cost program in Tigray is found to have positive impacts on improving land-related investment and productivity, land rental market participation and reducing land related conflicts (Holden *et al.* 2007, Holden *et al.* 2008, Holden *et al.* 2009).

[4] The fact that the LAC is directly elected in a democratic fashion rather than being part of the (often politicized) administrative structure was mentioned repeatedly as an important merit in interviews with groups as well as individual villagers.

[5] Although LAC members repeatedly emphasized the demanding nature of this task, it is critical to ensure transparency, especially in the identification of communal areas. This reduces the scope for error that could arise from the use of office records that may not be up to date.

[6] In one site, the volume of court cases is reported to have reduced from 20 to at most two per week (Adal 2008). This is important as, according to local government statistics, land conflict accounts for some 80% of rural crime. It also has a relevant gender aspect as in some cases widows were able to win court cases to hold on to their land rather than, as dictated by local tradition, have it revert back to the husband's lineage at the point of his death. In polygamous settings, the requirement to have separate certificates for any spouses beyond the first one is linked to a

at less than US $ 1 per parcel, program cost is an order of magnitude lower than the US $20–$60 per parcel for traditional titling reported in the literature. In fact, more than 80% of sample households were willing to pay an amount in line with the cost of service provision to replace certificates if lost or to transfer it, suggesting that the program could be self-sustaining.

To assess possible impacts, it is important to note that, in Ethiopia, land is state property that can neither be sold nor mortgaged, implying that we would expect no credit effects from land certification. Land rental also remains restricted in all regions except Amhara. There is, however, scope for positive impacts by increasing tenure security due to two factors. First, the constitutional guarantee of land access by every adult and the government's ability to resort to often discretionary land redistribution to implement it has long been a threat to land users.[7] In Amhara, where our survey was undertaken, a highly politicized land redistribution in 1997 reduced tenure security and increased conflict on a large scale (Ege 1997).[8] The topic acquired new urgency recently when Tigray region began enforcing a proclamation (law) to take away land from rural residents who had left their village for more than two years. Second, urban expansion and government-supported land grants to investors continue apace. In both cases, possession of a certificate can improve negotiating power or at least provide a basis for compensation, again implying that certification could lead to potentially large tenure security effects.

3. Data, descriptive evidence, and econometric approach

Our four-period household panel allows tracing adherence to regulations for implementing the program, so as to illustrate the evolution of outcome variables before and after certification and describe the econometric approach chosen to identify hypothesized program impacts.

3.1 Data and identification strategy

To assess program impact, we use data from four waves of a panel survey of rural households conducted in September–October 1999, July–August 2002, September–November 2004, and July–August 2007 in the East Gojjam zone of the Amhara region.[9] In each round, the survey, which was undertaken by the Department of Economics of Addis Ababa University in collaboration with Gothenburg University,

reduction in (reported) polygamy. Even male farmers acknowledge that joint titling increased their wives' willingness to work and invest as official co-owners. Households in areas where urban expansion is imminent are reported to be particularly eager to get certificates that could help them substantiate their claims for compensation if their land is taken for urban expansion. In fact, observers link the ability to use certificates for demanding compensation to the emergence of innovative, in-kind compensation arrangements in a number of peri-urban areas.

[7] The proclamation (law) in Amhara allows land redistribution if properly researched and decided upon at the community level. Tigray has recently started redistributing the land of anybody absent from the village for more than two years with a minimum income (US$ 100 per month).

[8] Data from the study villages confirm the widespread nature of the government sponsored land redistribution in Amhara region in 1997. The first round data that was collected in 2000 show that about 46% and 48% of the sampled households experienced a decrease and an increase in their holdings, respectively, since the formation of their household. Of this more than 80% of the changes occurred due to village level land redistribution and reallocation, and about 61% of the decreases and 33% of the increases in landholdings had happened in 1997. The fact that the highest percentage of parcels (22% while the second highest was just 10% in 1975, i.e., right after the radical land reform) were acquired in 1997 is an additional evidence for changes in landownership in the region in the specified year.

[9] The East Gojjam zone was selected purposefully to represent surplus producing areas of the region. The districts and the villages in each district were also selected based on similar criteria while the households in each village were selected randomly.

EDRI, and the World Bank, includes information on a panel of 900 households who had been randomly selected in the first phase, and more than 4,000 plots cultivated by these same households although the plots cannot be matched over time.[10] All sample villages are part of a SIDA-supported pilot that aimed to certify land and were therefore eventually covered by land certification.[11] The first three rounds of the panel covered the period before certification. At the time of the fourth round, some villages (referred to as treatment villages below) had been certified for more than 12 months so that certificates will have affected not only perceptions of tenure security but also decisions on investment and land market participation in the reference period for the survey.

Household evidence on process in the top panel of table 1 reinforces earlier notions: 85% in certified and 78% in control villages attended an average of 3.5 public information meetings, and 85% and 68%, respectively, thought they were well informed about the program. At the time of the survey, 87% of households in treatment villages had received a certificate, which they had held for an average of 17 months, compared to 36% and 8 months in controls, with 77.5% in treatment and 2.3% in control areas having held certificates for longer than 12 months so that it could affect decisions (e.g. on investment) during the 12 month-recall period of our survey. Plot level data in the table's bottom panel point towards some implementation differences. Almost all the plots (92%) in treatment villages were measured (95% with rope) in the field with the presence of more than half of neighbors in 60% of the cases and between one third and half in 20% of the cases. However, field measurement was done for less than two thirds of registered plots in control villages; 35% of these cases involved eye estimation only, and more than half or more than one third of the neighbors were present only in 35% and 11% of cases, respectively.

The village level certification process follows a sequence of information campaign and LAC formation, field adjudication and distribution of registration receipts, and eventually issuance of final certificates. Selection of villages to be certified was the responsibility of *woreda* officials who determined a roll-out plan in campaign-style moving from village to village to maximize targets. However, the fact that field work is possible only during the dry season (January to July/August) when agricultural labor demands are limited creates a discontinuity which we can utilize for identification. Thus, in most cases the process was initiated after the harvest and registration completed before the start of the next growing season. *Woreda* officials then used the agricultural growing season to complete the paperwork and distribute certificates as and when they were ready and road conditions permitted.[12]

[10] Information from one of the sampled villages is available only in the last two rounds, as it was added to the sample during the third round. For production information, the reference period was the main agricultural season (*meher*, i.e., from June-February) of 1998/99, 2000/01, 2003/04 and 2006/07 agricultural years.

[11] In view of the pilot's success, the program was expanded and has by now covered the entire region.

[12] A number of factors that can range from delays in delivery of printed certificates to the *woreda* to the sequencing of batches to sign or the lack or loss of owners' pictures can lead to delays in issuance of final certificates to individuals even in villages where the registration process has been completed and a majority received certificates.

Table 2 illustrates the timing of program implementation for the 7 villages (*kebeles*) in the three districts (*woredas*) of our survey. With the exception of two 'pilot' villages (Telma and Gozamim), one in the treatment and one in the control, the program was introduced in treatment villages in early 2004 and in early 2005 or even 2006 in control villages.[13] In 'regular' villages it took an average of 11 months to complete registration and another five months for the issuance of certificates. Three control villages had completed registration and two had started issuance of certificates at the time of the survey. In those that had started certification, the process commenced some 15 months later than in treated ones. The fact that even in villages which we define as certified (as the majority of households received certificates) some households may be excluded for reasons unknown to us raises the question of whether the intervention should be defined at the household- or the village-level. To account for this, we report estimates that are based on either the village or the household being the relevant unit of observation throughout.

We use a difference-in-differences (DID) approach comparing difference between pre- and post-program outcomes together with a phased and discontinuous roll-out. This will provide an unbiased estimate of program effects if there are no unobserved differences between treatment and control units that could affect changes in outcome variables over time. While this cannot be tested, an ability to show that unobservable differences between villages did not affect the rate of change in outcome variables before the program had been announced will increase our confidence in this condition being satisfied. We explicitly test the assumption of parallel trends in pre-intervention years for key variables of interest.

Our strategy is conservative in two ways. First, by defining treatment as receipt of a certificate rather than completion of the registration process which is certain to lead to a certificate, we implicitly assume that registration has no effect and that the expectation of a certificate will not impact behavior. As illustrated in table 2, at the time of the fourth round of our survey all villages had received information about the program and many households in 'non-certified' villages had undergone the registration process. If this led them to modify their behavior, it would reduce the size of the effect estimated here, implying that our estimate will constitute a lower bound of the true certification impact. Second, to the extent that we define the intervention at the village rather than the household level, our 'treated' category includes households who did not receive a certificate. If there is self-selection so that the benefit of receiving certificates for recipients is above the average, this would exert downward bias on the estimated effects of certification.

3.2 Descriptive evidence

[13] Both A. Gullit (treatment) and Telma (control) were used to pilot different methods of certification. In the former, high precision surveys were conducted with advanced technology including GPS and total stations, leading to a delay of 28 months between the start of the program and issuance of the first certificate. In the latter, some of the participatory processes were initially tested and the fact that the woreda would not be able to count it towards its achievement led to its temporary abandonment. Dropping either does not affect the substantive results reported here; results from doing so are available upon request.

To illustrate the evolution of key dependent variables, table 3 displays key household characteristics by participation status and year for the 356 and 477 households in treatment and control villages, respectively. There are some differences between households; for example, treated villages have slightly higher endowments of land per household (but not per capita), higher levels of human capital as proxied by literacy of the household head, more livestock and other animals, and use higher amounts of fertilizer per hectare. Also, some time-varying factors (e.g., a drought in 2002) affected both types of villages similarly. Attributes for the 3,972 and 4,699 plots in treatment and control villages, respectively, averaged over all periods as reported in table 4, point to a mean plot size of 0.3 and possession by the current owner for 21 years. With 4% of the plots having access to irrigation, it is rare in both villages. Even though there are small differences in the subjective land attributes (land quality and incline), there are no statistically significant differences between villages in the share of flat and gently sloped as well as good and medium quality land together.

Levels and changes for our outcome variables, i.e., perceived tenure security, land-related investment, and rental market participation, are displayed in table 5. High levels of tenure insecurity prior to program start and quick changes in this variable over time are particularly notable.[14] Possibly as a result of the 1997 redistribution, perceived tenure insecurity in 1999 was very high, with 78% and 75% who expected a change of land holdings due to administrative intervention in treatment and control villages, respectively. In the five years before the certification program, this decreased to 38% in treatment and control villages.[15] With the program, however, the trends start to diverge, dropping to 24% in treatment villages while increasing to 39% in controls. The share expecting an increase dropped from 19% to 4% in treatment and to 11% in control areas, whereas the share expecting a decrease remained unchanged in treatment areas but increased from 19% to 28% in control villages.[16]

We use a dummy for whether households constructed new soil conservation structures (e.g., terraces, soil or rock bunds, and hedgerows) or repaired existing ones at the plot level, and hours spent on conservation, to measure land-attached investment. Although comparable data is available only for the last two periods, the pre-program share of plots that had investment or repairs and the amount of time spent on such investment were significantly higher in control as compared to treatment villages. The difference in both narrowed significantly, and reversed for construction of new structures. For example, a decline in the share of plots where households voluntarily constructed new structures or repaired existing ones and the

[14] We use the response to the question of whether the household expects a change (increase or decrease) of land holdings through administrative action over the next five years and note that, as the question format was identical in all the four survey rounds, concerns about potential halo effects are unfounded.

[15] As the generalized expectation of an increase in holding size could exert considerable pressure on policy-makers, both of these outcomes may be relevant for tenure security.

[16] While less robust, a plot-level variable asking owners whether they were concerned about land conflict which was introduced only in the last round, points to significantly higher levels of tenure insecurity in the control villages (20%) as compared to the treatment villages (14%) in a simple cross section.

number of hours spent (from 36% to 24% and 8.2 to 5.5 hours, respectively) in control villages contrasts with an equally large increase (from 12% to 25% and 2.3 to 4.4 hours) in treatment villages. We observe a narrowing or reversal in the share of plots with any conservation structure (from 44% to 34% in control and 22% to 32% in treatment villages) and the share of constructing new structures in the last 12 months (from 10% to 8% and 7% to 10% in control and treatment villages, respectively).

Finally, a dummy for the type of net rental market participation and the amount of land transacted is used to capture potential rental market impacts of land certification. Before certification, the landlord share and mean area rented out were consistently higher in treatment than in control villages, a difference that narrowed from 2004. After certification, we note a clear increase in rental market participation in both areas. While the increase in renting out (7% vs. 5%) is marginally higher in treatment groups as compared to control group, the opposite is true for renting in, implying that more rigorous evidence will be needed to assess whether certification can be said to have had a significant impact on land market participation or whether, possibly as a result of the rather restrictive policy regime, no such impact materialized.

3.3 Econometric approach

To estimate program impacts on perceived tenure security, we use data from all four rounds to estimate

$$y_{it} = \lambda_t + \tau w_{it} + \mathbf{x}_{it}\boldsymbol{\gamma} + c_i + u_{it}, \quad (1)$$

where y_{it} is a dummy variable that takes a value of one if household *i* expects an increase (or a decrease) of its landholdings due to administrative intervention in the five years following the survey; w_{it} is the policy variable of interest (one for post-treatment period if household *i* lives in a 'treated village and zero otherwise; and equivalently for the case where treatment is defined at the household level); $\mathbf{x}_{it}$ is a vector of controls at the household level that include the head's age, gender, education, household assets (oxen, value of other livestock, roof material), and land size;[17] c_i captures household specific unobserved effects, λ_t is a full set of time dummies; and u_{it} is an *iid* error term. The null hypothesis that certification increases tenure security would imply that τ is negative and significant. A random effects probit model is appropriate if c_i is normally distributed with mean zero and variance σ_u^2 and independent from all right-hand side variables. As this may be unrealistic, we use Chamberlain's random effects probit (Chamberlain 1980, Wooldridge 2001) which relaxes this by allowing correlation between c_i and the means of time-varying covariates at the household level according to

[17] To allow for relative rather than absolute land size to affect the risk of expropriation, we use the amount of owned land per adult equivalent relative to the median of this variable in the village although results are similar if absolute land size is used.

$$c_i = \psi + \bar{\mathbf{x}}_i \boldsymbol{\xi} + a_i,$$

where $\bar{\mathbf{x}}_i$ is the vector of the average of time-varying household covariates for household *i* over all periods and a_i is an error term. All that is required is that $\mathbf{x}_{it}$ and a_i are independently and normally distributed with mean zero and variance σ_a^2. Adding $\bar{\mathbf{x}}_i$ as an explanatory variables to equation (1) in each time period allows estimation of the parameters λ, τ, $\boldsymbol{\gamma}$, ψ, $\boldsymbol{\xi}$ and σ_a^2 in a random effects probit model. In addition to the Chamberlain random effects probit, we also use a conditional logit model with household fixed effects as a robustness check.

While we are able to control for time-invariant fixed effects, τ will be an unbiased estimate of program impact only if there are no unobservable factors that affect changes in outcome variables differently between control and treatment villages. Although this assumption itself is not testable, data from the survey rounds prior to certification can be used to test whether during this period, outcome variables moved in parallel in the two sets of villages. To do so, we estimate different intercept terms for the treatment and control villages for each year and then test for the equality of the differences in the intercept terms between treatment and control villages over all the periods.

In contrast to the household-level analysis in equation (1), impacts of certification on land-related investment are assessed at the plot level. Dependent variables for land-related investment take the value of one if the plot received soil or water conservation investment during the past 12 months or the number of hours spent in undertaking such investment during the past 12 months. Using the notation introduced above, the random effects probit or tobit (depending on the choice of the dependent variable) model for land-related investment on plot *j* by household *i* is specified as:

$$y_{jit} = \psi + \lambda_t + \tau w_{it} + \mathbf{x}_{it}\boldsymbol{\gamma} + \mathbf{p}_{jit}\boldsymbol{\delta} + \bar{\mathbf{x}}_i\boldsymbol{\xi} + a_i + u_{jit}, \qquad (2)$$

where the only difference is the inclusion of $\mathbf{p}_{jit}$, a vector of plot level characteristics that includes size, soil quality, slope, and length of possession, and the addition of a plot specific error term u_{jit}. The hypothesis that certification increases incentives for land-related investment translates into $\tau > 0$. As earlier rounds did not include comparable information, our analysis is limited to the last two rounds.

Similar random effects probit and tobit specifications for participation on either side of the rental market and the amount of land transferred, respectively, are estimated for our rental market outcomes. As rental market participation may be persistent over time, for example due to non-convex transaction costs (Holden *et al.* 2008), we also estimate a specification that allows for state dependence of rental market

participation. The implied need to include the lagged dependent variable on the right-hand side of equation (1) gives rise to a nonlinear dynamic model that may suffer from the initial condition problem, i.e., the correlation between the unobserved effect and the initial observation of the dependent variable. To account for this, the distribution of the unobserved effect is modeled conditional on the initial observation in addition to the time-varying household level covariates (Wooldridge 2005). The reduced form equation to be estimated is

$$y_{it} = \psi + \lambda_t + \tau w_{it} + \mathbf{x}_{it}\boldsymbol{\gamma} + \rho y_{i,t-1} + \xi_0 y_{i0} + \bar{\mathbf{x}}_i\boldsymbol{\xi} + a_i + u_{it}, \quad (3)$$

where y_{it-1} is the lagged dependent variable and y_{i0} is the first realization of the dependent variable. The parameters in equation (3) are estimated using standard random effects probit or tobit, depending on the type of the dependent variable. As this procedure requires data from at least four periods, we are forced to drop one of the villages (A. Gulit) which was added to the survey during the third round. The hypothesis of a positive impact of certification on the propensity to rent out land translates into $\tau > 0$ in the probit and tobit equations for renting out or the area rented out. Again, we can test for the parallel trend assumption between treatment and control areas.

4. Econometric results

Results corresponding to the three main hypotheses suggest that, despite the limited time elapsed since its completion, certification has had a positive economic impact and improved tenure security, investment, and supply of land to the rental market. Even conservative estimates and a rough calculation of monetary benefits suggest that benefits exceed the cost significantly, allowing us to discuss ways in which the sustainability of impacts could be enhanced and other countries could benefit from Ethiopia's lessons.

4.1 Perceived tenure security

We find that, although certification failed to eliminate tenure insecurity, it has significantly reduced fear of land loss by some 10 percentage points, an estimate that is robust across specifications. Table 6 reports results from estimating equation (1) to identify the impact of certification on perceived risk of land loss or gain through administrative redistribution over the next five years. We report random effect probit estimates with treatment defined at village and household level (col. 1 & 4 and col. 2 &5, respectively) as well as conditional logit estimates with household fixed effects (col. 3 and 6). In all cases, results suggest that land tenure for treated households is significantly more secure as evidenced by the fact that they expect less administrative intervention. Estimated marginal effects from the Chamberlain specification with village level treatment indicator suggest that certification leads to a decrease of about 14 percentage points in the share of those expecting to gain and of about 9 percentage points in the share of those

expecting to lose from land redistribution. The estimated size of impact with treatment defined at the household level is the same for land loss and slightly lower for land gain.[18] Although not directly comparable in terms of marginal effects, conditional logit estimates point in the same direction. Tests of the parallel trend assumption (appendix table 2) imply that the share of those who expected to lose land through administrative interventions, arguably the more relevant indicator in our context, had moved in parallel during all of the three pre-treatment periods. The share of households expecting an increase in land holdings moved in parallel between 1999 and 2002 but started to diverge in the 2002-2004 period, consistent with the notion that initial dissemination of the certification program in some villages before September–November 2004 had given rise to some speculation about possible increases in land endowments.

Signs for coefficients on other variables are largely as expected. Coefficients on the time trend are highly significant and of large magnitude for gains but less significant for land losses, in line with descriptive evidence that points towards a reduction over time in the share of households who expect their holdings to increase rather than those that expect to lose land. Older household heads are more likely to fear land loss, consistent with the notion that administrative measures aim to redistribute productive assets among generations. A higher per capita land endowment relative to the village median increases fear of land loss and reduces perceived likelihood of gains, as expected in a system that aims to distribute a limited amount of overall land equitably among rural residents. The opposite is true for higher shares of good quality land, which could suggest that officials are either not good at assessing land quality or do not take it into account in making their decisions. Non-land physical assets, oxen, education, or possession of an iron roof have little impact on the perceived threat of land loss or gain. Interactions between the treatment dummy and assets, land, or the head's gender are insignificant throughout, providing little support to the notion that certification-induced tenure security effects are differentiated by wealth or gender.

4.2 Land-related investment

From an economic point of view, higher tenure security should manifest itself in land-related investment. Table 7 reports estimated marginal effects from probit and tobit models and conditional logit fixed effects for new investment in or repairs of conservation structures over the last 12 months. Results from the Chamberlain specifications with village and household level treatment indicators (cols. 1 and 2 for probit and 4 and 5 for tobit) point towards significant and economically meaningful impacts. This is consistent with the conditional logit estimates (col. 3). According to our estimates, the propensity to invest in soil and water conservation measures increases by between 20 and 30 percentage points while the number of

[18] The sign and significance of the estimates from the conditional logit model (col. 3 and 6) also confirm the results of the random effects probit analysis although we cannot directly compare the magnitudes due to the difficulty of estimating marginal effects for the conditional logit model. Hence the rest of the discussion is based on the random effects model.

hours spent on such activities increases by between 72% and 136%. Even considering the low base of investment, this is a very large effect, making it of interest to assess its (potential) economic impact.

Coefficients on other variables suggest that the propensity to make land-related investment increases with plot size but decreases in overall holding size. This is consistent with the notion that the presence of some fixed cost element increases payoffs from investment in conservation for larger fields but that, on larger holdings, there is increased competition among plots for investment. The propensity to undertake investment is significantly lower on flat plots, consistent with the fact that such plots are less prone to erosion and land degradation than hilly plots, implying less need to guard against these through adoption of soil conservation measures. As the investments considered do not involve any cash outlays, there is little reason to expect impacts to be differentiated by wealth, as is suggested by the lack of significance of the certification dummy's interaction with the various measures of wealth (not reported) throughout.

Given the recent nature of certification, such investment will not yet have affected agricultural production as reported in our survey. Thus, to obtain a measure of the size of the investment impact, we estimate a household-fixed effects production function with a dummy for the presence of a functioning conservation structure. Results, as reported in appendix table 1, suggest that such a structure increases output by about 9 percentage points, implying that, with mean annual output of ETB 3,300 (with 9.6 ETB to the US $), investment-induced certification impacts are between ETB 56 and 87/hectare (0.29 or 0.19*0.09*3,330). Even if we assume that some of the investment actually involves repairs of existing structures, our conservative estimate implies that the increment in output from certification-induced investment in the first year alone could be sufficient to cover program costs (US$ 1 per plot or US$ 3.2/ha). Although a few issues, such as the addition of a cadastral index map, inclusion of common property resources, and a mechanism to keep records up to date, will need to be added to ensure sustainability of Ethiopia's program, these are unlikely to increase the cost beyond what would be warranted in light of the benefits obtained, which could possibly be further increased by appropriate changes in policy.

4.3 Rental market participation

Rental markets are likely to become of increased importance as a catalyst of the local non-farm sector and having a certificate can, in principle, be an important incentive for farmers to rent out. Tables 8 and 9 present results from probit and tobit estimates of equation (3) that allow us to test whether, as expected, certification affected the propensity to rent out but left demand for land rental unaffected. In both cases, results from the Chamberlain specifications of the rent-out regressions in col. 1-3 (with treatment defined at village or household level) strongly support our hypothesis. Estimated marginal effects suggest that certification consistently increases the amount of land rented out by about one tenth of a hectare at the mean and the propensity to rent out by 13 or 9 percentage points for treatment defined at village or

household level, respectively. Estimated impacts for renting in are insignificant as expected if treatment is defined at the village level and marginally negative if treatment is defined at the household level (table 8, col. 6). Our dynamic analysis (cols. 2-3 and 5-6 in both tables) suggests that participation decisions and the amount of land transacted on both sides of the rental market are strongly and positively state-dependent. Thus, policy interventions affecting market participation at any given point in time will affect households' long-term trajectories.

Our results also point towards a significant impact of land endowments on renting out (positive) and renting in (negative) as would be expected if rental markets contribute to equalization of factor input ratios. Total owned area has a positive and significant effect in the leasing-out regressions as compared to a negative and significant effect on the leasing-in regressions. However, the absolute value of the marginal effect of total owned land on the amount of land rented out or in (table 9) is less than one, indicating that rental market participation allows only partial adjustment towards desired area of cultivated land (Bliss and Stern 1982). Contrary to what is found in studies from other countries, but consistent with evidence from Ethiopia (Deininger *et al.* 2008b, Ghebru and Holden 2009, Holden and Bezabih 2009, Tadesse *et al.* 2009), rental markets transfer land from relatively resource-poor households (mainly in terms of oxen power) that are often female-headed, to comparatively resource-rich households. Appendix table 2 demonstrates that the parallel trend assumption holds throughout the pre-intervention period for renting out (col. 3 and 5), the variable of primary interest in our analysis, implying that unobserved factors did not lead to differential evolution of this variable over time in treatment and control villages.

Rental markets in Ethiopia also have strong gender implications, as socio-cultural norms and factor market imperfections make self-cultivation of land by female headed households extremely rare, implying that they either rent out their land or, often due to insecure tenure, leave it fallow (Adal 2005). This is borne out by our results where gender of the household head and the number of oxen have significant impacts on the nature and magnitude of rental market transactions in terms of encouraging renting in and discouraging renting out. Older households are more likely to rent out and literate households are more likely to rent out larger areas of land. The significant coefficient on possession of an iron roof in the rent-in equation may point in the same direction by highlighting imperfections in financial markets that make renting in easier for those with greater wealth. To the extent that they allow productive use of plots that had been left uncultivated, or greater freedom in the choice of transaction partner to transfer land to those with higher levels of ability, certification-induced rental market effects could enhance productivity of land use. Such impacts can come about if (female) landlords were able to enter into longer term contracts or to select more productive tenants beyond their immediate social network due to the increased security

provided by certificates. As virtually all land is rented under sharecropping contracts, any productivity effects would translate directly into improved welfare for (female) landlords. Although beyond the scope of this paper, further study of impacts on women would be of interest.

5. Conclusion and policy implications

This paper was motivated by the fact that, despite a combination of supply and demand factors that has led to renewed recent interest in land registration, evidence on the impact of specific interventions is lacking so that it is not clear whether land tenure should be of greater concern to policy makers. To explore this, we use a four-period household panel to assess short-term impacts of Amhara's certification program on perceived tenure security, investment, and land market participation. Double differences and a pipeline comparison with household fixed effects provide estimates of program effects, noting that trends in both treated and control areas moved in parallel before the program had been announced.

We find certification to have resulted in a significant reduction of tenure insecurity and an increase in land-related investment and supply to the land rental market. Although tenure insecurity decreased markedly due to certification, it remains large, pointing to the need for complementary action on the policy front if the full potential of this intervention is to be realized. Estimated investment effects are similarly large, and our results suggest that, if the voluntary investments made following certification will be maintained or if additional investment will be forthcoming in the future, benefits exceed program cost. Furthermore, contrary to what was experienced in most other cases, the cost of maintaining the land administration system will not be a major constraint to its sustainability in the long term. Implementing a decentralized, transparent, and cost-effective process of land registration under African conditions is not only possible but, by reducing (but not eliminating) tenure insecurity, can have impacts such that the magnitude exceeds the cost of implementation, even in Ethiopia where policy restrictions rule out any credit effects *a priori*. This suggests that, in the many situations where population growth, urban expansion, or land sales to outsiders pose a threat to tenure security, a community-based process to certify and register rights may be economically and socially beneficial by securing existing rights and allowing right holders to individually or collectively take decisions on how to use such rights.

Given the short time elapsed since implementation of the program, our study is able to provide evidence of short term impacts only. Longer term effects could be larger or smaller than the ones ascertained here due to a number of factors related to physical maintenance and expansion of the system, future policy initiatives, and the extent to which certificates provide a reliable basis for predicting behavior by third parties, especially government officials. Follow-up research to explore the extent to which benefits from land certification are affected by the policy environment, as well as their distribution and longer-term trajectory, could provide important inputs into the policy dialogue in Ethiopia and beyond.

Table 1: Program characteristics at household and plot levels

	Certificates issued?	
	No	**Yes**
Household level data		
A member of the household attended public information meetings	0.78	0.85
Number of meetings attended	3.50	3.60
Well informed about the program	0.68	0.85
Has landholding certificate	35.55	87.47
Number of months since certified	8.07	17.15
Plot level data[1]		
Plot area was determined in the field	0.64	0.92
Plot area was determined at *kebele* office referring to previous records	0.35	0.05
Plot measured using tape and rope, if determined in the field	0.65	0.95
Plot measured using eye estimation, if determined in the field	0.35	0.00
More than half of the neighbors were present when measured	0.35	0.59
Half or less than half of the neighbors were present were present	0.11	0.20
Plot has a certificate	0.30	0.75
Number of months since certified (for certified plots only)	8.19	16.93
Plot is jointly certified with head and spouse (for certified plots only)	0.83	0.77
Number of households	481	359
Number of plots	2369	2143

Source: Own computation from AAU/Gothenburg/WB Survey.
[1]As registration was almost complete in all the survey villages, more than 99% of the plots were already registered at the time of the survey.

Table 2: Program characteristics by village

	Certificates issued 12 months before survey?						
	No				Yes		
District (*Woreda*) name	Gozamin		Enemay		Machakel		Gozamin
Village (*Kebele*) name	Kebi	Wolkie	Telma	S. Debir	Amanuel	D. Elias	A. Gulit
Kebele area in ha	630	2670	1964	2560	4373	1790	2172
No of households	1094	1050	1464	1275	1151	906	890
Program introduced	May 2005	Sep. 2006	Oct. 2003	Jun. 2005	Feb. 2004	Feb. 2004	Feb. 2003
Competed registration	Dec. 2005	NC	Aug. 2006	Dec. 2006	Jun. 2004	Jul. 2004	May 2005
Start of certificate distribution	Aug. 2006	NS	Sep. 2006	NS	Feb. 2005	Feb. 2005	Jun. 2005
No. of LAC members	15	20	21	35	14	14	18
Training days to LAC members	3	5	8	8	9	4	6
Number of village meetings	4	4	6	2	5	3	3

Source: Own computation from AAU/Gothenburg/WB Survey

NC=Not completed at the time of the survey. NS=Not started at the time of the survey.

Table 3: Household characteristics by treatment category over time

	No certificate				With certificate			
	1999	**2002**	**2004**	**2007**	**1999**	**2002**	**2004**	**2007**
Total owned land in hectares	1.34	1.35	1.61	1.47	1.57	1.59	1.89	2.06
Owned land per aeu in ha	0.36	0.34	0.36	0.32	0.37	0.34	0.36	0.38
Share of good quality land	0.36	0.32	0.31	0.44	0.36	0.33	0.28	0.39
Number of dependents	2.50	2.59	2.70	2.68	2.83	2.97	2.84	2.83
Number of adult male	1.24	1.41	1.65	1.79	1.41	1.54	1.71	1.95
Number of adult female	1.21	1.33	1.58	1.68	1.36	1.53	1.71	1.93
Number of oxen	1.20	1.19	1.17	1.29	2.22	2.00	1.99	2.06
Value of livestock (B)	1628.09	1684.46	1776.60	1962.13	2883.31	2841.36	2895.29	3081.29
Value of other animals (B)	857.10	921.82	1025.44	1123.97	1431.78	1529.34	1590.36	1736.75
Roof corrugated iron sheet	0.55	0.60	0.71	0.79	0.61	0.70	0.86	0.91
Age of household head (years)	44.17	45.66	48.08	49.81	44.87	46.67	48.72	50.46
Female headed household	0.13	0.12	0.15	0.17	0.10	0.07	0.17	0.19
Head can read and write	0.39	0.38	0.35	0.27	0.48	0.48	0.42	0.43
Value of crop output per ha (B)	1,926	634	2,596	3,283	2,564	880	2,187	2,804
Number of households	462	463	475	477	229	233	347	356

Source: Own computation from AAU/Gothenburg/WB Survey

Table 4: Plot Characteristics by Treatment Category

	No certificate 2004-2007	With certificate 2004-2007
Plot size in hectares	0.31	0.34
Number of years possessed	20.84	21.44
Good soil quality	0.38	0.35
Medium soil quality	0.37	0.43
Flat land	0.57	0.72
Gently sloped land	0.34	0.23
Irrigated land	0.04	0.04
Number of observations (plots)	4699	3972

Source: Own computation from AAU/Gothenburg/WB Survey

Table 5: Outcome Variables by Treatment Category

	None				With certificate			
	1999	**2002**	**2004**	**2007**	**1999**	**2002**	**2004**	**2007**
Expectations of land redistribution in the next five years and of conflict								
Expect change in holdings	0.75	0.62	0.38	0.39	0.78	0.64	0.38	0.24
Expect an increase in holdings	0.55	0.45	0.19	0.11	0.55	0.36	0.18	0.04
Expect a decrease in holdings	0.20	0.17	0.19	0.28	0.23	0.27	0.19	0.19
Concerned about land conflict (p)				0.20				0.14
Land related investment over the last 12 months (plot level)								
Repaired structure / built new one			0.36	0.24			0.12	0.25
Number of hours spent			8.22	5.51			2.26	4.38
Constructed new structure			0.10	0.08			0.07	0.10
Plot has conservation structure			0.44	0.34			0.22	0.32
Participation in land rental market								
Rent-out land	0.24	0.21	0.29	0.34	0.17	0.15	0.26	0.33
Area rented out (ha)	0.20	0.21	0.28	0.34	0.14	0.16	0.32	0.45
Rent-in land	0.37	0.26	0.20	0.36	0.49	0.31	0.36	0.45
Area rented in (ha)	0.25	0.19	0.15	0.29	0.29	0.19	0.27	0.44
Number of households	462	463	475	477	229	233	347	356
Number of plots			2284	2415			1886	2086

Source: Own computation from AAU/Gothenburg/WB Survey. Empty cells imply that no data was available.
Note: Except where indicated in the table, all variables are at the household level.

Table 6: Impact of certification on perceived land tenure security: Marginal effects

	Expect an increase			Expect a decrease		
	Chamberlain RE probit		Cond. logit	Chamberlain RE probit		Cond. logit
	$T_{Village.}$	$T_{Household}$	$T_{Village}$	$T_{Village.}$	$T_{Household}$	$T_{Village}$
Land use certificates issued	-0.135***	-0.099***	-0.941**	-0.095***	-0.095***	-0.598***
	(-4.13)	(-2.577)	(-2.567)	(-4.43)	(-4.292)	(-2.696)
Relative land size	-0.106***	-0.106***	-0.334**	0.041***	0.042***	0.066
	(-7.30)	(-7.245)	(-2.482)	(4.26)	(4.357)	(0.689)
Share of good quality land	0.070***	0.071***	0.283	-0.055**	-0.055**	-0.092
	(2.66)	(2.696)	(1.425)	(-2.35)	(-2.357)	(-0.465)
Number of dependents	-0.001	-0.001	0.006	0.019	0.019	0.107
	(-0.05)	(-0.104)	(0.061)	(1.57)	(1.557)	(1.314)
Number of adult male	0.008	0.008	0.076	0.027	0.026	0.154
	(0.37)	(0.366)	(0.536)	(1.52)	(1.474)	(1.299)
Number of adult female	-0.033	-0.033	-0.144	0.026	0.026	0.122
	(-1.55)	(-1.553)	(-1.010)	(1.44)	(1.440)	(1.004)
Number of oxen	0.003	0.004	0.020	-0.008	-0.008	-0.082
	(0.27)	(0.296)	(0.231)	(-0.78)	(-0.780)	(-1.028)
Value of other animals x 10^{-3} (Birr)	0.008	0.008	0.014	0.003	0.003	0.013
	(1.42)	(1.320)	(0.414)	(0.55)	(0.578)	(0.380)
Roof corrugated iron sheet	-0.020	-0.018	-0.241	0.032	0.033	0.237
	(-0.57)	(-0.534)	(-1.159)	(1.06)	(1.090)	(1.106)
Age of household head (years)	-0.016***	-0.016***	-0.008	0.010***	0.011***	0.070
	(-3.70)	(-3.689)	(-0.156)	(2.64)	(2.706)	(1.423)
Age of household head squared	0.000***	0.000***	-0.000	-0.000	-0.000	-0.000
	(2.75)	(2.755)	(-0.621)	(-1.41)	(-1.479)	(-0.731)
Female headed household	0.021	0.022	-0.308	-0.063	-0.065	-0.345
	(0.36)	(0.366)	(-0.789)	(-1.45)	(-1.512)	(-1.028)
Household head can read and write	0.013	0.010	0.022	0.020	0.019	0.119
	(0.40)	(0.307)	(0.110)	(0.66)	(0.642)	(0.626)
Year = 2002	-0.097***	-0.098***	-0.533***	-0.021	-0.021	-0.145
	(-4.95)	(-4.954)	(-4.147)	(-0.98)	(-0.979)	(-0.999)
Year = 2004	-0.252***	-0.254***	-1.591***	-0.070***	-0.070***	-0.362**
	(-13.32)	(-13.346)	(-8.271)	(-3.07)	(-3.062)	(-1.991)
Year = 2007	-0.333***	-0.346***	-2.309***	0.012	0.003	0.110
	(-15.50)	(-16.770)	(-8.873)	(0.36)	(0.085)	(0.484)
Number of observations	3042	3042	2031	3042	3042	1,658
Number of households	882	882	532	882	882	436
Log lik.	-1461.590	-1464.87	-527.30	-1502.370	-1502.92	-603.86
Chi-squared	517.886	522.775	483.713	126.407	126.719	34.718
Rho	0.070	0.071		0.047	0.041	
sigma_u	0.274	0.276		0.221	0.208	
Lik.-ratio test of rho=0	-1463.695	-1467.041		-1503.399	-1503.692	
Chibar2	4.209	4.348		2.059	1.539	

Note: The dependent variable is whether the household expects an increase or decrease in landholdings over the coming 5 years due to land redistribution and reallocation. The Chamberlain random effects (RE) specification includes the mean value of the time-varying household level variables (Chamberlain 1980), coefficients for which are not reported. A constant term is included in all the regressions. $T_{Village.}$ and $T_{Household}$ indicate that treatment is defined at the village and the household level, respectively. Absolute value of t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Impact of certification on propensity and magnitude of investment in soil & water conservation: Marginal effects

	Repairs and new investment last 12 months			Hours spent last 12 months[a]	
	Chamberlain RE probit		Cond. logit	Chamberlain RE tobit	
	$T_{Village.}$	$T_{Household}$	$T_{Village}$	$T_{Village.}$	$T_{Household}$
Land use certificates issued	0.291***	0.191***	2.345***	1.359***	0.723***
	(10.32)	(6.853)	(15.427)	(10.22)	(5.521)
Parcel size in hectares	0.061***	0.063***	0.255*	0.522***	0.519***
	(3.80)	(3.828)	(1.877)	(4.35)	(4.348)
Number of years possessed	0.000	0.000	-0.002	0.009**	0.007*
	(0.61)	(0.157)	(-0.363)	(2.34)	(1.724)
Good soil quality	-0.013	-0.016	-0.111	-0.055	-0.072
	(-1.14)	(-1.380)	(-1.062)	(-0.64)	(-0.834)
Medium soil quality	-0.013	-0.016	-0.122	-0.096	-0.098
	(-1.23)	(-1.407)	(-1.223)	(-1.17)	(-1.199)
Flat land	-0.121***	-0.134***	-0.806***	-1.009***	-1.026***
	(-5.89)	(-6.335)	(-5.575)	(-8.19)	(-8.264)
Gently sloped land	-0.023	-0.028*	-0.122	-0.217*	-0.216*
	(-1.57)	(-1.823)	(-0.836)	(-1.89)	(-1.874)
Irrigated land	0.019	0.014	0.086	0.078	0.082
	(0.83)	(0.600)	(0.455)	(0.48)	(0.501)
Total owned land in hectares	-0.062***	-0.051***		-0.355***	-0.316***
	(-7.24)	(-6.062)		(-6.89)	(-6.478)
Value of livestock x 10^{-3} (Birr)	-0.003*	-0.002		-0.013	-0.011
	(-1.91)	(-1.404)		(-1.17)	(-0.976)
Corrugated iron roof	-0.035	-0.043		-0.343*	-0.398**
	(-1.21)	(-1.433)		(-1.85)	(-2.139)
Number of dependents	0.024***	0.030***		0.244***	0.278***
	(2.60)	(3.171)		(3.75)	(4.267)
Number of adult male	0.015	0.022*		0.047	0.097
	(1.26)	(1.763)		(0.54)	(1.101)
Number of adult female	0.018*	0.033***		0.075	0.167**
	(1.66)	(2.956)		(0.95)	(2.102)
Age of household head (years)	0.007	0.006		0.044*	0.039
	(1.50)	(1.284)		(1.80)	(1.636)
Age of household head squared	-0.000***	-0.000**		-0.001***	-0.001***
	(-2.65)	(-2.535)		(-3.22)	(-3.383)
Female headed household	0.068	0.079*		0.514*	0.619**
	(1.47)	(1.657)		(1.80)	(2.131)
Head can read and write	0.010	0.012		0.047	0.107
	(0.56)	(0.606)		-0.265***	(0.817)
Year = 2007	-0.052***	-0.015	-0.708***	(-3.00)	0.029
	(-4.39)	(-1.354)	(-8.316)	8671	(0.346)
Number of observations	8671	8671	5045	856	8671
Number of households	856	856	478	-9686.428	856
Log likelihood	-3596.791	-3655.45	-1955.69	425.423	-9733.98
Chi-squared	387.139	298.990	389.623	0.588	341.367
Rho	0.647	0.621		6.923	0.564
sigma_u	1.354	1.281		7.023	6.702
Lik.-ratio test of rho=0	-4555.374	-4565.755			
$Chibar^2$	1917.167	1820.611			

Note: The Chamberlain specification includes the mean value of the time-varying household level variables (Chamberlain 1980), coefficients for which are not reported. A constant term is included in all the regressions. $T_{Village.}$ and $T_{Household}$ indicate that treatment is defined at the village and the household level, respectively. Absolute value of t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

[a]The dependent variable is log((number of hours spent on repairs and new investment last 12 months + 0.01)/0.01).

Table 8: Certification impact on rental market participation: Marginal effects from Chamberlain RE probit models

	Rented-out			Rented-in		
	$T_{Village.}$	$T_{Village.}$	$T_{Household}$	$T_{Village.}$	$T_{Village.}$	$T_{Household}$
Land use certificates issued	0.135**	0.127**	0.114**	-0.014	-0.011	-0.071*
	(2.36)	(2.38)	(1.984)	(-0.34)	(-0.24)	(-1.700)
Total owned land in hectares	0.065***	0.055***	0.057***	-0.103***	-0.091***	-0.088***
	(5.34)	(4.79)	(5.083)	(-5.89)	(-5.82)	(-5.714)
Share of good quality land	-0.013	-0.030	-0.034	-0.051	-0.053	-0.053
	(-0.32)	(-0.70)	(-0.796)	(-1.15)	(-1.19)	(-1.198)
Number of dependents	-0.005	0.002	0.002	-0.029	-0.019	-0.018
	(-0.21)	(0.08)	(0.071)	(-1.20)	(-0.80)	(-0.775)
Number of adult male	-0.029	-0.033	-0.029	-0.060*	-0.043	-0.040
	(-0.82)	(-0.90)	(-0.811)	(-1.68)	(-1.22)	(-1.134)
Number of adult female	0.006	0.021	0.022	-0.015	-0.008	-0.005
	(0.20)	(0.70)	(0.733)	(-0.48)	(-0.26)	(-0.165)
Number of oxen	-0.086***	-0.091***	-0.091***	0.075***	0.088***	0.086***
	(-3.76)	(-4.05)	(-4.061)	(3.30)	(3.83)	(3.749)
Value of other animals x 10^{-3} (Birr)	-0.002	0.004	0.004	0.011	0.008	0.009
	(-0.20)	(0.38)	(0.365)	(1.60)	(1.00)	(1.169)
Roof corrugated iron sheet	-0.055	-0.076	-0.076	0.105**	0.114**	0.116**
	(-0.85)	(-1.16)	(-1.146)	(2.11)	(2.16)	(2.218)
Age of household head (years)	-0.012*	-0.011*	-0.011*	0.004	0.007	0.007
	(-1.69)	(-1.65)	(-1.659)	(0.42)	(0.86)	(0.831)
Age of household head squared	0.000*	0.000*	0.000*	0.000	-0.000	-0.000
	(1.72)	(1.67)	(1.711)	(0.02)	(-0.52)	(-0.492)
Female headed household	0.143	0.226**	0.231**	-0.149**	-0.177***	-0.175***
	(1.39)	(2.19)	(2.243)	(-2.54)	(-2.62)	(-2.578)
Household head can read and write	0.082	0.090	0.093	0.019	0.038	0.042
	(1.42)	(1.55)	(1.586)	(0.37)	(0.73)	(0.799)
Initial year participation as landlord		0.124***	0.123***			
		(2.84)	(2.813)			
Lagged participation as landlord		0.331***	0.330***			
		(7.48)	(7.466)			
Initial year participation as tenant					0.174***	0.175***
					(5.29)	(5.335)
Lagged participation as tenant					0.273***	0.279***
					(7.45)	(7.585)
Year = 2007	0.067**	0.032	0.043	0.164***	0.171***	0.184***
	(2.08)	(0.89)	(1.256)	(4.77)	(4.66)	(5.121)
Number of observations	1424	1302	1302	1424	1302	1302
Number of households	736	657	657	736	657	657
Log lik.	-553.486	-462.047	-463.05	-645.492	-553.622	-552.40
Chi-squared	213.926	408.790	407.158	157.204	348.470	348.577
Rho	0.425	0.038	0.038	0.502	0.038	0.039
sigma_u	0.859	0.199	0.199	1.003	0.200	0.201
Lik.-ratio test of rho=0	-567.517	-461.536	-462.532	-668.248	-553.266	-552.082
Chibar2	28.061	1.021	1.045	45.511	0.711	0.645

Note: The Chamberlain specification includes the mean value of the time-varying household level variables (Chamberlain 1980), but not reported. A constant term is included in all the regressions. $T_{Village.}$ and $T_{Household}$ indicate that treatment is defined at the village and the household level, respectively. Absolute value of t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9: Certification impact on size of land rented: marginal effects from Chamberlain RE tobit models

	Land rented-out			Land rented-in		
	$T_{Village.}$	$T_{Village.}$	$T_{Household}$	$T_{Village.}$	$T_{Village.}$	$T_{Household}$
Land use certificates issued	0.089***	0.092***	0.102***	0.007	0.020	-0.012
	(2.78)	(2.83)	(2.864)	(0.28)	(0.75)	(-0.451)
Total owned land in hectares	0.087***	0.075***	0.076***	-0.061***	-0.051***	-0.049***
	(11.14)	(9.61)	(9.925)	(-6.49)	(-5.47)	(-5.318)
Share of good quality land	0.015	-0.001	-0.004	0.007	0.006	0.005
	(0.56)	(-0.04)	(-0.134)	(0.30)	(0.24)	(0.215)
Number of dependents	-0.001	-0.003	-0.003	-0.014	-0.018	-0.017
	(-0.05)	(-0.18)	(-0.207)	(-0.98)	(-1.27)	(-1.221)
Number of adult male	-0.017	-0.028	-0.027	-0.041**	-0.039*	-0.038*
	(-0.76)	(-1.24)	(-1.192)	(-1.99)	(-1.87)	(-1.833)
Number of adult female	0.008	0.017	0.016	-0.004	-0.003	-0.001
	(0.42)	(0.84)	(0.814)	(-0.19)	(-0.16)	(-0.065)
Number of oxen	-0.098***	-0.099***	-0.098***	0.041***	0.042***	0.041***
	(-6.46)	(-6.49)	(-6.479)	(3.23)	(3.22)	(3.157)
Value of other animals x 10^{-3} (Birr)	-0.003	0.004	0.003	0.009**	0.006	0.007
	(-0.47)	(0.55)	(0.517)	(2.09)	(1.37)	(1.495)
Roof corrugated iron sheet	-0.053	-0.060	-0.060	0.063*	0.073**	0.075**
	(-1.36)	(-1.49)	(-1.499)	(1.83)	(2.18)	(2.246)
Age of household head (years)	-0.009**	-0.008*	-0.007*	0.001	0.002	0.002
	(-2.28)	(-1.79)	(-1.776)	(0.24)	(0.48)	(0.446)
Age of household head squared	0.000**	0.000**	0.000**	0.000	-0.000	-0.000
	(2.31)	(1.99)	(2.029)	(0.34)	(-0.05)	(-0.017)
Female headed household	0.076	0.095*	0.101*	-0.120**	-0.123**	-0.119**
	(1.41)	(1.67)	(1.771)	(-2.37)	(-2.48)	(-2.392)
Household head can read and write	0.063*	0.088**	0.089**	0.003	0.016	0.018
	(1.70)	(2.27)	(2.292)	(0.09)	(0.51)	(0.579)
Initial value of rented-out land in ha		0.035	0.032			
		(1.58)	(1.461)			
Lag of rented-out land in hectares		0.079***	0.078***			
		(3.36)	(3.327)			
Initial value of rented-in land in ha					0.112***	0.110***
					(6.34)	(6.285)
Lag of rented-in land in hectares					0.137***	0.139***
					(8.38)	(8.470)
Year = 2007	0.047**	0.040*	0.044**	0.083***	0.077***	0.086***
	(2.35)	(1.85)	(2.111)	(4.15)	(3.51)	(4.004)
Number of observations	1424	1302	1302	1424	1302	1302
Number of households	736	657	657	736	657	657
Log lik.	-958.803	-818.433	-818.23	-987.544	-863.260	-863.45
Chi-squared	525.993	538.083	540.750	329.679	442.058	440.150
Rho	0.326	0.198	0.197	0.289	0.000	0.000
sigma_u	0.605	0.453	0.451	0.506	0.000	0.000

Note: The Chamberlain specification includes the mean value of the time-varying household level variables (Chamberlain 1980), but not reported. A constant term is included in all the regressions. $T_{Village.}$ and $T_{Household}$ indicate that treatment is defined at the village and the household level, respectively. Absolute value of t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix table 1: Determinants of value of crop output: household fixed effect estimates

	Value of crop output (log)
Plot has soil and water conservation structures	0.091***
	(5.60)
Plot size (hectares)	0.276***
	(23.56)
Male adult labor (days)	0.334***
	(21.84)
Female adult labor (days)	-0.001
	(0.09)
Hired labor (days)	0.023
	(1.16)
Oxen (days)	0.128***
	(10.96)
Chemical fertilizer (kg)	0.155***
	(14.54)
Manure (kg)	0.027**
	(2.27)
Dummy female family labor[a]	-0.011
	(0.31)
Dummy hired labor[a]	-0.087**
	(2.33)
Dummy chemical fertilizer[a]	0.125***
	(3.40)
Dummy manure[a]	0.213***
	(2.92)
Number of year possessed	-0.000
	(0.02)
Good soil quality	0.185***
	(9.55)
Medium soil quality	0.110***
	(6.12)
Flat land	0.031
	(0.97)
Gently sloped land	0.055*
	(1.70)
Irrigated land	0.138***
	(3.47)
Year = 2002	-0.884***
	(42.02)
Year = 2004	0.383***
	(18.25)
Year = 2007	0.671***
	(32.09)
Constant	4.259***
	(40.46)
Number of observations	11689
Number of households	844
R^2	0.554

Note: Absolute value of t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.
[a]The value of the dummy is 1 if the input is not used, and the value is 0 if the input is used. All inputs are in logs.

Appendix table 2: Test of parallel trend assumption using pre-treatment data for perceived tenure security and rental market participation: Marginal effects from Chamberlain specification

	Probit				Tobit	
	Expect an increase	**Expect a decrease**	**Rented-out**	**Rented-in**	**Rented-out**	**Rented-in**
Total owned land in hectares	-0.123***	0.039***	0.027***	-0.062***	0.050***	-0.015
	(-6.257)	(3.247)	(2.731)	(-3.517)	(5.635)	(-1.535)
Share of good quality land	0.088**	-0.079***	-0.025	0.013	0.003	0.017
	(2.326)	(-2.653)	(-1.002)	(0.343)	(0.154)	(0.881)
Number of dependents	-0.027	0.006	-0.017	0.030*	-0.017	0.018*
	(-1.364)	(0.383)	(-1.367)	(1.681)	(-1.549)	(1.869)
Number of adult male	-0.028	0.016	-0.014	0.021	-0.026	0.003
	(-0.882)	(0.671)	(-0.709)	(0.743)	(-1.450)	(0.184)
Number of adult female	-0.075**	0.006	-0.017	0.020	-0.021	0.008
	(-2.409)	(0.258)	(-0.971)	(0.691)	(-1.325)	(0.484)
Number of oxen	0.015	-0.012	-0.048***	0.050***	-0.061***	0.011
	(0.904)	(-0.952)	(-3.866)	(3.216)	(-5.269)	(1.540)
Value of other animals x 10^{-3} (Birr)	-0.001	0.005	-0.007	0.000	-0.007	0.003
	(-0.102)	(0.731)	(-0.778)	(0.031)	(-0.792)	(0.551)
Roof corrugated iron sheet	-0.065	0.048	0.015	0.085***	0.005	0.044***
	(-1.390)	(1.333)	(0.720)	(2.784)	(0.267)	(2.602)
Age of household head (years)	-0.019***	0.014***	-0.000	-0.011	-0.003	-0.007*
	(-2.997)	(2.796)	(-0.001)	(-1.644)	(-0.994)	(-1.890)
Age of household head squared	0.000**	-0.000**	0.000	0.000	0.000	0.000
	(2.283)	(-2.342)	(0.105)	(0.799)	(1.405)	(1.246)
Female headed household	-0.056	-0.109**	0.218**	-0.094	0.082*	-0.049
	(-0.712)	(-2.266)	(2.525)	(-1.429)	(1.816)	(-1.125)
Household head can read and write	0.038	0.017	0.016	0.015	0.014	0.005
	(0.816)	(0.469)	(0.552)	(0.364)	(0.500)	(0.242)
Treated, Year=2000	0.690***	-0.286***	-0.050	0.323	-0.069	0.130
	(18.287)	(-16.947)	(-0.842)	(1.612)	(-1.073)	(1.386)
Treated, Year=2002	0.624***	-0.284***	-0.068	0.043	-0.074	0.033
	(10.324)	(-16.675)	(-1.416)	(0.278)	(-1.159)	(0.434)
Treated, Year=2004	0.588***	-0.290***	0.008	0.135	0.024	0.079
	(8.197)	(-17.182)	(0.088)	(0.763)	(0.307)	(0.951)
Control, Year=2000	0.733***	-0.384***	-0.072	0.193	-0.087	0.111
	(13.002)	(-11.755)	(-1.213)	(1.073)	(-1.357)	(1.282)
Control, Year=2002	0.692***	-0.396***	-0.098**	0.057	-0.100	0.044
	(10.456)	(-12.356)	(-1.986)	(0.366)	(-1.615)	(0.574)
Control, Year=2004	0.532***	-0.408***	-0.049	-0.029	-0.053	0.000
	(5.331)	(-12.457)	(-0.730)	(-0.215)	(-0.796)	(0.003)
Number of observations	2,096	2,096	2,095	2,095	2,095	2,095
Number of households	742	742	741	741	741	741
Log-Likelihood	-1211.42	-986.98	-737.32	-997.41	-1,164.72	-1,406.77
Chi-squared	373.088	656.293	303.506	296.983	545.533	353.759
rho	0.112	0.038	0.407	0.426	0.165	0.233
sigma_u	0.355	0.198	0.829	0.862	0.438	0.414
Lik.-ratio test of rho=0	-1210.942	-1023.220	-761.404	-1,041.222		
Chibar2	0.959	72.484	48.176	87.633		
Test of parallel trends 2000 & 2002	2.64	1.69	0.11	3.92*	0.08	0.67
Prob > Chi2	0.10	0.19	0.74	0.05	0.78	0.41
Test of parallel trends 2000, 2002, 2004	7.95**	1.78	1.07	9.55***	3.49	8.55***
Prob > Chi2	0.02	0.41	0.58	0.01	0.17	0.01

Note: The dependent variables are as defined in tables 6, 8 and 9. All the specifications include the mean value of the time-varying household level variables (Chamberlain 1980), coefficients for which are not reported. Absolute value of t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

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