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The Role of Land Certification in Reducing Gaps in Productivity between Male and Female Owned Farms in Rural Ethiopia[1]

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1. Introduction

Formalizing land rights in most of the developing world has been advanced as a way of ensuring tenure security for landholders. Such rights could confer particular advantages to women in terms of increasing their status as farmers both within the household and in the community (e.g., Gebru, 2011; Lastaria-Cornhiel et al., 2003). However, formalized land rights may largely take a patrilineal shape, with poor and vulnerable household groups, particularly women, losing out in the process (Plateau, 2000; Besley and Burgess, 2000; Deininger et al., 2003).

In light of this, donor and implementing development agencies, which have been supporting efforts to formalize land rights since the 1980s, adopted the view that explicit recognition of women's rights and their active participation in designing and implementing land policy had to become integral features of future designs (USAID, 2010; Lastaria-Cornhiel, 2005). The Ethiopian land certification program could be considered such an attempt to explicitly incorporate women's land rights. The program's emphasis on gender equity is highlighted by the issuance of certificates in the name of both spouses, and inclusion of at least one female member in the local land administration committees (Deininger et al., 2008a).

Features of the land certification program have been previously assessed in relation to several economic variables of interest (e.g., Holden et al., 2009; Deininger et al., 2011). Among studies that focus on female-headed households, Holden et al. (2011) show that the land certification program in the Tigray Region in Ethiopia enhanced their participation in the land rental market. In addition, Holden and Ghebru (2013) find a significant positive effect of certification on food security and nutrition of female-headed households. However, these previous studies do not extend to analyzing the productivity-enhancing effects of the program for women, crucially through direct impacts of increased tenure security and through the efficiency-enhancing effects of land markets. Indeed, as pointed out by Deininger et al. (2011), analyzing the effect of land certification on the productivity of female farmers may contribute to important insights about the impacts of the program. Accordingly, the major contribution of this paper is that we address the gaps in these studies by explicitly assessing features of the Ethiopian land certification program with respect to the productivity of female-headed households in the Amhara region.

From the perspective of the broader literature, the role of tenure security in enhancing investment and improving the allocative efficiency of the land market, and thus increasing land productivity, is well established[1]. Based on this, the central premise of our paper is that gains in tenure security, particularly through the land rental market, are expected to enhance the productivity of the land owned by women. In this respect, the novel contribution of this study is to extend the literature on the relationships between enhanced tenure security and improved land rental markets to quantify the gains in productivity of land owned by women[2]. The conceptual framework in the next section presents the mechanisms by which underlying tenure insecurity plays a role in determining the performance of land productivity owned by women. Specifically it discusses how enhanced tenure security, through the certification program, could translate into gains in productivity, by focusing on female-headed households in Ethiopia.

In section 2, a literature review and general hypotheses of the paper are presented. Section 3 gives a brief background on Ethiopian land policy, women's land rights, and the certification program. The survey strategy and data are discussed in section 4, while the estimation methodology is provided in section 5. Section 6 presents the empirical findings and section 7 concludes.

2. **The certification program, participation in the land rental market, and the productivity of female-owned land: a conceptual framework**

Tenure insecurity of female-headed households might stem from formal barriers associated with limited land access though land allocation by communities and inheritance from families (Kevane and Gray, 1999; Agarwal, 1994). It might also source from informal barriers, where women's ability to exercise their rights may be limited by lack of effective control over the land, lack of legal knowledge, customary laws overruling constitutional rights, weak implementation of laws, lack of physical capacity and financial problems (Deininger et al., 2008b; Teklu, 2005; Quisumbing and Pandolefelli, 2010; Lastarria-Cornhiel et al., 2003; Dey, 1981; Yngstrom; 2002). Taken together, women's weak position as land holders makes them inherently more tenure insecure than their male counterparts.

The land certification program in Ethiopia is primarily expected to increase tenure security for all households. Given that women's pre-program tenure security was lower, we may expect a larger increase in tenure security for female-headed households. The major hypothesis of this paper is that increased tenure security, through land certification, contributes to increased productivity of female-owned farms. Such farms are usually comprised of several plots, some of which are rented out, while the rest are owner-operated. The mechanisms by which productivity can be enhanced for both rented out and owner-operated portions of farms owned by female-headed households are associated with some key features of female-headed households in Ethiopia, which we discuss below.

Female-headed households in rural Ethiopia are characterized by lack of assets (including animal draught power) as well as labour shortages (Holden and Bezabih, 2008; Gebru, 2011). The lack of productive labour is largely attributed to taboos against women undertaking major farming activities, such as ploughing with oxen (Gebru, 2011; Bashaw, 2005)[3]. Such prohibitions in Ethiopia contrast with the active participation of women in farming in the rest of Sub-Saharan Africa, where female members of the household (especially wives) farm and manage separate plots (e.g., Udry, 1996).

Without such complementary non-land factors of production, female-headed households are left to either heavily rely on the land rental market for production and/or to manage their land less than efficiently (Holden and Bezabih, 2008). In addition, the fact that the main agricultural activities are undertaken only by men might lead to tendencies to disregard the role of women as proper farmers (Mutimba and Bekele, 2002), undermining women's positions as farmers and landowners[4]. In line with this, compared to plots owned by male-headed households, productivity is shown to be lower on plots owned by female-headed households, both rented out and owner-operated (Holden and Bezabih, 2008; Bashaw, 2005; and Yigremew, 2001).

Land rentals may also be sub-optimal for female-headed households, through choices of tenants and enforcement of the terms of rentals. In many instances, female-headed households are persuaded to rent out land to tenants of low productivity or to relatives and in-laws[5]. Such tenants may feel entitled to prioritise working on their own plots and therefore under-provide effort on land rented from female landlords. This in turn implies that female-owned plots that are rented out may be sub-optimally managed, particularly during peak labour and oxen seasons (days), when tenants are labour constrained (Holden and Bezabih, 2008). In addition, female-headed households may engage in frequent tenant turnovers, for fear that keeping a tenant for too long on an insecure holding might weaken their tenure relative to a claim the tenant might assert; as a result, the female-headed household might forgo the gains from longer-term land rentals[6]. Similarly, owner-operated plots may also be managed sub-optimally, given the constraints to labour and oxen we discussed above.

Accordingly, we hypothesize that the gains in tenure security for women as a result of the program translate into improvement in land market participation and greater productivity for farms owned by female-headed households. Further, by ensuring women's participation in the land rental market in a fairer manner, the proportion of land rented out will be increased to an optimal level, such that efficiency in the management of the non-leased portion of their land will also increase. In sum, the land certification program has the potential to increase productivity on both rented out and owner-operated land of female-headed households.

It should be noted that we focus on the comparison of female- versus male-headed households as opposed to male and female plot owners within the household. This is because our survey data lacks detailed information on actual labour and managerial inputs for each individual plot within a farm, making meaningful comparison impossible.

Nonetheless, there are several merits to separately looking into inter-household gender-based differentials in productivity. First, female-headed households are increasingly significant as a category of households,[7] which makes comparisons between male- and female-headed households important. Second, such inter-household comparisons enable us see the benefits of increased tenure security through better resource allocation at a household level, which might not be captured in intra-household comparisons unless there is detailed information on the bargaining dynamics between genders and resource allocation within a household. One key benefit of enhanced tenure security that intra-household comparisons may not capture is land market participation, which is a decision made at a household level and which might not be captured by the observed gains in male/female operated plots within the household. Further, both the significant emphasis on land rental markets and the smaller emphasis on labour contribution are also well-suited to the Ethiopian agricultural setting and the constraints women face.

3. Ethiopian Land Policy, the Evolution of Women's Land Rights, and the Land Certification Program

Rural women in Ethiopia have historically held an inferior position in relation to men in terms of property rights. Under Ethiopia's feudalistic land tenure system, women did not own land independently, but only had access to land (use rights) as wives and as daughters (Crummy, 2000). The land reform proclamation of February 1975 that followed the overthrow of the feudalist government by a military government (the Derg) was marked by nationalizing of all rural land and granting of usufruct rights to farmers (Kebede, 2008). Per the 1975 legislation, spouses enjoyed joint ownership of the land, implying that, on paper, men and women were entitled to the same land rights. However, women's rights to land depended on marriage and were, in most cases, not registered separately (Crewett et al., 2008).

The EPRDF[8]-led government that overthrew the Derg in 1991 largely maintained the land policy of its predecessor, keeping all rural and urban land under state ownership (Gebreselassie, 2006). Significant changes included formal confirmation that land rights are to be granted to men and women, including the right to lease out land, albeit with restrictions on the share of land and limits on the lease period (Crewett et al., 2008).

Such provisions enabled women to claim land directly from the village level distribution for the last 20 years or so (Teklu, 2005). For married women, marital land tends to be her access to land, as a woman is expected to move to her husband's home after marriage. Oxen or cattle tend to be the property contributed by the women, while men mainly contribute land and a house. The head of the household manages most assets brought to marriage (Fafchamps and Quisumbing, 2005).

Stemming from this, upon divorce, the customary law indicates a woman shares all property she owned during marriage except for the land and the house (Fafchamps and Quisumbing, 2005). Further, women's claim over land could be affected because of lack of implementation of constitutional laws, biases from male-dominated institutional services, and customary laws overruling the constitutional right of women (Gebru, 2011; Teklu, 2005). In addition, most divorced women tend to be persuaded by arbitrators to enter into a sharecropping arrangement with the ex-husband (Fafchamps and Quisumbing, 2005)[9].

The Ethiopian certification program was initiated in response to widespread concerns over land tenure insecurity associated with state land ownership. The program follows the Federal Rural Land Administration Proclamation of 1997, revised in 2005, and has been implemented in the four most populous regions of the country: Tigray, Amhara, Oromiya, and the Southern Nations and Nationalities (SNNR) (Adenew and Abdi, 2005).

The focus of the empirical analysis in this paper is on the Amhara National Regional State (ANRS), in which the program commenced in 2004. The overarching responsibility for implementation of the land registration process and the development of a Land Administration System in the Amhara Region lies within the Environmental Protection, Land Administration & Use Authority (EPLAUA) (Adinew and Dadi, 2005). The process of land registration starts with an awareness meeting between the woreda and kebele[10] administration and farmers about the purpose and organization of land registration and certification (Palm, 2010). The discussions are followed by the election of Land Administration and Use Committees (LACs), along with provision of training for the elected LAC members. This is a local consultation process in which most of the input for adjudication and demarcation of land is provided by the local community (Adinew and Dadi, 2005). The neighbourhood farm households, jointly with LAC members, walk the farm fields in order to identify the individual household plots and plot borders, with neighbours as witnesses, prior to entering this information into forms. Responsibility for approving the legal status of the holding is held by the woreda EPLAUA head together with the LAC chairperson. The actual evidence of registration is issued in two stages: temporary paper evidence, followed by the Book of Holdings (Olsson and Magnérus, 2007).

4. Survey strategy and data

The data used for the empirical analysis is taken from the Sustainable Land Management Survey, conducted in the 14 kebeles and five different woredas selected from the zones of East Gojjam and South Wollo of the Amhara National Regional State in 2005 and 2007[11]. Each of the survey rounds consists of 1,500 randomly selected households and over 7,500 plots. About half of the sampled kebeles in each zone received certification at least 14 months before the beginning of the survey in 2007.

4.1. The choice of control and treatment kebeles and construction of the certification variable

As discussed in section 3, the certification program was designed with the intention that all woredas (and kebeles) within the region would be reached simultaneously. However, due to shortages in financial and manpower resources at both kebele and woreda levels, a campaign style gradual roll-out was adopted. The process was typically initiated in the slack agricultural seasons owing to the availability of the famers for interviews and the conduciveness of the dry-weather roads for field work by the officials. The officials prepared and completed the certificates for distribution during the peak agricultural season. The discontinuity created by agricultural seasonality and road conditions along with the campaign-style roll-out creates a time gap in the implementation in the different woredas. Accordingly, the kebeles, and households within kebeles in which the program was implemented at least 14 months prior to the survey in 2007, are taken as the treatment group and the rest of the kebeles in our sample as the comparison group[12].

Because our analysis focuses on certification and female-headed households, we present descriptive statistics for the key variables by gender of the household head and certification status of the kebele, respectively.[13] One key issue in the descriptive statistics is the significant difference between treatment and control kebeles with respect to land size, plot fertility, and oxen and livestock ownership. Such observable biases rule out direct comparison between treatment and control groups to identify the impact of certification. However, the mechanisms that enable identification of the impact of the program on productivity under such circumstances are discussed in Section 5.

4.3. Characteristics of Female-headed Households and Land Market Participation

As can be seen in Table 1, 16 percent of our sample households have a female head[14]. Of these, 87 percent have a head of household who is illiterate. The corresponding share of male-headed households is 49 percent. Female-headed households, further, have less access to male labour, have smaller landholdings and own substantially less livestock and oxen than do male-headed households. However, there does not seem to be gender-based discrepancy in terms of soil fertility or plot slope. About 20 percent of the households have experienced land-related conflict, while about seven percent have experienced land loss (mainly through redistribution and at times through settlement of conflict). With respect to perceived tenure, about 22 percent of male-headed households expect an increase in future holdings, compared to a slightly lower percentage (19%) for female-headed households. Similarly, the percentage of male-headed households who expect a decrease in their holdings is about 31 percent, compared to 35 percent of female-headed households who expect a decrease in holdings.[15]

<<Table 1 about here>>

About 10 percent of the surveyed households engage in renting out land. Of these, 93 percent are sharecropped and 7 percent rented under fixed rent contracts[16]. Among households renting out land, female-headed and households with illiterate heads are overrepresented (among households with female heads, 32 percent rent out part of their land). Households that rent out land are further characterized by having fewer male adults in the household and owning less oxen and livestock. Finally, land rented out is characterized by lower fertility than owner-operated land. Because females to some extent are prevented from farming the land, and because households with fewer male adults and oxen have limited ability to farm their land effectively, we may thus expect that these households have incentives to rent out land to less resource-constrained households.

<<Table 2 about here>>

5. Empirical Approach and Estimation Methodology

Accurate identification of the impact of a project would require that participants and nonparticipants have the same ex-ante chance of participating in the program. This implies that observed or unobserved attributes prior to the introduction of the program have no impact on the likelihood of actual participation. Ideally, treated and control groups would be identical in every respect other than the intervention itself and quantifying the project impact would only require computing the difference between the average of the outcome variable in the treatment and control groups. However, as such instances are rare in real-world settings, a study evaluating impact must address selection bias stemming from inadequate controls for observable heterogeneity plus bias stemming from unobservable factors (Ravallion, 2007).

Accordingly, three sources of potential bias could be addressed using the following three methods. The propensity score matching method enables controlling for observed biases, such as the difference in the characteristics of certified and non-certified households that we noted in our data. The unobservable biases associated with confounding factors that are not observed in the data are accounted for by the difference-in-difference method. In addition, the common trend assumption tests are used to test for the presence of trend-based unobservables. The formulations of the propensity score matching and test of common trends assumptions, along with the corresponding estimation results, are presented in Appendix B.

5.1. The Difference-in-Difference approach

This approach compares the change in land productivity of certified kebeles (treatment group) with the corresponding change in non-certified kebeles (control group). By accounting for both observed and unobserved differences between the control and treatment groups (Wooldridge, 2002), the difference-in-difference method captures the causal effect of the program on plot-level productivity.

5.1.1 Productivity Analysis with Certification

Our econometric analysis of the impact of certification starts with assessing the relationships between certification and productivity on all the plots in the survey. Accordingly, the plot-level pooled productivity equation is given by:

$$\ln(y_{pit}) = \alpha + \lambda_t + \delta\tau_t + \vartheta c_v + \phi\tau_t c_v + \gamma g_i + \theta g_i c_v \tau + \varpi S_{it} + \mu X_{pit} + w_i + u_{pit} \quad (1)$$

where, for kebele *v*, household *i*, plot *p*, and year *t*, $\ln(y_{pit})$ is the log of the value of output per hectare; τ_t is a year dummy for 2007 (after certification); and c_v is a dummy variable identifying whether the plot is located in a treatment or control village. The coefficient on the interaction variable $\tau_t c_v$ thus corresponds to the effect of certification. We will henceforth refer to this variable as post-treatment. While g_{it} represents the gender (female-headed household) dummy, S_{it} represents observable socioeconomic characteristics, excluding gender, and X_{pit} is a vector of observable physical plot characteristics. Finally, w_i represents unobservable time-invariant household characteristics and u_{pit} denotes the remainder disturbance that can vary over time as well as across households. In order to analyze the specific impacts of certification on our group of interest, female-headed households, and the relationship between certification and participation in the land market, we also run separate regressions for plots owned by female-headed households and rented out plots.

Because it may be presumed that the observed covariates are correlated with the unobserved individual effects, and because we want to keep time-invariant variables such as gender visible, our estimation procedure involves the pseudo-fixed effects estimation approach (Wooldridge, 2002). The approach involves explicitly modeling the relationship between time-varying regressors and the unobservable effect in an auxiliary regression (Mundlak, 1978). In particular, w_i can be approximated by its linear projection onto the observed explanatory variables:

$$w_i = \omega Z_{it} + r_i \qquad (3)$$

where r_i represents the random error term and Z_{it} is a vector of all the time-varying regressors in equation (2). Averaging over t for a given observational unit i and substituting the resulting expression into equation (1) gives:

$$\ln(y_{pit}) = \alpha + \lambda_t + \delta\tau_t + \vartheta c_v + \phi\tau_t c_v + \gamma g_i + \theta g_i c_v \tau + \varpi S_{it+}\mu X_{pit} + \omega \bar{Z}_{it} + v_{pit} \qquad (4)$$

where $v_{pit} = r_i + u_{it}$.

5.1.2 Analysis of the impact of certification on rented out and owner-operated plots

The decision to rent out a portion of all the plots held by the household and to operate on the rest of the plots is likely to be non-random if rented out plots have systematically different characteristics from self-managed plots. In particular, unobserved variables may influence both the decision to rent out and productivity, resulting in inconsistent estimates of the effect on productivity of renting out. In such instances, an appropriate model of analysis is the endogenous switching regression model (Maddala, 1983), a system of equations consisting of the rent-out equation and productivity regimes for the rented out and owner-operated categories.

Because our estimation deals with selection bias and unobserved heterogeneity simultaneously, individual additive effects of both sources of estimation bias may be correlated with each other. Accordingly, Wooldridge (1995), as well as Dustmann and

Rochina-Barrachina (2007), suggest obtaining inverse Mill's ratios for each time period in the selection equation and using the resulting inverse Mill's ratios in the succeeding productivity equations.

Equation (4) represents the plot selection, while equations (5) and (6) represent owner-operated and rented out plots. In order to ensure identification of the decision to rent out land, in addition to the set of standard control variables, two variables that are not included in the productivity regressions are included: experience of past land-related conflict and experience of losses in land holdings, as represented by $Conflict$ and $Loss$ in equation (4) below[17].

The decision to rent out a plot as represented by equation (5):

$$L_{pit} = \begin{cases} 1 \; if \; \alpha + \lambda_t + \delta\tau_t + \vartheta c_v + \phi\tau_t c_v + \gamma g_i + \theta g_i c_v + \varpi S_{it} + \varrho Conflict + \varsigma Loss + \mu X_{pit} + \beta \bar{R}_{it} + \omega \bar{Z}_{it} + \\ 0 \; otherwise \end{cases}$$

where L_{pit} is an indicator variable equal to 1 if the plot is leased out and zero otherwise. A similar specification as (3) applies to owner-operated and rented out plots, as given in equations (6) and (7), respectively:

$$\ln\left(y_{pit}\right)^{N} = \alpha + \lambda_t + \delta\tau_t + \vartheta c_v + \phi\tau_t c_v + \gamma g_i + \theta g_i c_v + \varpi S_{it} + \mu X_{pit} + \phi imr_{it} + \omega \overline{Z}_{it} + v_{pit} \quad (6)$$

$$\ln\left(y_{pit}\right)^{R} = \alpha + \lambda_t + \delta\tau_t + \vartheta c_v + \phi\tau_t c_v + \gamma g_i + \theta g_i c_v + \varpi S_{it} + \mu \widetilde{X}_{pit} + \phi imr_{it} + \omega \overline{Z}_{it} + v_{pit} \quad (7)$$

where the superscripts N and R represent owner-operated and rented-out plots, respectively. The variable *imr* stands for the inverse Mill's ratio from the plot rent equation.

6. Results and Discussion

In this section, we present the results of our empirical analysis. We start with an analysis of the impact of certification on productivity, on the whole sample and on a female-headed household-only sample. We then proceed with an analysis of the effect of certification on the choice to rent out plots and the conditional effect on productivity. In the main text, we present the results of our estimations. Results in elasticity form are available in Appendix C.

6.2 Determinants of productivity: the impact of certification

Table 3 presents the estimation results of the difference-in-difference analysis which considers the effects on productivity on i) all plots in the pooled sample, ii) rented-out plots and iii) female-owned plots. As can be seen in Table 3, our empirical analysis suggests that treated kebeles have significantly higher productivity, ceteris paribus. Our estimations further produce a significant coefficient on the post-treatment variable in the regression based on the female-headed household sample, and on the interaction variable between post-treatment and female head in the pooled sample. These results suggest that land certification had a positive and significant effect on productivity, and that the effect is relatively robust. In addition, our results suggest that the effect of certification is positive and significantly stronger for female-headed households. In other words, land certification seems be associated with a significant increase in productivity in general and on farms belonging to female heads in particular[18].

The effect of certification on productivity on rented out plots is insignificant, although we find that rented out plots have significantly higher productivity, thus suggesting that the rental market may contribute to greater efficiency. This lack of effect on productivity on rented out plots is interesting, since the increase in tenure security derived from land certification is expected to enhance the functioning of land rental markets, leading to gains in increased efficiency. How these gains in efficiency actually turn into overall farm-level productivity and specifically into productivity on own-managed plots is explored further in section 6.3.

<< Table 3 about here >>

Regarding the results for the remaining covariates, plots belonging to female-headed households display consistently and significantly lower productivity than plots belonging to households with male heads. This is in line with previous findings (see section 1). We further find a significant and negative effect of the age of the household head on plot productivity. This effect is, however, very small and not present if we restrict our sample to plots belonging to female-headed households. The differences in results between the pooled and female-headed sample, and particularly the insignificance in the latter, may be the consequence of a smaller sample size. It is worth noting that size and sign of the coefficients may be the consequence of a non-linear relationship between age of household head and productivity. We may, for example, expect that very young *and* very old household heads have less control and make poorer production-related decisions. If this is the case, the relation between age and productivity corresponds to an "inverted U" rather than a straight line.

Turning to total landholdings, we find that larger farm size is associated with lower productivity per hectare, and that the effect is relatively large. This result may be caused by, e.g., a correlation between the size of the landholdings and soil fertility, and/or a higher intensity in the use of productivity inputs on smaller plots (Carter, 1984). The relatively large negative effect may thus point to low input intensity and constraints to input use. The number of livestock, measured in tropical livestock units and commonly used as a measure of wealth, is a positive and significant determinant of productivity. This is in line with the expectation that wealthier households have better physical and human resources that complement land productivity. The results also show that the number of oxen present on the farm is a significant determinant of plot productivity. This is indicative of the crucial role of oxen as a source of draught power. It is also in line with the anecdotal evidence regarding the overall scarcity of this resource, given the considerable cost of acquiring a pair of oxen.

However, we also find that very few of the soil characteristics available in the dataset have an impact on productivity. We have information on soil colour (red, black and other colour), plot slope (flat, medium steep and steep) and a measure of fertility (fertile, medium fertile and non-fertile soil) as reported by the respondent. As expected, our results suggest a positive correlation between fertile (*lem*) soil and productivity, but the effect is relatively small and only significant at the 10 percent level. None of the other soil characteristics display a significant correlation with plot productivity.

Finally, we find no significant correlation between tenant characteristics and plot productivity. We have information regarding the age of the tenant, the number of oxen owned and whether the tenant owns land in addition to the land that he rents from the landlord.

6.3. The impact of certification on the decision to rent out land and the productivity of owner-operated and rented out plots.

Table 4 presents the results of the switching regressions. As in Table 3, column 1 contains the results of a panel data probit regression of the covariates on the decision to rent out land, while column 2 presents the effects on productivity on rented out plots, corrected for selection into renting out, and column 3 displays the effects on productivity on self-managed plots, corrected for selection into renting out.

<< Table 4 about here >>

Our analysis suggests a positive and significant effect of land certification on the decision to rent out a plot. The results also show that women are significantly more likely to rent out land. However, we do not find that the effect of certification is significantly stronger for plots belonging to female-headed households. In addition, conditional on the decision to rent out land, and corrected for potential selection bias, we do not find a significant relationship between certification and productivity on rented out plots. While the not-so-strong links between the productivity of rented out land and certification appear surprising, this can be explained by the corresponding results for owner-operated plots and certification.

As discussed in section 1 and 2, the observed positive effect of certification on the productivity of self-managed plots may come from two sources. First, if land certification reduces the fear of land redistribution by the government or land grabbing by tenants, it may increase incentives for farm households to undertake short- and long-term investments on the land. This, in turn, is likely to increase productivity on plots operated by the landowners themselves (owner-operated plots). Second, if households have insufficient access to labour and draught power to farm their land efficiently, and if certification has made it safer or at least easier to rent out land, we may expect that certification has also made the self-managed land size more optimal in relation to inputs available to the household. In other words, certification may have led to a more optimal level of renting out, so that the land area actually operated by the farm household is balanced to the non-tradable, non-land factor endowments such as labour and oxen available to the household.

The results suggest that female-headed households are significantly more likely to rent out plots than are male-headed households, and that the effect is relatively large[19]. Based on the discussion in section 1 and 2, this result is expected. We do not find a significant increase in plot productivity for female-headed households relative to male-headed households due to certification (column 2 and 4). This result suggests that certification has not managed to completely close the gender gap in productivity on rented out plots. However, note that the effect of certification on female-headed household is positive and significant when certification is identified at the household level, and that having a female head is not associated with significantly lower productivity on self-managed plots. This is interesting because we found a relatively strong and negative effect of female heads in the regressions where we did not correct for selection.

At first sight, it is somewhat surprising that farm size (total landholdings) is a negative determinant of the renting out decision. Intuitively, more land combined with capital and labour scarcity should be associated with a larger tendency to rent out land. However, the result may be explained by fear of redistribution if households with large land holdings are more likely to be targets of redistribution and if renting out land signals excessive holdings.

To generate a valid corrector for selection bias, we used experience of land conflict and experience of land loss as exclusion variables in the probit regression for the decision to rent out land. The main motivation for using these variables as identifiers for the decision to rent out land is that these two variables should be related to incentives (or disincentives) to rent out land, but there is little reason to believe that they should affect productivity.

Our analysis shows that land conflict is positively associated with land market participation, while experience of land loss has a negative impact. Conflict over land could arise from either inheritance or poorly demarcated borders, while loss of land is generally associated with the land being a target of local government level redistribution.

As described above, we estimate a correction factor (the inverse Mills ratio, imr) from the selection equation for each year. As can be seen in Table 4, the coefficient on the inverse Mills ratio is positive and significant for self-managed plots, using both levels of certification[20]. This result suggests that self-managed plots have a systematically higher level of productivity than rented-out plots.

7. Conclusions

The central hypothesis tested in this paper is to what extent gender-based differences in tenure insecurity that translate into gaps in productivity are narrowed down by a security-enhancing land reform intervention, such as the Ethiopian Land certification Program.

Our results suggest that, in accordance with expectations, certification has had positive effects on productivity. Furthermore, the certification program is shown to have particularly benefitted female-headed households, indicating that it tends to relax constraints related to tenure security by a relatively greater margin than that experienced by male-headed households. Finally, we show that the increase in productivity of female-headed households partly stems from the positive impact of certification on female-headed households' tendency to participate in the land rental market. However, due to the short time lapse since the implementation of the program, we did not look into the long-term productivity effects.

It should be noted that the analysis does not go into the possible impacts of the program on crop selection and its impact on productivity. Given the multi-cropping nature of the farms, with about 40 different types of crops under consideration, going in depth into crop choice analysis might shift the focus away from analysis of gender and productivity and land certification. For the future, a more detailed analysis of crop choice and yield differences across crop types and optimal crop portfolio, in the context of gender differentials in productivity, could better illuminate our understanding of these relationships.

Pre-certificate levels of tenure insecurity may differ depending on whether land is acquired independently from the government or through inheritance from family or husband. The level and source of insecurity in the two cases, as well as their impact on land market participation, are likely to be different. Such heterogeneity is interesting from both academic and policy perspectives, and is worth investigating as a separate future research question.

Looking into intra-household gender dynamics in the context of certification would also be an interesting addition to the literature. Indeed, many have argued that, in patriarchal societies, independent or joint ownership is essential to women's access to control over land (Giovarelli and Lastarria-Cornhiel, 2004), in spite of gender-neutral laws and even gender-sensitive legislation and land programs (Deere and Leon, 2001). Accordingly, recent land reforms in developing countries increasingly emphasize joint ownership of land for husbands and wives (Holden et al., 2011). Studies assessing joint titling programs in many cases show that it has promoted better land rights for women (Lastarria-Cornhiel et al., 2003; Gebru, 2011). Analysis of joint titling in the context of Ethiopia would be even more interesting due to heterogeneity across regions, with some regions not incorporating joint certification for husband and wife.

At a more general level, an important stride has been made in survey designs incorporating gender-disaggregated data at a household level, which enabled comparison of the performance of male- and female-owned farms, as in the analysis in this paper. However, greater efforts are needed to capture the intra-household gender dynamics through collecting detailed information on gender-based plot management and decision making.

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Table 1: Key household and farm characteristics by gender of household head

	Male Mean	*Std.dev*	Female Mean	*Std.dev*
Household characteristics				
Household head				
Age	50.73	*15.23*	54.15	*15.41*
Iliiterate	0.49	*0.50*	0.87	*0.34*
N male adults in hh	2.25	*1.26*	1.31	*1.19*
N female adults in hh	1.99	*1.10*	2.11	*1.07*
Livestock (TLU)	4.89	*3.63*	2.59	*2.76*
Oxen (N)	1.92	*1.47*	0.97	*1.22*
Land area (hectar)	1.93	*1.39*	1.29	*1.04*
Household rents out land	0.10	*0.30*	0.32	*0.47*
Experience of land loss	0.07	*0.26*	0.05	*0.21*
Experience of land conflict	0.20	*0.40*	0.20	*0.40*
Expect increase in holdings	0.22	*0.41*	0.19	*0.39*
Expect decrease in holdings	0.31	*0.46*	0.35	*0.47*
Expect no change in holdings	0.32	*0.47*	0.34	*0.48*
Uncertain about changes	0.15	*0.35*	0.11	*0.31*
N obs	2675		504	
Plot characteristics				
Plot area	0.34	*0.32*	0.31	*0.25*
Fertile soil	0.48	*0.50*	0.58	*0.49*
Non-fertile soil	0.15	*0.36*	0.10	*0.31*
Flat slope	0.69	*0.46*	0.75	*0.43*
Steep slope	0.05	*0.21*	0.04	*0.20*
N obs	13378		1808	

Table 2: Characteristics of owner-operated and rented out plots

	Owner_operated plots		Rented out plots	
	Mean	*Std.dev*	Mean	*Std.dev*
Household head				
Age	56,43	*17,68*	51,09	*14,55*
Female	0,37	*0,48*	0,07	*0,25*
Illiterate	0,70	*0,46*	0,51	*0,50*
N male adults in hh	1,48	*1,12*	2,36	*1,30*
N female adults in hh	1,95	*1,12*	2,06	*1,08*
Livestock (TLU)	1,48	*2,19*	5,10	*3,37*
Oxen (N)	0,42	*0,90*	2,00	*1,34*
Land area (hectares)	1,45	*1,16*	2,12	*1,43*
Fertile land	0,43	*0,50*	0,50	*0,50*
Flat slope	0,66	*0,47*	0,66	*0,47*
N	11228		1055	

Table 3. Productivity regression estimation results

	KEBELE LEVEL CERTIFICATION			HH LEVEL CERTIFICATION		
	Pooled	Rented out plots	Female head	Pooled	Rented out plots	Female head
Hh i treated village	**0.495*** **	0.000	-0.034	-0.039	0.136	0.008
	(0.070)	(0.345)	(0.142)	(0.043)	(0.200)	(0.107)
Post treatment	**0.180*** **	*-0.109*	**0.414** **	**0.118** **	*-0.154*	*0.168*
	(0.052)	(0.283)	(0.184)	(0.053)	(0.228)	(0.148)
Female head * post treatment	**0.274** **	0.272		0.092	**0.427* **	
	(0.117)	(0.295)		(0.093)	(0.223)	
Year=2007	**-0.325*** **	-0.012	**-0.240** **	**-0.301*** **	-0.009	**-0.243** **
	(0.033)	(0.160)	(0.117)	(0.033)	(0.148)	(0.108)
Household head is female	**-0.170*** **	**-0.320** **		**-0.165*** **	**-0.375*** **	
	(0.051)	(0.136)		(0.049)	(0.130)	
Age of hh head	**-0.003*** **	0.002	**-0.005* **	-0.002*	0.002	0.000
	(0.001)	(0.004)	(0.003)	(0.001)	(0.003)	(0.002)
Rented out plots	**0.200*** **		**0.294*** **	**0.224*** **		**0.222*** **
	(0.047)		(0.090)	(0.046)		(0.074)
Hh head is illiterate	0.054*	-0.075	-0.135	0.019	0.010	-0.180
	(0.032)	(0.143)	(0.155)	(0.030)	(0.124)	(0.120)
Total land holdings by hh	**-0.787*** **	**-1.041** **	-0.517	**-0.825*** **	**-0.991*** **	-0.687
	(0.135)	(0.430)	(0.443)	(0.147)	(0.367)	(0.423)
Plot size in hectares: calculated	**-1.125*** **	**-1.675*** **	**-1.246*** **	**-1.165*** **	**-1.516*** **	**-1.239*** **
	(0.060)	(0.205)	(0.175)	(0.060)	(0.172)	(0.146)
N male adults in hh	0.021	0.085	0.042	0.009	0.114	0.035
	(0.050)	(0.228)	(0.045)	(0.050)	(0.211)	(0.035)
N male adults in hh squared	0.003	0.013		0.009	-0.001	

	(0.005)	(0.028)		(0.006)	(0.027)	
N livestock per hectare	**0.046*** **	0.021		**0.006*** **	0.002	
	(0.009)	(0.048)		(0.002)	(0.042)	
N oxen per hectare	0.010	-0.007	**0.069*** **	**0.055*** **	0.064	**0.175** **
	(0.013)	(0.109)	(0.021)	(0.017)	(0.100)	(0.077)
Soil type (color) of parcel:black	0.012	0.036	-0.113	0.012	0.002	-0.025
	(0.043)	(0.156)	(0.127)	(0.044)	(0.151)	(0.118)
Soil type (color) of parcel:red	0.007	0.083	0.090	-0.001	0.048	0.067
	(0.043)	(0.160)	(0.124)	(0.043)	(0.157)	(0.114)
Slope of parcel:meda	0.055	0.083	0.003	0.078*	0.086	-0.001
	(0.048)	(0.315)	(0.164)	(0.045)	(0.302)	(0.134)
Slope of parcel:dagetama	0.045	0.113	0.015	0.051	0.139	-0.004
	(0.050)	(0.296)	(0.174)	(0.047)	(0.286)	(0.144)
Soil quality of parcel:lem	**0.070***	0.017	-0.081	**0.063***	-0.011	0.056
	(0.037)	(0.156)	(0.110)	(0.035)	(0.138)	(0.092)
Soil quality of parcel: lem-tef	0.034	0.021	-0.014	0.048	-0.092	0.110
	(0.035)	(0.142)	(0.116)	(0.033)	(0.123)	(0.090)
Tenant under 30 years old		0.459			0.413	
		(0.283)			(0.261)	
Tenant owns land		-0.082			0.027	
		(0.149)			(0.132)	
Tenant owns oxen		0.062			0.010	
		(0.053)			(0.030)	
Land rented out to relative		0.189			0.169	
		(0.161)			(0.145)	
Chamberlain- Mundlak Effects	YES	YES	YES	YES	YES	YES

Kebele fixed effects	YES	YES	YES	YES	YES	YES
Constant	**6.907*** **	**7.129*** **	**7.078*** **	**7.518*** **	**7.264*** **	**7.372*** **
	(0.100)	(0.395)	(0.305)	(0.093)	(0.461)	(0.305)
Chi2	2223.288	318.841	181.422	2058.710	342.200	506.832
N	12217	709	1261	13395	808	1618

Table 4. Switching regression estimation results

	KEBELE LEVEL CERTIFICATION			HH LEVEL CERTIFICATION		
	Decision to rent out	Rented out plots	Self managed plots	Decision to rent out	Rented out plots	Self managed plots
Hh i treated village	-0.177	-0.224	**0.476*** **	**-0.349** **	0.149	-0.073
	(0.339)	(0.397)	(0.063)	(0.169)	(0.212)	(0.054)
Post treatment	**0.274***	*-0.124*	**0.243*** **	**0.301** **	*-0.145*	**0.169** **
	(0.142)	(0.322)	(0.048)	(0.137)	(0.234)	(0.068)
Female head * post treatment	0.076	0.372	0.197	-0.129	**0.459** **	*-0.066*
	(0.231)	(0.276)	(0.133)	(0.187)	(0.226)	(0.098)
Year dummy, 2006	**-0.378*** **	*0.160*	**-0.383*** **	**-0.292*** **	0.104	**-0.361*** **
	(0.077)	(0.167)	(0.029)	(0.075)	(0.129)	(0.033)
Household head is female	**1.088*** **	**-0.704*** **	-0.089	**1.249*** **	**-0.700** **	-0.030
	(0.149)	(0.251)	(0.064)	(0.144)	(0.305)	(0.068)
Age of hh head	**0.021*** **	-0.006	**-0.002***	**0.024*** **	-0.004	-0.001
	(0.004)	(0.006)	(0.001)	(0.003)	(0.006)	(0.001)
Hh head is illiterate	-0.089	-0.017	0.034	-0.136	0.068	-0.008
	(0.106)	(0.162)	(0.025)	(0.103)	(0.126)	(0.027)
Total land holdings by hh 10 ha	**-3.241*** **	-0.040	**-0.728*** **	**-3.020*** **	-0.290	**-0.801*** **
	(0.397)	(0.790)	(0.150)	(0.362)	(0.628)	(0.188)
Plot size in hectars: calculated	**0.503*** **	**-1.845*** **	**-1.123*** **	**0.487*** **	**-1.606*** **	**-1.161*** **
	(0.099)	(0.230)	(0.062)	(0.095)	(0.177)	(0.064)
N male adults in hh	**-0.351** **	0.200	-0.020	**-0.399*** **	0.194	-0.021
	(0.148)	(0.236)	(0.055)	(0.140)	(0.176)	(0.044)
N male adults in hh squared	**0.052** **	-0.005	**0.010***	**0.052** **	-0.014	**0.016*** **
	(0.023)	(0.036)	(0.005)	(0.022)	(0.031)	(0.006)

N livestock per hectare	0.005	-0.006	**0.048*** **	-0.004	-0.008	0.007
	(0.030)	(0.059)	(0.010)	(0.023)	(0.050)	(0.018)
N oxen per hectare	**-0.406*** **	0.135	0.009	**-0.383*** **	0.176	0.047
	(0.069)	(0.134)	(0.031)	(0.059)	(0.138)	(0.038)
Soil quality of parcel:lem	**-0.418*** **	0.086	0.046	**-0.376*** **	0.011	0.039
	(0.101)	(0.176)	(0.035)	(0.097)	(0.117)	(0.040)
Soil quality of parcel: lem-tef	-0.185*	0.082	0.035	**-0.165* **	-0.074	0.045
	(0.095)	(0.156)	(0.036)	(0.091)	(0.101)	(0.035)
Soil type (color) of parcel:black	-0.062	0.012	0.018	-0.001	-0.019	0.003
	(0.123)	(0.160)	(0.050)	(0.121)	(0.150)	(0.044)
Soil type (color) of parcel:red	**-0.249** **	0.135	-0.003	-0.192	0.074	-0.025
	(0.126)	(0.185)	(0.050)	(0.124)	(0.193)	(0.044)
Slope of parcel:meda	-0.088	-0.024	0.071	-0.091	0.002	0.092*
	(0.136)	(0.359)	(0.048)	(0.133)	(0.308)	(0.050)
Slope of parcel:dagetama	0.037	0.038	0.068	0.070	0.069	0.073
	(0.139)	(0.355)	(0.056)	(0.137)	(0.293)	(0.050)
Tenant under 30 years old		0.443*			0.417	
		(0.248)			(0.263)	
Tenant owns land		-0.083			0.027	
		(0.162)			(0.119)	
Tenant owns oxen		0.058			0.005	
		(0.057)			(0.033)	
Land rented out to relative		0.184			0.158	
		(0.183)			(0.157)	
Experience of land conflict	**0.296*** **			**0.301*** **		
	(0.089)			(0.085)		
Experience of land loss	**-0.431** **			**-0.358** **		

	(0.170)			(0.158)		
Inversed Mill's ratio		-2.894	**0.749***		-2.177	**1.014****
		(1.786)	(0.428)		(1.660)	(0.400)
Chamberlain- Mundlak Effects	YES	YES	YES	YES	YES	YES
Kebele fixed effects	YES	YES	YES	YES	YES	YES
Constant	-0.585	**9.057*****	**6.425*****	**-0.993*****	**8.604*****	**6.851*****
	(0.367)	(1.187)	(0.289)	(0.370)	(1.100)	(0.303)
lnsig2u						
Constant	**0.670*****			**0.686*****		
	(0.114)			(0.108)		
Adjusted_r2		0.211	0.277		0.199	0.268
Chi2	533.7427	2392.882	5165.002	572.3385	3471.459	11659.65
N	12217	709	11174	13395	808	12226

Appendix A: Characterisation of the study setting and description of the variables used in the regressions

The agricultural system in the study area is characterized as a mixed crop-livestock farming system. Crops are grown on individual farms, while livestock are herded on communal grazing lands, which are the major sources of animal feed. The cropping system itself is a multi-cropping system where a farm is divided into several plots, with each plot allotted to a single crop. The crop production system consists of cereals, pulses, legumes, oil seeds and other crops, with a given farm typically growing different crop types.

The definition of variables used in the analysis and the descriptive statistics are presented in Table A1 and Table A2, respectively. The descriptive statistics are categorized as the pooled sample and the treatment and gender categories.

<<Table A1 about here>>

<<Table A2 about here>>

Dependent variable: plot-level productivity

The major dependent variable, plot-level productivity, is measured as the crop revenue per hectare. The purpose of the conversion into revenue is to enable comparison across crops; because this is a plot-level analysis (as opposed to a farm-level analysis), no aggregation is made across crops. As expected, average productivity is significantly higher in kebeles belonging to the treatment group. The distribution of crops grown by male- and female-headed households appears to show no significant difference, as presented in Table A3.

<<Table A3about here>>

Socioeconomic characteristics

Slightly over half the respondents in the sample are illiterate. For female-headed households, this figure is much higher; about 86 percent are illiterate. While the proportion of illiterate male heads of household is significantly lower in certified than non-certified kebeles, no significant difference in literacy can be found for female-headed households between certified and non-certified kebeles. The average number of male and female adults per hectare is about 2.

Female-headed households have fewer adult male members and more adult female members. Households in certification kebeles have a significantly lower number of male adults compared to households in non-certified kebeles; in addition, male-headed households in certification kebeles own significantly more land than their counterparts in non-certification kebeles. With regard to indicators of wealth, such as number of oxen and livestock, there are no significant differences between female-headed households in certified and non-certified villages. However, male-headed households in certification villages own significantly more oxen and livestock (measured in tropical livestock units) per hectare than their counterparts in control villages. In addition, households in treatment kebeles rent out land to a slightly lesser extent than households in the control kebeles.

Physical farm characteristics

Four measures of plot characteristics are identified in our data: plot size, plot slope, soil fertility and soil colour. The average plot size is slightly higher for certified than non-certified households. On average, 69% and 77% of the plots in the certified and non-certified category are flat, with moderately steep and steep plots making up the rest. In addition to topographic features, plots are defined by their soil colour, which is also a rough representation of other features such as water retention capacity and texture. Accordingly, black soil has clayish texture with maximum water retention capacity, while reddish or brownish soil has medium texture and light-coloured soil has coarse texture (Coobels et al., 2008). A larger proportion of plots per farm have black or red soil colour in both of the certification categories.

Further assessment of soil fertility maintenance measures indicates that farmers in the study area adopt a wide range of soil and water conservation technologies. These include stone bund terrace (41%), soil bund terrace (24.5%), *fanjo* and grass planting (20%), cut-off drain, check dam construction or river diversion (19%). Farmers that did not participate in any type of conservation activity make up about 21% of the total sample.

Manure use could, to some degree, be correlated with oxen availability, although there are other farm animals that contribute to manure, such as sheep, goats and cows. From anecdotal evidence and our observations in the study area, manure is used as fertilizer on plots and also as complementary building material for walls and floors of mud buildings. It is also used for smoothing the floors of houses, which do not normally have any flooring. Animal dung accounts for 12 percent of the total energy demand of farm households (WBISPP, 2004). We do not have full information on exactly how manure is allocated into different uses; it can be argued that a good portion of it is used on farms. Manure is likely to be applied on plots that are closer to the homestead due to its bulky nature.

Tenure security measures

Our survey data consists of three alternative measures of tenure security: perception, experience of conflict and changes in the size of land holdings. The perception variable is based on the question of whether the household expects to experience increase, decrease or no change in its land holdings in the coming five years. The respondents chose between expectations of 'increase', 'decrease', 'no change' or 'do not know'. Land conflict is a dummy variable based on the question 'Have you ever faced any conflicts or claims regarding the land you own?' The experience of change in the size of holdings is related to the question of whether there were changes in the area of land under the 'ownership' of the household during the two years before the corresponding survey. The respondents answers – 'gain', 'loss', or no change –depended on their experience of changes in the size of their holdings. The 'loss' variable is a dummy variable taking the value one if the respondent answered that he/she lost land during the past two-year period. Loss includes loss of land due to village redistribution, land reallocation and family redistribution. Unlike the change in land holding, the conflict does not have a time period specified. The lack of a time frame in the conflict variable may lead to potential bias with respect to the likelihood of conflict resolution with the passage of time. The descriptive statistics further suggest that a high share of sampled households are tenure insecure: about 20 percent of the households have experienced land-related conflict. Households in certification villages are less likely to have experienced land conflict or land loss. However, there is no significant difference in land loss for female-headed households.

<<Table A1 about here>>

<<Table A2 about here>>

Appendix B: Generating comparable samples and ensuring randomness between treated and non-treated groups

Appendix B1: Generating comparable groups based on observables – PSM

In order to minimize differences between our treated and non-treated groups, in terms of observable characteristics, we conduct a propensity score matching (PSM) procedure. In order to facilitate reading, we only describe the purpose and intuition of the PSM method here (for a slightly more technical description, see Appendix 2). The main purpose of PSM is to choose a sample of households in the treatment and control groups that are as similar as possible to each other in important observed aspects. More specifically, PSM balances the observed distribution of covariates across households in the two groups[21]. Assuming that the balancing is successful, the conditional probability of participation in the program (i.e., receiving a certificate) should be equal in treatment and control groups. The difference in this conditional probability is called the 'propensity score' and is the relevant summary statistic evaluated to ensure that the samples are sufficiently balanced (Rosenbaum and Rubin 1983). The matched samples are then used for the difference-in-difference analysis.

<<Table B1 about here>>

Appendix B2: Results for the common trend assumption test

As discussed in section 5, the validity of the difference-in-difference results hinges on the assumption of common trends, i.e., the assumption that the trend in productivity would have been the same in the two groups in the absence of certification. The results from the common trends analysis are presented in *Table B2* below. The figures represent a test of the extent to which the change in the intercept (i.e., the trend) is significantly different between certified and non-certified villages in the pre-certification time period. As can be seen in the table, the test suggests that, between the years 2000 and 2002, there was indeed a significant difference in the trend between the two groups. However, for the time period 2002 and 2004, this difference is insignificant. In other words, the productivity patterns in the treatment villages seem to have been relatively parallel to those of the control villages during the pre-policy change period in the years 2002 and 2004. This finding is similar to Deininger *et al.* (2011), who, using the same data for their analysis, find similar evidence of only a slight difference in trends within their variables of interest.

Table A1: Variable description

Variable name	Variable description
Female head of hh	1 = female household head, 0 = male household head
Age of hh head	Household head's age (in years)
Household head illiterate	1 = illiterate, 0 = other
N. male adults	Number of male working-age family members in hh
N. female adults	Number of female working-age family members in hh
Oxen per hectare	Number of oxen per hectare
Livestock per hectare	Number of livestock in tropical livestock units per hectare
Landholdings (ha)	Total farm size in hectares
Fertile soil	1 = plot has highly fertile soil, 0 = other soil fertility
Medium fertile plot	1 = plot has medium fertile soil, 0 = other soil fertility
Infertile plot (reference)	1 = plot has infertile soil, 0 = other soil fertility
Black soil	1 = plot has black soil, 0 = other color of soil
Red soil	1 = plot has red soil, 0 = other color of soil
Other soil (reference)	1 = plot has grey, white or sandy soil, 0 = other color of soil
Flat slope	1 = plot has flat slope, 0 = other slope of plot
Medium slope	1 = plot has medium slope, 0 = other slope of plot
Steep slope	1 = plot has steep slope, 0 = other slope of plot
Plot size in ha	Total plot size (in hectares)
Conflict	1 = hh has experienced land-related conflict in the past 5 years, 0 = no experience of land conflict
Loss	1= hh has lost land in the past 5 years (due to, e.g., sales, conflict or redistribution), 0= no experience of land loss
Tenant is 30 years or younger	1= tenant is 30 years of age or younger 0= tenant is over 30 years of age
Tenant owns land	1= tenant owns land, 0= tenant does not own land
N oxen owned by tenant	Number of oxen owned by the tenant
Land rented out to relative	1= land is rented out to relative, 0= land is rented out to non-relative
Self-managed plots	1= plot is managed by owner 2= plot is managed by tenant (rented out)
Hh in the treated village	1 = plot/hh is located in treatment kebele 0 = plot/hh is located in control kebele
Post treatment	1= plot/hh is located in treatment kebele and time period is after certification, 0= otherwise
Value of plot output per hectare	The log of the value of output per hectare

Table A2: Descriptive Statistics of Variables Used in the Regressions for the years 2005 and 2007

	Total sample			Female headed hh			Male headed hh		
	Control villages	Certification villages	p-value of differences	Control villages	Certification villages	p-value of differences	Control villages	Certification villages	p-value of differences
Household characteristics									
N	1879	1300		273	242		1606	1058	
Female headed hh	0,145	0,186	0,001						
Age of hh head	51,458	49,396	0,000	52,766	50,798	0,100	51,236	49,076	0,000
Hh head is illiterate	0,573	0,514	0,001	0,861	0,860	0,483	0,524	0,435	0,000
No male adults	2,179	1,981	0,000	1,509	1,128	0,000	2,293	2,176	0,009
No female adults	2,047	1,964	0,018	2,231	1,946	0,001	2,016	1,968	0,140
Landholdings (ha)	1,739	1,960	0,000	1,302	1,283	0,420	1,813	2,115	0,000
Livestock per ha	3,002	4,805	0,001	2,502	5,010	0,122	3,087	4,758	0,001
Oxen per ha	1,225	1,495	0,014	0,967	1,326	0,205	1,269	1,534	0,008
Experience of land conflict	0,220	0,178	0,001	0,238	0,165	0,020	0,217	0,181	0,010
Experience of land loss	0,108	0,065	0,000	0,062	0,050	0,266	0,116	0,068	0,000
Plot-level characteristics									
N	8172	7083		892	973		7280	6110	
Ln(value of yield)	6,627	6,802	0,000	6,466	6,767	0,000	6,647	6,808	0,000
Rented out plots	0,089	0,078	0,007	0,281	0,282	0,496	0,065	0,045	0,000
Self-managed plots	0,911	0,922	0,007	0,719	0,718	0,504	0,935	0,955	0,000
Plot area	0,356	0,319	0,000	0,343	0,274	0,000	0,358	0,326	0,000
Fertile soil	0,461	0,526	0,000	0,534	0,618	0,000	0,452	0,511	0,000

medium fertile soil	0,379	0,338	0,000	0,323	0,300	0,145	0,386	0,345	0,000
Not fertile soil	0,158	0,136	0,000	0,143	0,082	0,000	0,160	0,144	0,005
other soil	0,002	0,000	0,000				0,002		0,000
Black soil	0,472	0,368	0,000	0,474	0,474	0,493	0,472	0,351	0,000
Red Soil	0,424	0,605	0,000	0,393	0,492	0,000	0,428	0,623	0,000
Other colour of soil	0,103	0,027	0,000	0,132	0,034	0,000	0,100	0,026	0,000
Slope of plot: Steep	0,065	0,027	0,000	0,070	0,070	0,000	0,065	0,028	0,000
Slope of plot: Medium	0,303	0,203	0,000	0,262	0,161	0,000	0,308	0,209	0,000
Slope of plot: Flat	0,628	0,767	0,000	0,668	0,816	0,000	0,623	0,760	0,000
Tenant characteristics									
N	293	189		108	82		185	107	
Young tenant (<30 years)	0,345	0,312	0,229	0,318	0,293	0,356	0,357	0,327	0,304
Tenant owns land	0,857	0,868	0,365	0,879	0,854	0,312	0,843	0,879	0,198
No oxen, tenant	2,150	2,958	0,000	2,140	2,817	0,006	2,168	3,065	0,000

Table B1: Propensity score matching results

Sample	Pseudo R2	LR chi2	p>chi2	MeanBias	MedBias
Kebele level certification					
Women					
Raw	0.179	67.67	0.000	21.1	16.1
Matched	0.008	1.69	1.000	2.8	3.0
Men					
Raw	0.167	303.22	0.000	14.9	12.7
Matched	0.005	5.12	0.954	2.7	2.0
Household level certification					
Raw	0.036	60.57	0.000	9.5	10.9
Matched	0.013	12.64	0.555	2.9	2.5

Table B2: Test of the Common Trends Assumption

	Kebele level certification		hh level certification	
	Chi-2	Prob>chi2	Chi-2	Prob>chi2
2000-2002	55.40	0.000	3.8	0.051
2002-2004	1.58	0.2085	0.34	0.563

Appendix C: Regression results in elasticity form

Table C1. Productivity regression estimation results: Elasticities

	KEBELE LEVEL CERTIFICATION			HH LEVEL CERTIFICATION		
	Pooled	Rented out Plots	Female headed hh	Pooled	Rented out plots	Female headed hh
Household in treated village, dummy	0.074***	0.000	0.077	-0.006	0.020	0.001
	(0.011)	(0.050)	(0.047)	(0.006)	(0.029)	(0.016)
Post treatment dummy	0.027***	-0.016	0.067**	0.018**	-0.022	0.026
	(0.008)	(0.041)	(0.028)	(0.008)	(0.033)	(0.023)
Female head dummy * post treatment dummy	0.041**	-0.002		0.014	0.062*	
	(0.018)	(0.023)		(0.014)	(0.033)	
year==19992005	-0.049***	0.040	-0.041**	-0.045***	-0.001	-0.037**
	(0.005)	(0.043)	(0.018)	(0.005)	(0.022)	(0.016)
Household head is female	-0.026***	-0.047**		-0.025***	-0.055**	
	(0.008)	(0.020)		(0.007)	(0.019)	
Age of hh head	-0.000**	0.000	-0.000	-0.000*	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Rented out plots	0.030***		0.025*	0.033***		0.034**
	(0.007)		(0.013)	(0.007)		(0.011)
Hh head is illiterate	0.008*	-0.011	-0.034*	0.003	0.001	-0.027
	(0.005)	(0.021)	(0.020)	(0.005)	(0.018)	(0.018)
Total land holdings by hh 10 ha	-0.118***	-0.152**	-0.119	-0.123***	-0.144**	-0.099
	(0.020)	(0.063)	(0.074)	(0.022)	(0.053)	(0.065)
Plot size in hectars: calculated	-0.169***	-0.245***	-0.186***	-0.174***	-0.221***	-0.188***
	(0.009)	(0.030)	(0.028)	(0.009)	(0.025)	(0.022)
Number of male adults in hh	0.003	0.012	0.011	0.001	0.017	0.005
	(0.008)	(0.033)	(0.012)	(0.007)	(0.031)	(0.011)
Number of male adults in hh squared	0.001	0.002	-0.000	0.001	-0.000	-0.000
	(0.001)	(0.004)	(0.002)	(0.001)	(0.004)	(0.002)
N livestock per hectar (tropical livestock units)	0.007***	0.003	-0.000	0.001***	0.000	0.002
	(0.001)	(0.007)	(0.004)	(0.000)	(0.006)	(0.002)
Number of oxen per hectar	0.001	-0.001	0.011**	0.008***	0.009	0.023*
	(0.002)	(0.016)	(0.005)	(0.003)	(0.015)	(0.012)
Soil characteristics		YES			YES	
Tenant landlord-relationships		YES			YES	

Table C2. Switching regression estimation results: Elasticities:

	kebele level certification		Hh level certification	
	Rented out	owner-operated	Rented out	owner-operated

	plots	Plots	plots	plots
hh i treated village	-0.033	0.072***	0.022	-0.011
	(0.058)	(0.009)	(0.031)	(0.008)
post treatment	-0.018	0.0365***	-0.021	0.025**
	(0.047)	(0.007)	(0.034)	(0.010)
Female head * post treatment	0.054	0.030	0.015	-0.054***
	(0.040)	(0.020)	(0.019)	(0.005)
ethyear==1999	0.023	-0.058***	0.067**	-0.010
	(0.024)	(0.004)	(0.033)	(0.015)
Household head is female	-0.103**	-0.013	-0.102**	-0.004
	(0.037)	(0.010)	(0.044)	(0.010)
Age of hh head	-0.001	-0.000*	-0.001	-0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Hh head is illiterate	-0.003	0.005	0.010	-0.001
	(0.024)	(0.004)	(0.018)	(0.004)
Total land holdings by hh 10 ha	-0.006	-0.109***	-0.042	-0.120***
	(0.115)	(0.023)	(0.091)	(0.028)
Plot size in hectars: calculated	-0.270***	-0.169***	-0.234***	-0.174***
	(0.033)	(0.009)	(0.026)	(0.010)
N male adults in hh	0.029	-0.003	0.028	-0.003
	(0.034)	(0.008)	(0.026)	(0.007)
N male adults in hh squared	-0.001	0.002*	-0.002	0.002**
	(0.005)	(0.001)	(0.005)	(0.001)
N livestock per hectar	-0.001	0.007***	-0.001	0.001
	(0.009)	(0.002)	(0.007)	(0.003)
N oxen per hectar	0.020	0.001	0.026	0.007
	(0.020)	(0.005)	(0.020)	(0.006)
Inverse Mill's ratio	-0.423	0.113*	-0.317	0.152**
	(0.262)	(0.064)	(0.241)	(0.060)
Soil Characteristics	YES		YES	
Tenant-landlord relationships	YES		YES	

Appendix D: Selection equations – estimation of year-specific inverse Mill's ratio

	Kebele level certification		hh level certification	
	Decision to rent out land		Decision to rent out land	
	1997	1999	1997	1999
Hh in treated village	-0.289*	0.908***	-0.142*	-0.142
	(0.173)	(0.227)	(0.077)	(0.092)
Household head is female	0.675***	0.619***	0.756***	0.758***
	(0.073)	(0.096)	(0.068)	(0.085)

Age of hh head	0.011***	0.025***	0.014***	0.024***
	(0.002)	(0.002)	(0.002)	(0.002)
Hh head is illiterate	0.047	-0.195**	-0.013	-0.187**
	(0.061)	(0.081)	(0.060)	(0.076)
Total land holdings by hh 10 ha	-3.701***	-2.729***	-3.631***	-2.411***
	(0.380)	(0.324)	(0.363)	(0.279)
Plot size in hectares: calculated	0.333***	0.546***	0.327***	0.416***
	(0.094)	(0.142)	(0.094)	(0.129)
N male adults in hh	-0.170	-0.166	-0.345***	-0.031
	(0.123)	(0.130)	(0.116)	(0.127)
N male adults in hh squared	0.017	0.041***	0.023*	0.027*
	(0.013)	(0.014)	(0.013)	(0.015)
N livestock per hectare	-0.119***	0.166***	-0.087***	0.093***
	(0.030)	(0.029)	(0.027)	(0.022)
N oxen per hectare	-0.467***	-0.503***	-0.459***	-0.450***
	(0.049)	(0.056)	(0.047)	(0.054)
Soil quality of parcel:lem	-0.175**	-0.354***	-0.169**	-0.311***
	(0.081)	(0.106)	(0.079)	(0.099)
Soil quality of parcel: lem-tef	-0.104	-0.232**	-0.082	-0.194**
	(0.076)	(0.105)	(0.074)	(0.098)
Soil type (color) of parcel:black	0.210*	-0.078	0.194*	-0.046
	(0.115)	(0.118)	(0.117)	(0.113)
Soil type (color) of parcel:red	-0.004	-0.203	-0.037	-0.174
	(0.116)	(0.123)	(0.118)	(0.117)
Slope of parcel:meda	-0.014	0.097	-0.067	0.115
	(0.117)	(0.162)	(0.115)	(0.154)
Slope of parcel:dagetama	0.073	0.006	0.022	0.031
	(0.119)	(0.169)	(0.117)	(0.161)
Experience of land conflict	0.228***	0.061	0.181***	0.084
	(0.064)	(0.081)	(0.061)	(0.074)
Experience of land loss	-0.827***	-0.053	-0.879***	0.020
	(0.161)	(0.151)	(0.162)	(0.130)
Chamberlain- Mundlak Effects	YES	YES	YES	YES
Kebele fixed effects	YES	YES	YES	YES
Constant	-0.111	-1.314***	-0.422*	-0.659**
	(0.227)	(0.300)	(0.224)	(0.266)
chi2	1529.949	937.625	1690.977	1103.189
N	6278	5939	6854	6541

[1] Secure property rights are shown to lead to enhanced investment and increased productivity (e.g., Besley, 1995; Deininger and Jin, 2006; Lanjouw and Levy, 2002; Do and Iyer, 2002; Feder 1988). Similarly, allocative efficiency of land rental markets is enhanced by increased tenure security (Otsuka, 2007; de Janvry et al., 2001; Holden et al., 2008).

[2] The focus on women is crucial given that gender gaps in agricultural productivity have been documented by many studies across the developing world (e.g., Sridhar 2008; Tikabo 2003; Agarwal 2003; Holden et al., 2001; Cook 1999; Quisumbing, 1996; Udry 1996).

[3] The exorbitant transaction costs associated with the markets for complementary non-land factors (i.e., labour and oxen) bar them from playing effective factor adjustment roles, making the land rental market a more effective factor ratio equalizing mechanism (e.g., Bliss and Stern, 1982; Eswaran and Kotwal, 1985; Skofias, 1995; Sadoulet et al., 2001).

[4] Women may also have limited access to agricultural technologies and credit markets, associated with their perceived position as farmers (Fletschner and Kenney, 2011; Umeta, 2013).

[5] This was confirmed to the authors by informal discussions with female heads of households who felt that, although they are free by law to rent land to whomever they prefer, they would be alienated by their in-laws if they rejected the tenancy arrangement. Holden and Bezabih (2008) found significantly higher levels of inefficiency linked to contracts of female landlords with in-law tenants, owing to the difficulty of evicting one's relatives and the high transaction costs of screening and selecting better tenants.

[6] In line with this, Bellemare (2010) argue that, when choosing the terms of contract, the landlord considers the impact of his/her choice on the probability that he/she will retain future rights to the rented land. On the tenant's part, expectations of being evicted from the (rented) land may curb the incentive to exert a high level of effort.

[7] Female-headed households are a rising category of households both in the developing and developed world (Chant, 2003). Female-headed households with stronger legal or customary decision making power (such as divorced or widowed) are considered *de jure*, while those who lack such power (with an out-migrated husband) are considered *de facto* (Kennedy and Peters, 1992). As of 2011, the proportion of female-headed households in Ethiopia was estimated to be 26.10 percent compared to the examples of Haiti (40.6 percent), Zimbabwe (44.6 percent) and Malawi (28.1 percent) (World Bank, 2011). The female-headed household group itself is heterogeneous, consisting of women who are never-married, divorced, and widowed, and those whose husbands have temporarily out-migrated (Seebens, 2007).

[8]EPRDF (Ethiopian People's Revolutionary Democratic Front) is the ruling political coalition in Ethiopia.

[9] In a male-headed household, decision making concerning crop choice, sale of produce and input use tends to be male-dominated (Tiruneh et al., 2001).

[10]Kebele is the smallest administrative unit in Ethiopia, while woreda is the next largest, formed of a collection of kebeles.

[12] In addition to the certification at a kebele level, we also have a household level certification measurement that identifies which households actually received certification in each kebele. The advantage of having a kebele as a unit of analysis is that, as the majority of households received certificates in the certified villages, spillover effects are likely. In addition, the households that did not receive certificates were mainly excluded for temporary reasons such as shortage of papers or delays in registering the households to the program. This implies that the group of households that did not receive certificates in the certified villages is mainly constituted of households waiting for their certificate. However, in villages where a considerable minority of the households are not certified and/or these households do not expect with certainty they will be certified (although they were all eventually certified), defining the intervention at household level is justified. It should be noted that defining certification at the household level might imply that households within the certified villages that did not receive certification may not have been part of the process at all, making the household level measure more conservative than the kebele level measure. The results from the household level certification are generally comparable with those of the kebele level certification, although the latter are slightly less significant. The results for the household level certification are available upon request.

[13] A more detailed description of the variables used in the regressions can be found in Appendix A.

[14] Further investigation of our data shows that female-headed households are comprised of widows (49%), married (with husband away for a significant period of time, 25%), divorced (19%), separated (4%), and single (3%).

[15] For ease of comparison across the gender categories, the descriptive statistics includes the time period after certification. Descriptive statistics for the period before certification show a small gender difference related to land conflict: 20 percent of female-headed households and 18 percent of male-headed households had experienced land-related conflict.

[16] Fixed rent involves cash rentals, although in some cases it could also cover cash loans. Sharecropping generally involves output sharing and in some cases cost-sharing (Bezabih, 2009). The dominance of sharecropping and the activeness of land markets are similar to other findings in the highlands of Ethiopia (Teklu and Lemi, 2004; Pender and Fafchamps, 2006, Deininger et al., 2008; Holden and Bezabih, 2008).

[17] The choice of experience of loss of land as a factor in the decision to rent out is based on our observation that loss of land is almost always an outcome of redistribution through the kebele administration, which decides on redistributing land away from a household based on the land area-family size ratio. Further, there are no reasons to believe that the redistributions will have skewedness with respect to land fertility, as original land redistributions (in 1975) focused on being egalitarian and land allotted to a farm household consisted of fertile, moderately fertile and infertile parcels. Similarly, the experience of conflict may not necessarily be associated with land fertility (and hence productivity), as adjacent lands leading to border-related conflicts are not necessarily fertile plots.

[18] It should be noted that we do not find a significant relationship between land certificates and the gender of the household head when we identify certification on the household level. As discussed in section 4, the household level certification is a more conservative estimate compared to the kebele level, as the possible spillover effects as well as households that are in the process of receiving certificates are not accounted for. The results for the household level certification are available upon request.

[19] The estimation results for the plot selection equation and the inverse Mill's ratio are presented in Appendix D.

[21] The propensity score matching method is a semi-parametric approach, which does not require an exclusion restriction or a particular specification of the selection equation to construct the counterfactual.