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Abstract

The importance of providing secure land rights to smallholder farmers in developing countries is now widely recognized. In line with this, our paper analyzes the impact of land certification on boosting productivity of female-headed households in Ethiopia, which are believed to be systematically more tenure insecure than their male counterparts. Based on parametric and semi-parametric analyses, the impact of certification on plot-level productivity is positive and significant. However, certification has different impacts on male and female productivity: male-headed households gain significantly and women gain only modestly. Hence, the results indicate that, while certification is clearly beneficial to farm-level productivity, it does not necessarily lead to more gains for female-headed households.

Key Words: productivity, female-headed households, land certification

JEL Classification: D2, Q12, Q15

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Introduction

Gender gaps in agricultural productivity have been documented by many studies across the developing world. In Ethiopia, for instance, Holden et al. (2001) found that land productivity differentials between male- and female-headed households persist in farms in the Ethiopian highlands, even after controlling for the impact of market imperfections. Similarly, in Nepal, male-managed farms produce more per hectare, accompanied by a higher value of marginal product per adult family males than adult family females (Sridhar 2008). In addition, Quisumbing (1996) argued that allocative efficiency differentials exist across male- and female-headed households, due to endogenous input choices and intra-household resource allocations. Even within the same household, empirical evidence from Burkina Faso (Udry 1996) showed that plots controlled by women are farmed much less intensively than similar plots within the household controlled by men. Other studies have found a systematic downward bias in the productivity of female-owned plots in Africa and Asia (Tikabo 2003; Agarwal 2003; and Cook 1999).

A number of studies point to lack of access to resources (particularly land) faced by rural women in the developing world as major sources of their economic underperformance.[1] Based on a critical analysis of cases from five South Asian countries, Agarwal (1994) argued that the single most important economic factor affecting rural women's situations is the gender gap in command of arable land: few women have ownership rights to land and even fewer have control over it, in terms of production and management decisions. Across Africa, women's rights to property derive from men in the household and may be coupled with obligations and other

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[1] Women also face an array of constraints in their day-to-day economic activities, including access to extension services (e.g., Mutimba and Bekele 2002; Saito and Spurling 1992), to credit (e.g., Barham and Chitemi 2008), and to output markets (Rashid and Townsend 1993; de Mel et al. 2007). Other studies have associated lack of control of resources by women with lower agricultural productivity (Quisumbing 1996).

restrictions regarding use of land (Okali 1983; Goheen 1988, 90–105; Derman et al. 2007; Dey 1981; Yngstrom 2002; Roberts 1988, 97–114).

In this paper, we assess the impact of the recent curtailments in the rapid and low-cost rural land certification program in Ethiopia, which was intended to relieve the inherent insecurity of tenure in land holdings and ease constraints to participation in the land markets by improving the productivity of female land owners. Our analysis adds to the existing literature on the relationship between land reforms and economic performance in two significant ways.

First, the impact of land reforms on the economic performance of female-headed households has rarely been studied. Because land is a critical resource, there have been a number of revisions of land legislation (some with direct and indirect provisions to improve women's land rights). However, the literature investigating the impact of interventions on the livelihoods of female farmers is still relatively thin and is mainly qualitative analysis. Exceptions include Holden, Deininger, and Ghebru (2009), who showed that, as a result of the land certification program, female heads of household in Tigray, Ethiopia, were more likely to rent out land. The systematic lower tenure security of women before the certification and their reliance on the land-lease market to start seems to support this.

Second, assessment of the efficiency and equity of land reforms has yielded decidedly mixed results. Because land reforms help secure property rights, they are expected to lead to a number of benefits. Deininger et al. (2007) argued that these benefits could include incentives for land-related investment, enhanced gender equality and bargaining power by women, improved governance, reduced conflict potential, and lower transaction costs for productivity-enhancing land transfers (either rental or sale).[2] In line with this, Holden, Xu, and Jiang (2009) showed that forest tenure reforms in China, which instituted written documentation of forest land rights, in the form of forest land certificates for a specific time period, enhances tenure security beyond what other perceived use-rights to land do. Similarly, in their study of the impact of low-cost

[2] The broader literature on rural land security provides strong evidence that in many cases secure tenure improves the livelihoods of the rural poor through increased investment, land market participation, and productivity. In many instances, tenure security is found to correlate with management or conservation investments on the land (Besley 1995; Sjaastad and Bromley 1997; Holden and Yohannes 2002; Deininger and Jin 2006). Similarly, evidence of the impact of participation in the land-rental market also supports this claim (e.g., Ghebru and Holden 2008, 74–92; Lunduka et al. 2009; Gebreselassie 2005).

land certification in the Amhara region of Ethiopia, Deininger et al. (2009) found that the land reform increased soil conservation investment and participation in the land rental market.

However, empirical evidence of the impact of land reform does not always ensure that land reforms live up to intended objectives. For instance, land titling in Kenya brought little increase in land market activity (Place and Migot-Adholla 1998); Jacoby and Minten (2005) found the same results in a similar study in Madagascar. In some instances, land titling programs benefit the wealthy and powerful at the expense of the poor and marginalized (Besley and Burgess 2000; Cotula et al. 2004; Deininger et al. 2003). Even where legislation does strengthen women's property rights, lack of legal knowledge and weak implementation may limit women's ability to exercise their rights (Deininger et al. 2008).

In sum, the degree of success of a particular land reform could be dependent on the features of the reform and the pre-existing tenure structure, as well as the adequate institutional infrastructure supporting the reform so that it attains its desirable outcomes (Deininger et al. 2009). Hence, the impact of land certification in Ethiopia on the productivity of female-headed households should be investigated on its own merits. Accordingly, this paper assesses the mechanisms by which the program can contribute to reducing the gender gaps in the productivity of male- and female-headed households in Ethiopia.

This paper hypothesizes two ways that land certification can help reduce the gender gap in economic performance. First, increased tenure security, as a direct outcome of certification, should increase the productivity of female-headed households by increasing, for instance, land-related investment. Second, tenure security encourages female-headed households to participate in the land rental market,[3] which typically involves land transfer to more efficient operators. Bellemare (2009) argued that tenure security is an important factor in land transaction behavior.

To compare the patterns of productivity among the sample plots before and after certification, we used a "difference-in-differences" approach. The role of certification is identified as the estimated difference-in-differences of productivity pre- and post-certification between the two groups of plots. Following Deininger et al. (2009), who applied a similar methodology to the analysis of the impact of land certification on tenure security and investment

[3] Female-headed households are heavily reliant on the land-rental market as a mechanism to adjust their factor endowments to cultivated land because of the shortage of male labor for farming activities (Bezabih and Holden 2009).

in soil conservation activities, we selected plots that received certification in the year 2005 as treatment plots, and designated plots that did not receive certification prior to, or in 2005, as the control plots. Our major findings indicate that, while certification consistently increases overall plot productivity, the systematic link between certification and gender gaps in productivity is less consistent and more dependent on the nature of land rentals that female-headed households engage in.

The paper is organized as follows. Section 1 gives a brief background on Ethiopian land policy, women's land rights, and certification. The estimation methodology, along with some considerations in the estimation procedure, is provided in section 2. Section 3 details the survey design and data employed in the empirical analysis. Section 4 presents the empirical findings and section 5 concludes the paper.

1. Ethiopian Land Policy, Women's Land Rights, and Land Certification

Prior to 1975, Ethiopia's long, feudalistic system of land tenure rarely recognized independent land ownership by women, except through marriage and inheritance. While women could inherit land from their parents or deceased husbands, they could not own land in their own right (Crummy 2000).

The Derg[4] regime that overthrew the last imperial government in 1975 abruptly instituted a series of measures that changed the political and economic landscape of the country from a feudal system to a socialist state (Kebede 2002). Among the many radical measures, the land reform proclamation of February 1975 nationalized all rural lands, announcing that all land was owned by the state and given to farmers on a right-to-use (usufruct) basis, organized via peasant associations (Kebede 2008). The farmers' membership in the peasant associations made them *claimants*, endowed with rights, such as access, some management rights, and limited exclusion rights. 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 not registered separately; they therefore had no control of the land (Crewett et al. 2008).

[4] A repressive communist military junta in power in Ethiopia from the 1970s through the end of the 1980s, headed by Mengistu.

The EPRDF-led[5] government that overthrew the military government (Derg) in 1991 largely maintained the land policy of its predecessor, keeping all rural and urban land under public (government) ownership (Gebreselassie 2006). Significant changes included formal confirmation that land rights were to be granted to men and women, including the right to lease out land. However, most regions limited the period of the lease and restricted leasing rights to only a share of the farmland. The severe limitations in these provisions still exist, particularly for women. For instance, divorced women lack secure land rights, due to numerous exceptions which strictly curtail these rights (Crewett et al. 2008).

Pre-existing land-tenure systems in many developing countries are characterized as rigid and highly intertwined with sociocultural customs, leaving huge room for efficient reforms (Nega et al. 2003). Women, in particular, are often disadvantaged by both statutory and traditional land-tenure systems (Agarwal 1994; Lastarria-Cornhiel 1997; Kevane and Gary 1999). They have weak property and contractual rights to land, water, and other natural resources (Quisimberg et al. 2009).

Since the 1990s, most African countries have passed new land legislation to remedy some of the 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 (Deininger et al. 2009). However, whether these moves have improved the status of women remains debatable. In some cases, privatization has led to different land rights being concentrated in the hands of a few people, while other people (such as poor rural women or ethnic minorities) lose the few rights they have and generally are not able to participate fully in the land market (Lastarria-Cornhiel, 1997). In addition, Khadiagala (2001) and Tripp (2004) argued that traditional institutions suffer from a limited ability to deal with gender-related conflict and tend to be gender-biased. Even with recent reforms, gender equality has not been thoroughly addressed.[6]

Among other equity and efficiency concerns, the land certification program in Ethiopia attempts to address gender bias concerns of the current land-tenure system. The program issues a non-alienable joint certificate to both spouses that confers equity and joint land ownership. The certificates include maps of the land and photos of both husband and wife. Women are also

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

[6] Many African countries have recently revised their land legislation to offer greater tenure security to land users, recognize traditional arrangements, and strengthen women's rights (Deininger et al. 2006).

actively involved in the certification process, and the land administration committees at the *kebele* [7] level are required to have at least one female member (Deininger et al. 2007).[8]

2. Empirical Methodology and Estimation Considerations

An ideal setting to evaluate impact would require that participants and nonparticipants have the same ex-ante chance of participating in the program. The implication is that observed or unobserved attributes prior to the introduction of the program have no impact on the likelihood of actual participation. In reality, however, evaluation of impact generally involves deliberate placement of participants in the treatment and control groups, reflecting both the choices made by those eligible and the administrative assignment of the opportunities to participate. The factors, then, upon which participation in the program is based can be observable to the researcher. However, factors unobserved by the evaluator, but known to those deciding participation and influencing outcomes, could also come into play. Thus, a study evaluating impact needs to address selection bias stemming from inadequate controls for observable heterogeneity plus bias stemming from unobservables (Ravallion 2007).

Addressing selection bias for observables can, in principle, be assessed using linear regression models. Nonparametric methods are superior in this case because selection of observables is related to the assumption of no distributional or functional forms. When involvement in the program is independent of outcomes, given the observables, then the relevant summary statistic to be balanced between the two groups is the conditional probability of participation, called the "propensity score" (Rosenbaum and Rubin 1983). The probabilities that a valid comparison group can be found is termed the region of common support.

Non-random participation also yields a bias if some of the variables that jointly influence outcomes and program involvement are unobserved by the evaluator.

[7] The land administration committee is a grass roots, kebele-level (the smallest administrative unit in Ethiopia) structure responsible for the issuance of certificates.

[8] This could be seen as part of a comprehensive effort by governments and development practitioners to improve the conditions of rural women. A significant number of studies documents promising interventions to improve women's health, education, and nutritional status (see, for example, King et al. 2007; Allen and Gillespie 2001, both cited in Quisimberg et al. 2009).

2.1 Semi-Parametric Approach

The first step of computing a propensity score in propensity score matching is to estimate a standard probit or logit participation model with control variables. The predicted values are used to estimate the propensity score for each observation in the participant and the non-participant samples. The comparison group is then formed by picking the "nearest neighbor" with similar characteristics for each participant (Jalan and Ravallion 2003) to test for systematic differences in the covariates between the treatment and comparison groups constructed by propensity score matching.

Rosenbaum and Rubin (1983) showed that matching on the propensity score is equivalent to matching on all the observed covariates. Based on this property, the propensity score can also be used to delineate the common support group, where the non-participants have the same propensity score that is higher than some cut-off level.

The propensity score is given by:

$$e(x) \equiv \Pr(w = 1 \mid X = x) = E(w \mid X = x) \tag{1}$$

where *w* is the indicator of exposure to treatment, and *x* is the multidimensional vector of pretreatment characteristics. Accordingly, the average treatment effect on the treated (ATT) can be estimated as:

$$ATT = \{E[E(y \mid w = 1)], \Pr(x)\} - \{E(y_o \mid w_0 = 0), \Pr(x) \mid w = 1\}\} \tag{2}$$

2.2 Parametric Approach and the Difference-in-Differences Method

The basic intuition of the difference-in-differences approach is that to study the impact of some "treatment," one compares the performance of the treatment group pre- and post-treatment, relative to the performance of some control group pre- and post-treatment. In principle, the control group shows what would have happened to the treatment group in the absence of any treatment—a no-treatment group (Slaughter 2001). In our case, this suggests that one can compare the level of productivity of plots given certificates pre- and post-certification to the productivity of control plots pre- and post-certification.

Our parametric regression analysis proceeds as follows. First, the relationships between the gender of the household head and land productivity are specified to establish the existence of significant productivity differences between farms owned by male and female household heads.

The productivity equation is then relaxed to take into account land certification and land leasing behavior.

2.3 Basic Productivity Analysis

Our assessment of the relationship between gender of the household head and plot-level productivity is given by:

$$\ln(y_{pit}) = \alpha + \varpi S_{it} + \gamma g_{it} + \mu X_{pit} + u_{pit} \tag{3}$$

where, for household *i*, plot *p*, and year *t*, $\ln(y_{pit})$ is the log of the value of output per hectare; S_{it} represents socioeconomic characteristics, excluding gender; X_{pit} is a vector of physical plot characteristics; and u_{pit} is an error term.

The decision to rent out a plot as represented by equation (4):

$$L_{pit} = \begin{cases} 1\ if\ \ \beta^{P} S_{it} + \gamma^{P} X_{pit} + u_{pit} > 0, \\ 0 \quad otherwise \end{cases} \tag{4}$$

where L_{pit} is an indicator variable equal to 1 if the plot is leased out.

A similar specification applies to self-managed and rented-out plots, as given in equations (5) and (6), respectively:

$$y_{pit}^{N} = \alpha^{N} + \varpi^{N} S_{it}^{N} + \gamma^{N} g_{it}^{N} + \mu^{N} X_{pit}^{N} + \eta^{N} * imr_{pit}^{N} + u_{pit}^{N} \quad \text{and} \tag{5}$$

$$y_{pit}^{R} = \alpha^{R} + \varpi^{R} S_{it}^{R} + \gamma^{R} g_{it}^{R} + \mu^{R} X_{pit}^{R} + \eta^{R} * imr_{pit}^{R} + u_{pit}^{R} \tag{6}$$

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

2.4 Extended Productivity Analysis with Certification

In considering the possible impact of certification on plot-level productivity, we extended the framework in equations (3), (4), and (5) by including the impacts of certification. Accordingly, the pooled productivity equation is given by:

$$\ln(y_{pit}) = \alpha + \varpi S_{it} + \gamma g_{it} + \vartheta c_{pit} + \phi g_{it} * c_{pit} + \mu X_{pit} + u_{pit} \tag{7}$$

where c_{pit} represents the certificate variable, defined as a dummy variable. (1 represents the post-treatment period if plot *p* and household *i* are located in the treated village, and 0 otherwise.) In addition, equations (4) and (5), representing rented-out and self-managed plots, respectively, are extended in the same manner to account for the impacts of certification.

All the equations are estimated using the both random effects and Mundlak's fixed effects estimators. To elaborate on our use of these alternative estimators, we set up an equation that decomposes the error term ξ_{it} into a fixed effect α_i and a random noise, u_{it} :

$$\xi_{it} = \alpha_i + u_{it} \tag{8}$$

The random effects estimator is based on the implicit assumption of no correlation between the fixed effect α_i and the regressors/observed covariates (Wooldrige 2001). A violation of the assumption underlying the random effects specification that $E(y_{it} \mid Z_{it} = 0)$, where Z_{it} equals all observed covariates in equations (3) through (7), leads to biased parameter estimates. To remedy this, Mundlak (1978) suggested explicitly modeling the relationship between time-varying regressors Z_{it} and the unobservable effect α_i in an auxiliary regression. Adding the pseudo fixed effects, or the Mundlak-Chamberlain's random effects model, would control for the fixed effect without having to rely on the data transformation in the fixed-effects estimator and the associated shortcoming of removing any time-constant explanatory variables along with α_i.

3. The Data

The data in this analysis came from the Sustainable Land Management Survey conducted in 2005 and 2007, in two zones of the Amhara National Regional State in Ethiopia. A total of 14 villages were included in the study, 7 from East Gojjam and the other 7 from South Wollo. East Gojjam has a greater agricultural potential than South Wollo.Table 1 presents the distribution of plots by treatment, rental, and gender categories.

Table 1. Distribution of Plots by Certification, Treatment, and Gender

	No treatment		**Treatment**		**Total**
	Male	***Female***	***Male***	***Female***	
Self-managed	4,389	436	3,700	552	9,077
Rented out	1,101	169	695	120	2,085
Total	5490	605	4,395	672	11,162

As seen in table 1, the no-treatment category has more plots than the treatment category. The proportion of rented plots in the two categories is closer: there are 20 percent more rented plots in the no-treatment category than the treatment category. Slightly more males owned plots in the no-treatment category, while the opposite holds for female-owned plots. This implies that there has been, on average, more female participation in certification (i.e., registering and being issued certification for plots they farm). Looking at the rental categories, the descriptive statistics show that, after certification, land rentals by women increased slightly, while land rentals by men decreased.

Table 2. Description of Variables Used in the Regressions

Variable name	Variable description
Socioeconomic characteristics	
Sex of household head	1 = female household head, 0 = male household head
Age of household head	Household head's age (in years)
Age of household head squared	The square of the household head's age (in years)
Household head able to read	Household head's formal education (1 = read only; 0 = other)
Household head able to write	Head's formal education (1 = read and write; 0 = other)
Household head illiterate	Head's formal education (1 = illiterate; 0 = other)
Adult male labor per hectare	The number of male working-age family members of the landlord per hectare
Adult female labor per hectare	The number of female working-age family members of the landlord per hectare
Adult male labor per hectare squared	The square of the number of male working-age family members of the landlord per hectare
Adult female labor per hectare squared	The square of the number of female working-age family members of the landlord per hectare
No. of oxen per hectare	The number of oxen per hectare
No. of livestock per hectare	The number of livestock per hectare
Total farm size	Total farm size (in hectares)
Physical plot characteristics	
Fertile plot	Fertile plot (1 = fertile; 0 = not fertile)
Medium fertile plot	Medium fertile plot (1 = medium fertile; 0 = not medium fertile)
Infertile plot	Infertile plot (1 = infertile; 0 = not infertile)
Other plot-fertility category	Other plot-fertility category (1 = other fertile; 0 = not other fertile category)
Black soil	Black soil in plot (1 = black; 0 = not black)
Red soil	Red soil in plot (1 = red; 0 = not red)
Grey soil	Grey soil in plot (1 = grey; 0 = not grey)

Sandy soil	Sandy soil on plot (1 = sandy; 0 = not sandy)
Dark red soil	Dark red soil in plot (1 = dark red; 0 = not dark red)
Flat plot	Flat plot (1 = flat; 0 = not flat)
Medium slope	Medium sloped plot (1 = medium; 0 = not medium)
Steep slope	Steep sloped plot (1 = steep; 0 = not steep)
Plot distance from homestead	Distance of the plot from homestead (in minutes walking)
Plot size	Total plot size (in hectares)
Input application	
Fertilizer in kg/ha	Fertilizer applied on plot per hectare
Manure in kg/ha	Manure applied on plot per hectare
Tenure security variables	
Household's expectation of increase in land holdings	Dummy variable for whether the household expects increase in land holdings (1 = yes; 0 = no)
Household's expectation of decrease in land holdings	Dummy variable for whether the household expects decrease in land holdings (1 = yes; 0 = no)
Household's expectation of no change in land holdings	Dummy variable for whether the household expects no change in land holdings (1 = yes; 0 = no)
Household's expectation of uncertainty in future land holdings	Dummy variable for whether the household is uncertain about change in land holdings (1 = yes; 0 = no)
Plot distribution by rental categories	
Self-managed plots	A dummy variable indicating whether the plot is managed by the owner or not (1 = owner; 0 = no)
Rented-out plots	A dummy variable indicating whether the plot is rented out (1 = rented out; 0 = no)
Landlord-tenant relationships	
Landlord (male and female) with blood-related tenant	A dummy variable indicating whether the tenant is a blood relation or not (1 = blood relation; 0 = no)
Female landlord with blood-related tenant	A dummy variable indicating whether the tenant is a blood relative if the landlord is a female
Landlord (male and female) with in-law tenant	A dummy variable indicating whether the tenant is an in-law or not
Female landlord with in-law tenant	A dummy variable indicating whether the tenant is an in-law if the landlord is a female
Dependent variables	
Plots in the treatment category	Plots in the certificate village (1 = treatment; 0 = no)
Plots in the treatment category for ethyear = 1999	Plots in the certificate village for the Ethiopian year 1999 (1 = treatment; 0 = no)
Value of plot output per hectare	The log of the value of output per hectare

Table 2 gives a detailed definition of the variables used in the regressions. Descriptive statistics of the characteristics of plots and sample households in the survey, along with tenant-landlord relationships, are presented in table 3 below. The first two columns in table 3 presents the characteristics of participants and nonparticipants in the certification program, and the third and fourth columns in the table give the description by gender.

Slightly over half the respondents in the sample never attended school. That fraction is slightly higher in the no-treatment category, while the proportion of household heads who can read and write is higher in the treatment category. In the no-treatment category, the average number of male and female adult members per hectare of land is 1.367 and 1.323, respectively; these figures are slightly higher for the treatment category. The average holdings size is 1.765 hectares in the no-treatment group, and 1.968 in the treatment category. The distribution of plot characteristics in the two certification groups is uniform.

Table 3. Descriptive Statistics of Variables Used in the Regressions

Variable	Certificate = 0		Certificate = 1		Male head		Female head	
	Mean	***Std. dev.***	***Mean***	***Std. dev.***	***Mean***	***Std. dev.***	***Mean***	***Std. dev.***
Socioeconomic characteristics								
Sex of household head	0.099	0.299	0.128	0.334	0.000	0.000	1.000	0.000
Age of household head	50.877	14.871	49.300	13.932	49.813	14.452	52.811	14.293
Household head able to read	0.076	0.265	0.076	0.266	0.083	0.276	0.018	0.134
Household head able to write	0.377	0.485	0.429	0.495	0.442	0.497	0.083	0.276
Household head illiterate	0.529	0.499	0.474	0.499	0.457	0.498	0.872	0.334
Adult male labor per hectare	1.367	1.261	1.174	1.087	1.297	1.144	1.124	1.478
Adult female labor per hectare	1.323	1.456	1.194	1.125	1.158	1.107	2.097	2.218
Adult male labor per hectare squared	3.458	12.608	2.559	10.169	2.991	11.162	3.448	14.254
Adult female labor per hectare squared	3.868	20.887	2.693	9.200	2.565	11.869	9.313	35.826
No. of livestock per hectare	1.998	2.405	2.359	2.225	2.191	2.115	1.957	3.594
No. of oxen per hectare	1.709	1.660	1.635	1.626	1.598	1.476	2.245	2.497
Physical plot characteristics								
Fertile plot	0.463	0.499	0.545	0.498	0.488	0.500	0.601	0.490
Medium fertile plot	0.374	0.484	0.356	0.457	0.355	0.479	0.305	0.461
Infertile plot	0.161	0.368	0.135	0.341	0.155	0.362	0.094	0.292
Other fertility category	0.002	0.046	0.000	0.017	0.001	0.036	0.000	0.000

Black soil type	0.412	0.492	0.325	0.469	0.363	0.481	0.446	0.497
Red soil type	0.432	0.495	0.597	0.491	0.517	0.500	0.427	0.495
Grey soil type	0.062	0.241	0.040	0.197	0.043	0.203	0.052	0.223
Sandy soil type	0.025	0.155	0.018	0.134	0.017	0.131	0.018	0.133
Dark red soil type	0.069	0.253	0.051	0.221	0.059	0.235	0.056	0.231
Flat slope	0.655	0.475	0.740	0.411	0.699	0.459	0.749	0.434
Medium slope	0.277	0.448	0.307	0.430	0.250	0.433	0.200	0.401
Steep slope	0.065	0.247	0.050	0.218	0.048	0.214	0.050	0.218
Plot distance from homestead in minutes walking	19.000	22.505	17.505	20.678	18.402	21.818	17.562	20.646
Plot size in hectares	0.333	0.270	0.299	0.256	0.319	0.267	0.300	0.244
Total farm size in hectares	1.765	0.953	1.968	1.156	1.922	1.055	1.362	0.935
Input application								
Fertilizer in kg/ha	130.478	435.420	231.982	620.780	189.877	530.621	79.423	530.467
Manure in kg/ha	1886.142	7961.808	1331.350	3141.842	1689.712	6476.631	1148.345	3496.119
Tenure security variables								
Household's expectation of increase in land holdings	0.143	0.350	0.122	0.328	0.135	0.342	0.122	0.327
Household's expectation of decrease in land holdings	0.295	0.456	0.266	0.442	0.285	0.451	0.252	0.434
Household's expectation of no change in land holdings	0.283	0.450	0.371	0.483	0.321	0.467	0.345	0.476
Household's expectation of uncertainty in future land	0.277	0.448	0.241	0.428	0.258	0.437	0.281	0.450

Plot distribution by rental categories								
Self-managed plots	0.793	0.405	0.847	0.360	0.823	0.381	0.779	0.415
Rented-out plots	0.066	0.248	0.042	0.201	0.038	0.191	0.187	0.390
Landlord-tenant relationships								
Tenant is related to landlord (male and female)	0.055	0.229	0.047	0.211	0.051	0.221	0.050	0.219
Tenant is related to spouse of landlord (male and female)	0.013	0.112	0.013	0.114	0.013	0.113	0.013	0.112
Tenant is related to female landlord	0.008	0.090	0.003	0.051	0.000	0.000	0.050	0.219
Tenant is related to spouse of female landlord	0.002	0.041	0.001	0.034	0.000	0.000	0.013	0.112
Dependent variables								
Share of plots in treatment category	0.275	0.446	0.426	0.495	0.455	0.498	0.527	0.499
Share of plots in treatment category if Ethyear = 1999					0.011	0.102	0.013	0.115
Value of production per hectare	6.652	1.122	6.752	1.050	6.719	1.085	6.524	1.116

With regard to indicators of wealth, such as number of oxen and livestock, households in the no-treatment category owned an average of 1.765 oxen per hectare, compared to 1.635 in the treatment category. Livestock ownership (measured in tropical livestock units) is 1.998 and 2.559 in the no-treatment and treatment categories, respectively. The difference in physical characteristics between plots treated or not treated does not exhibit a particular pattern, suggesting that the plots in the treatment and no-treatment categories are not very different.

Being in the treatment category increases the proportion of households that see no change in their expectation of future land holdings. The proportion of households that expect to increase or decrease their holdings, as well as those that are uncertain, is less in the treatment than the no-treatment sample.

Land productivity measured in terms of the log of value of production per hectare is higher in the treatment than the no-treatment group. Similarly, external input applications of fertilizer and manure are much higher in the treatment than the no-treatment category.

The third and fourth columns in table 3 present the summary statistics of the values of the variables of interest differentiated by gender. Female heads of households are older and they are more illiterate (87 percent) than male household heads (45 percent). On average, male-headed households have more adult male laborers, but fewer adult female laborers. The number of livestock and oxen per hectare are also greater for male-headed households, but female-headed households have both larger family sizes and larger plot sizes, on average. The average number of both livestock and oxen is lower in the female-headed households. Female landlords were more likely to have blood-related or in-law tenants. Statistics on physical farm characteristics between male and female-headed households suggest that the differences are not significant in all cases. The observed outputs are also significantly larger for male-headed households.

Land productivity is higher for male-owned plots than female-owned plots. These gender-based differences are also statistically significant for all plot characteristics, although these variables arguably do not account for all the unobservable differences in land quality. In addition, relative to men and controlling for farm size, female-owned plots actually receive more fertilizer than male-owned plots, although manure per hectare tends to be higher for male-owned plots.

4. Results and Discussion of the Parametric and Nonparametric Analyses

4.1 Determinants of renting out plots

The probit results of the determinants of renting out plots are presented in table 4. Our results suggest that, overall, renting seems to be dependent on household characteristics and there is limited heterogeneity on whether a household leases in or leases out plots. Gender has a positive impact on the likelihood of renting out a plot. This is in line with arguments by Holden and Bezabih (2008) that female-headed households are hugely dependent on renting out for production. Again, reflecting the limited use of female labor in agricultural production, households with a large number of adult female members are more likely to rent out their land. The opposite effect holds for households with more adult male family members per hectare of land. Given limited opportunities for hired labor, older households are also likely to rent out their land, as reflected by the positive coefficient of age. Households with more oxen and livestock per hectare are less likely to rent out land. This is expected because the average land holding in the study area is small. Plot characteristics seem to be less important in the renting out decision.

4.2 Basic Productivity Analysis

The basic productivity equations analyze the determinants of productivity without taking into account the impact of certification. The results in table (4) present this analysis in four categories: pooled productivity regression that includes all the plots, pooled productivity regression with Mundlak’s fixed effects, rented-out plots, and non-rented-out plots. The results show that, across all categories, plots owned by female-headed households are significantly less productive. This is in line with previous studies, which have revealed a gender gap in land productivity (Holden and Bezabih 2008; Bezabih and Holden 2009).

Table 4. Random Effects Probit Determinants of Plot-Renting Behavior

Variable	Rent out	Variable	Rent out
Age of the household head	-0.004*** (0.001)	Medium fertile plot	0.045 (0.078)
Sex of the household head	-0.242*** (0.043)	Infertile plot	0.082 (0.076)
Household head able to read	-0.058 (0.038)	Black soil	-0.045 (0.043)
Household head able to write	-0.080*** (0.023)	Red soil	0.097* (0.043)
No. of adult female family members per hectare	-0.048** (0.018)	Grey soil	0.045 (0.061)
No. of adult male family members per hectare	0.041* (0.018)	Sandy soil	-0.063 (0.084)
No. of adult female family members per hectare squared	0.002 (0.001)	Steep slope	-0.002 (0.044)
No. of adult male family members per hectare squared	-0.001 (0.002)	Ethyear = 1999	0.007 (0.042)
No. of tropical livestock units per hectare	0.047*** (0.007)	Constant	7.507*** (0.153)
No. of oxen per hectare	0.059** (0.020)	N	2,085
Total farm size in hectares	0.02 (0.014)	LR Chi2 (20)	701.71
Plot size in hectares	-0.855*** (0.042)	Pseudo R2	0.0592
Fertile plot	0.048 (0.076)		

* = significant at 10%; ** significant at 5%; *** = significant at 1%

The negative coefficient for gender in the rented-out productivity equation indicates that plots owned (and rented out) by female-headed households are operated suboptimally, compared to similar plots owned by male-headed households. The lower productivity of female-owned plots also implies that female-headed households may lack the necessary factors of production to work their farms efficiently and are unable to fully adjust their cultivated area by renting out a sufficient amount of land.

Older households are less productive. Education seems to have no significant effect on productivity, except for the pooled productivity regression, where it exhibits a significant, negative impact. The importance of availability of male labor is shown by the positive impact of male adult members of a household in the pooled- and owned-plot regressions and the negative impact of female labor in the owned-plot categories. This also strengthens our earlier argument that lower productivity of female owned plots may be explained by factor constraints, such as labor.

Tropical livestock units, used as proxy for household wealth, are only significant in the owned-plots category and exhibit a negative impact on the pooled regression with time invariant covariates. The number of oxen per hectare is a positive determinant of productivity. Plot size is a consistently significant and negative determinant of productivity, while farm size is only significant in the pooled regression category.

Of the plot characteristics, fertility is the most important determinant of productivity, with all three fertility categories positive and significant. Plots with steep and moderately steep slopes are also significant. In the input categories, both fertilizer and manure are significant, but with very small magnitudes.

The presence of significant selection into self-managed and rented-out plots was verified by the significance of the inverse Mill's ratio. This indicates that plots are not randomly sorted into rented and self-managed plots. Instead, their selection into either category depends on plot and household characteristics.

4.3 Extended Productivity Analysis

Table 5 below presents the estimation results of the productivity analysis, controlling for the impacts of certification and tenant-landlord relationships for pooled, rented-out, and self-managed plots across estimators. The objective of this analysis is to see if productivity gaps between male- and female-owned farms can be narrowed by certification.

Table 6 below presents the productivity analysis extended to include certification and tenant-landlord relationships. The coefficients, estimated by adding the treatment variable and the treatment interacted with gender, represent the certification and the impact of certification, given that the head is female. The impact of certification on productivity is positive and significant, and results are relatively robust for rented-out/self-managed and pooled plots, as well as across estimators. The gender and treatment interaction is positive and significant for one category only, indicating that while female-headed households might have gained modestly from the reform, male-headed households benefitted much more from certification in terms of productivity. The impact of kinship variables is negative and significant for plots owned by women and rented out to spouse’s relatives. This implies that female-headed households do not have effective command over their relatives as tenants, leading the tenants to exert less than optimal effort on their rented-out land. This result is in line with the findings by Bezabih and Holden (2009) and Kassie and Holden (2007).

Table 5. Random Effects and Mundlak's Fixed Effects Determinants of Productivity (No Certification of Plot)

Variable	Pooled	Pooled†	Rented	Rented†	Self-managed	Self-managed†
† Indicates the estimate is the Mundlak's fixed effect counterpart to the random effects estimation.						
* = significant at 10%; ** significant at 5%; *** = significant at 1%						
††The prefix "avg_" indicates the average of the time variant variables over the two survey periods.						
Age of household head	-0.006***	-0.005***	-0.005***	-0.002	-0.006***	-0.005***
	-(0.001)	-(0.001)	(0.001)	-(0.002)	-(0.001)	-(0.001)
Sex of household head	-0.170***	-0.141***	-0.175***	-0.201*	-0.177***	-0.141***
	-(0.034)	-(0.034)	(0.035)	-(0.081)	-(0.040)	-(0.039)
Household head able to read	-0.057	-0.033	-0.065	-0.069	-0.045	-0.029
	-(0.038)	-(0.038)	(0.038)	-(0.092)	-(0.043)	-(0.043)
Household head able to write	-0.060**	-0.073**	-0.070**	-0.054	-0.063*	-0.076**
	-(0.023)	-(0.023)	(0.023)	-(0.050)	-(0.026)	-(0.026)
No. of adult female members per hectare	-0.029	-0.015	-0.036*	-0.044	-0.046*	-0.015
	-(0.017)	-(0.020)	(0.017)	-(0.056)	-(0.019)	-(0.023)
No. of adult male members per hectare	0.033	0.029	0.037*	0.036	0.036	0.028
	-(0.018)	-(0.018)	(0.018)	-(0.057)	-(0.020)	-(0.020)
No. of adult female members per hectare squared	0.002	0.001	0.002	0.002	0.002	0.001
	-(0.001)	-(0.001)	(0.001)	-(0.006)	-(0.001)	-(0.001)
No. of adult male members per hectare squared	-0.001	0	-0.002	-0.002	-0.002	0
	-(0.002)	-(0.002)	(0.002)	-(0.010)	-(0.002)	-(0.002)
No. of tropical livestock units per hectare	0.035***	0.025***	0.034***	0.040*	0.034***	0.019*
	-(0.005)	-(0.007)	(0.005)	-(0.017)	-(0.005)	-(0.008)
No. of oxen per hectare	0.012	0.006	0.021	0.077	0.022	0.012

	-(0.009)	-(0.011)	(0.012)	-(0.042)	-(0.013)	-(0.015)
Total farm size in hectares	-0.071***	-0.197***	0.013	-0.093	-0.065***	-0.217***
	-(0.013)	-(0.022)	(0.014)	-(0.050)	-(0.016)	-(0.026)
Fertile plot	0.049	-0.014	-0.863***	0.305*	-0.011	-0.09
	-(0.077)	-(0.076)	(0.044)	-(0.154)	-(0.090)	-(0.089)
Medium fertile plot	0.04	-0.036	0.042	0.196	-0.001	-0.093
	-(0.079)	-(0.078)	(0.077)	-(0.157)	-(0.092)	-(0.091)
Infertile plot	0.12	0.021	0.039	0.246	0.073	-0.045
	-(0.077)	-(0.076)	(0.078)	-(0.150)	-(0.089)	-(0.088)
Black soil	0.022	0.051	0.087	-0.333*	0.115	0.145
	-(0.075)	-(0.074)	(0.076)	-(0.150)	-(0.086)	-(0.085)
Red soil	0.163*	0.154*	-0.028	-0.102	0.224**	0.218**
	-(0.074)	-(0.073)	(0.043)	-(0.148)	-(0.085)	-(0.084)
Grey soil	0.061	0.107	0.109*	0.03	0.087	0.143
	-(0.087)	-(0.086)	(0.043)	-(0.181)	-(0.099)	-(0.097)
Dark red soil	0.025	0.075	0.016	-0.184	0.087	0.146
	-(0.084)	-(0.083)	(0.060)	-(0.176)	-(0.095)	-(0.094)
Steep slope	0.085*	0.064	-0.085	-0.056	0.124**	0.09
	-(0.042)	-(0.042)	(0.084)	-(0.094)	-(0.048)	-(0.047)
Medium slope	0.06	0.052	0.039	-0.091	0.107*	0.09
	-(0.042)	-(0.041)	(0.042)	-(0.090)	-(0.047)	-(0.047)
Fertilizer in kg/ha	0.000***	0.000***	0.035	0.000***	0.001***	0.000***
	(0.000)	(0.000)	(0.041)	(0.000)	(0.000)	(0.000)
Manure in kg/ha	0.000***	0.000***	0.000***	0.000*	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
avg_land[††]		0.205***		-0.769		0.297

		-(0.026)		-(0.887)		-(0.454)
avg_madult††		0		0.013		0.252***
		-(0.015)		-(0.059)		-(0.030)
avg_fadult††		-0.787***		0.064*		-0.018
		-(0.092)		-(0.029)		-(0.018)
avg_oxen††		0.008		-0.060*		-0.001
		-(0.008)		-(0.025)		-(0.016)
avg_livestock**		-0.000***		-0.004		0.017
		(0.000)		-(0.012)		-(0.012)
avg_manure††		0.000***		-0.000***		-0.000***
		(0.000)		(0.000)		(0.000)
avg_fertilizer††		-0.397***		0.000***		0.000***
		-(0.029)		(0.000)		(0.000)
Ethyear = 1999	-0.416***	7.080***	0.000***	-0.388***	0.178	-0.370***
	-(0.027)	-(0.131)	(0.000)	-(0.089)	-(0.456)	-(0.040)
Constant	6.961***	7.182***	-0.602	7.717***	-0.399***	6.816***
	-(0.129)	(0.117)	(0.383)	-(0.545)	-(0.038)	-(0.304)
N	11162	11162	2085	2085	9077	9077
R squared	0.1295	0.1197	0.0945	0.0874	0.098	12.89
F statistic	51.33	51.29	8.91	8.46	41.93	42.91
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000

Table 6. Determinants of Productivity (Certification, Rent Variables, Difference-in-Difference)

Variable	Pooled	Pooled†	Rented	Rented†	Self-managed	Self-managed†	Rented out (tnt.cxs)	Rented out (tnt.cxs)(2)
Age of household head	-0.006***	-0.005***	-0.005*	-0.004*	-0.007***	-0.007***	-0.005*	-0.004*
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Gender of household head	-0.210***	-0.188***	-0.219*	-0.192*	-0.190***	-0.145**	-0.194*	-(0.169)
	(0.040)	(0.040)	(0.088)	(0.088)	(0.052)	(0.052)	(0.095)	(0.095)
Household head able to read	-(0.064)	-(0.032)	-(0.143)	-(0.091)	-(0.070)	-(0.048)	-(0.150)	-(0.099)
	(0.038)	(0.038)	(0.092)	(0.092)	(0.043)	(0.043)	(0.092)	(0.092)
Household head able to write	-0.065**	-0.069**	-(0.042)	-(0.050)	-0.063*	-0.063*	-(0.040)	-(0.048)
	(0.023)	(0.023)	(0.050)	(0.050)	(0.026)	(0.026)	(0.050)	(0.050)
No. of adult female members per hectare	-(0.031)	-(0.016)	(0.028)	-(0.038)	-(0.033)	(0.008)	(0.034)	-(0.033)
	(0.017)	(0.020)	(0.052)	(0.058)	(0.020)	(0.024)	(0.051)	(0.057)
No. of adult male members per hectare	0.035*	(0.026)	(0.029)	(0.050)	(0.032)	-(0.002)	(0.005)	(0.022)
	(0.018)	(0.022)	(0.056)	(0.065)	(0.020)	(0.025)	(0.057)	(0.066)
No. of adult female members per hectare	(0.002)	(0.001)	(0.001)	(0.003)	0.003*	(0.001)	(0.000)	(0.003)
	(0.001)	(0.001)	(0.006)	(0.006)	(0.001)	(0.001)	(0.006)	(0.006)
No. of adult male members per hectare squared	-(0.001)	(0.000)	-(0.002)	-(0.001)	-(0.002)	-(0.001)	(0.001)	(0.002)
	(0.002)	(0.002)	(0.010)	(0.010)	(0.002)	(0.002)	(0.010)	(0.010)
No. of tropical livestock units per hectare	0.033***	0.025***	0.043*	0.038*	0.018*	(0.002)	0.047**	0.041*
	(0.005)	(0.007)	(0.018)	(0.019)	(0.008)	(0.010)	(0.018)	(0.019)
No. of oxen per hectare	(0.011)	(0.008)	(0.003)	(0.034)	-(0.025)	-(0.040)	-(0.008)	(0.027)

† Indicates the estimate is the Mundlak's fixed effect counterpart to the random effects estimation.

* = significant at 10%; ** significant at 5%; *** = significant at 1%

†† The prefix "avg_" indicates the average of the time variant variables over the two survey periods.

	(0.009)	(0.011)	(0.041)	(0.044)	(0.023)	(0.024)	(0.041)	(0.044)
Total farm size in hectares	-0.077***	-0.204***	-0.077**	-(0.080)	-0.081***	-0.246***	-0.083**	-(0.084)
	(0.013)	(0.023)	(0.029)	(0.051)	(0.015)	(0.026)	(0.029)	(0.051)
Fertile plot	(0.042)	(0.006)	0.303*	(0.281)	-(0.051)	-(0.099)	0.306*	(0.282)
	(0.076)	(0.076)	(0.153)	(0.151)	(0.089)	(0.089)	(0.152)	(0.151)
Medium fertile plot	(0.043)	-(0.010)	(0.214)	(0.191)	-(0.018)	-(0.082)	(0.215)	(0.189)
	(0.079)	(0.078)	(0.157)	(0.156)	(0.091)	(0.091)	(0.156)	(0.155)
Infertile plot	(0.122)	(0.063)	(0.287)	(0.263)	(0.077)	(0.009)	0.296*	(0.270)
	(0.077)	(0.076)	(0.151)	(0.150)	(0.089)	(0.088)	(0.151)	(0.150)
Black soil	(0.021)	(0.049)	-0.339*	-0.304*	(0.152)	0.188*	-(0.291)	-(0.261)
	(0.075)	(0.074)	(0.154)	(0.152)	(0.087)	(0.086)	(0.154)	(0.153)
Red soil	0.153*	(0.143)	-(0.059)	-(0.082)	0.241**	0.239**	-(0.015)	-(0.044)
	(0.074)	(0.073)	(0.150)	(0.149)	(0.086)	(0.085)	(0.151)	(0.150)
Grey soil	(0.082)	(0.109)	(0.049)	(0.049)	(0.118)	(0.149)	(0.092)	(0.087)
	(0.087)	(0.086)	(0.184)	(0.182)	(0.099)	(0.097)	(0.184)	(0.182)
Dark red soil	(0.029)	(0.071)	-(0.184)	-(0.156)	(0.115)	(0.166)	-(0.139)	-(0.118)
	(0.084)	(0.083)	(0.178)	(0.177)	(0.096)	(0.095)	(0.179)	(0.177)
Steep slope	(0.072)	(0.066)	-(0.077)	-(0.038)	0.144**	0.133**	-(0.085)	-(0.048)
	(0.042)	(0.042)	(0.097)	(0.098)	(0.050)	(0.050)	(0.097)	(0.097)
Moderate slope	(0.051)	(0.058)	-(0.118)	-(0.078)	0.117*	0.118*	-(0.132)	-(0.093)
	(0.042)	(0.041)	(0.091)	(0.091)	(0.048)	(0.047)	(0.090)	(0.091)
Fertilizer in kg/ha	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Manure in kg/ha	0.000***	0.000***	(0.000)	0.000*	0.000***	0.000***	(0.000)	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

ptreatment	0.120***	0.121***	(0.020)	(0.007)	0.142***	0.147***	(0.018)	(0.005)
	(0.027)	(0.027)	(0.062)	(0.062)	(0.030)	(0.030)	(0.063)	(0.063)
fptreatment	(0.086)	(0.073)	(0.271)	(0.268)	(0.116)*	(0.093)	(0.367)	(0.356)
	(0.066)	(0.066)	(0.291)	(0.288)	(0.072)	(0.072)	(0.298)	(0.295)
Inverse Mill's ratio			(0.007)	(0.074)	0.286*	0.358**	(0.086)	(0.075)
			(0.216)	(0.214)	(0.119)	(0.118)	(0.057)	(0.057)
Tenant is relative of landlord (male and female)							(0.066)	(0.078)
							(0.151)	(0.149)
Tenant is relative of landlord for female							-(0.025)	-(0.026)
							(0.089)	(0.088)
Tenant is spouse's relative of landlord							-0.972***	-0.977***
							(0.261)	(0.259)
Tenant is spouse's relative of landlord *for female							(0.053)	(0.117)
							(0.216)	(0.214)
avg_land††		0.136***		-(0.034)		0.179***		-(0.038)
		(0.025)		(0.057)		(0.029)		(0.057)
avg_madult††		-(0.001)		0.074*		(0.027)		0.077**
		(0.016)		(0.030)		(0.019)		(0.030)
avg_fadult††		(0.004)		-(0.033)		(0.032)		-0.032
		(0.018)		(0.031)		(0.022)		(0.031)
avg_oxen††		-(0.004)		-0.055*		(0.010)		-0.063*
		(0.013)		(0.025)		(0.016)		(0.025)
avg_livestock††		(0.006)		-(0.005)		(0.016)		-0.003
		(0.008)		(0.012)		(0.012)		(0.012)
avg_manure††		-0.000***		-0.000***		0.000***		-0.000***

		(0.000)		(0.000)		(0.000)		(0.000)
avg_fertilizer††		0.000***		0.000***		0.000***		0.000***
		(0.000)		(0.000)		(0.000)		(0.000)
Ethyear =1999	-0.478***	-0.442***	-0.446***	-0.438***	-0.466***	0.413***	-0.493***	-0.481***
	(0.030)	(0.031)	(0.073)	(0.074)	(0.033)	(0.036)	(0.079)	(0.080)
Constant	6.996***	6.952***	7.198***	7.152***	6.596***	6.483***	7.118***	7.092***
	(0.129)	(0.130)	(0.342)	(0.344)	(0.194)	(0.193)	(0.343)	(0.344)
N	11162	11162	2085	2085	9077	9077	2085	2085
R squared	0.1295	0.1158	0.0832	0.1045	0.1019	0.1225	0.0914	0.112
F(23, 11070)	51.33	46.4	8.24	8.33	40.38	39.13	7.95	8.1
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

4.3 The Semi-Parametric Estimation

The results of the semi-parametric results are in the appendix in tables A1 and A2. The results of the propensity score matching (table A1) show that education of household head and number of male and female adults in a household are important in explaining participation in certification. The results also indicate that female-headed households are more likely to have participated in the land-certificate program. The estimated propensity scores from table A1 were used to generate matched observations for treatment and control villages, using kernel matching methods (table A2). The matching results show that only one observation from the original sample fell out of the matching sample range. Hence, we used the original sample in our parametric regression analysis. Our measurement of the average treatment effect on the treated category showed that productivity has increased as a result of the certification.

5. Conclusions

We evaluated the effectiveness of the land certification policy on improving the welfare of female-headed households, as measured in terms of plot-level productivity.

The land certification program in Ethiopia is meant to reduce the inherent insecurity of land holdings associated with state ownership of land. It should ease the constraints from reduced tenure security, such as limited land market participation, and promote better land management and investment, and better production decisions associated with an increased sense of ownership. In previous studies, the productivity differentials between male- and female-headed households have been explained by differences in tenure insecurity (Holden and Bezabih 2008; Bezabih and Holden 2009).

For female landowners, who are believed to be systematically more tenure insecure and more reliant on the land-lease market, the land certification program is expected to lead to increased productivity. Thus, it can be argued that interventions that lead to an enhanced sense of land ownership and increased participation in the land-lease market would boost land productivity of female farmers and, consequently, narrow the gender gaps in productivity.

Our results show that plots owned by female-headed households are significantly less productive. This is in line with previous studies that have revealed a gender gap in land productivity. This also indicates that female-headed households are unable to take full advantage of their cultivated area by renting out sufficient amounts of land. Our study suggests that certification programs that seek to reduce tenure insecurity and increase productivity may have greater effects on male-headed households than female-headed households. Controlling for the possibility that certification has a different impact on male and female productivity shows that male-headed households gain significantly and women gain only modestly. Hence, while certification is clearly beneficial to farm-level productivity, it does not necessarily lead to more gains for female-headed households.

The major policy implication of the study is confirmation that effective land reforms do improve the welfare of rural households. The analysis and the results presented in this paper help fill a gap in the literature on the role of reforms in improving economic performance of rural stakeholders in general, and the impact of certification in increasing the productivity of female farmers in particular. The clearest result emerging from our analysis is that the tenure-enhancing impacts of certification appear to boost productivity, most likely by encouraging proper land management and improving input use. Although the impact of certification on enhancing female productivity is less consistent across results, it does bring modestly positive changes and shows the potential of such reforms in reaching rural women.

Future studies that relate imperfections in the process of land reforms with intended economic outcomes can further illuminate our understanding of the relationships between female productivity and land reforms.

Appendix

Table A1. Logit Estimates of Selection into Certification

Variable	Coefficient	Variable	Coefficient
Age of household head	-0.006*** (0.001)	No. of adult male members per hectare	-0.066*** (0.019)
Gender of household head	0.477*** (0.059)	Total farm size in hectares	0.294*** (0.021)
Household head able to write	0.180*** (0.039)	Plot size in hectares	-0.982*** (0.077)
Other fertility category	0.438*** (0.034)	Plot distance from homestead in minutes	-0.003*** (0.001)
No. of adult female members per hectare	0.004 (0.016)		
Constant		-0.283** (0.087)	
Pseudo R-squared	0.0331		
Observations	11162		
Log likelihood	-9658.92		
Chi2	661.03		

* = significant at 10%; ** significant at 5%; *** = significant at 1%

Table A2. Results from the Propensity Score Matching

	Treated	Controls	Difference	S.E.	T-stat	Total
ATT	6.771012	6.71998	0.051031	0.023211	2.2	–
Total no. of observations	4,815	5,928	–	–	–	10,743
No. of observations with common support	4,814	5,928	–	–	–	10,742

References

Agarwal, B. 1994. *A Field of One's Own: Gender and Land Rights in South Asia*. Cambridge: Cambridge University Press.

———. 2003. Gender and Land Rights Revisited: Exploring New Prospects via the State, Family, and Market. *Journal of Agrarian Change* 3(2): 184–224.

Barham, J., and C. Chitemi. 2008. Collective Action Initiatives to Improve Marketing Performance: Lessons from Farmer Groups in Tanzania. CAPRi Working Paper, no. 74. Washington, DC: International Food Policy Research Institute.

Bellemare, M. 2009. The (Im)possibility of Reverse Share Tenancy. MPRA Paper, no. 23681. Munich Personal RePEc Archive. Munich, Germany: University Library of Munich.

Besley, T. 1995. Property Rights and Investment Incentives: Theory and Evidence from Ghana. *Journal of Political Economy* 103(5): 903–937.

Besley, T., and R. Burgess. 2000. Land Reform, Poverty Reduction and Growth: Evidence from India. *Quarterly Journal of Economics* 115(2): 389–430.

Bezabih, M., and S. Holden. 2009. Contract Renewal Differentials of Female- and Male-Owned Farms in Ethiopia. Photocopy. University of Portsmouth, UK.

Chabé-Ferret, S. and J. Subervie. 2010. Evaluating Agro-environmental Schemes by DID Matching: Theoretical Justification, Robustness Tests, and Application to a French Program. Paper presented at the Fourth World Congress of Environmental and Resource Economists, Montreal, Canada, June 2010.

Cook, S. 1999. Surplus Labour Productivity in Chinese Agriculture: Evidence from Household Survey Data. *Journal of Development Studies* 35(3): 16–44.

Cotula, L., C. Toulmin, and C. Hesse. 2004. Land Tenure and Administration in Africa: Lessons of Experience and Emerging Issues. London: IIED. http://www.iied.org/pubs/pdfs/9305IIED.pdf. Accessed July 2010.

Crewett, W., A. Bogale, and B. Korf. 2008. Land Tenure in Ethiopia: Continuity and Change, Shifting Rulers, and the Quest for State Control. CAPRi Working Paper, no. 91. Washington, DC: International Food Policy Research Institute.

Crummy, D. 2000. *Land and Society in the Christian Kingdom of Ethiopia*. Champaign, IL, USA: University of Illinois Press.

de Mel, S., D. McKenzie, and C. Woodruff. 2007. Who Does Microfinance Fail to Reach? Experimental Evidence on Gender and Microfinance Returns. Preliminary draft. Washington, DC: World Bank.

Derman, B., R. Odgaard, and E. Sjaastad. 2007. Conflicts over Land and Water in Africa. Oxford: James Currey.

Dey, J. 1981. Gambian Women: Unequal Partners in Rice Development Projects? *Journal of Development Studies* 17(3): 109–22.

Deininger, K., D.A. Ali, and T. Alemu. 2009. Impacts of Land Certification on Tenure Security, Investment, and Land Markets. EfD Discussion Paper 09–11. Washington, DC, and Gothenburg, Sweden: Resources for the Future and Environment for Development.

Deininger, K., D.A. Ali, S.T. Holden, and J. Zevenbergen. 2007. Rural Land Certification in Ethiopia: Process, Initial Impact, and Implications for Other African Countries. Policy Research Working Paper WPS 4218. Washington, DC: World Bank. http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2007/04/19/000016406_20070419124805/Rendered/PDF/wps4218.pdf. Accessed July 2010.

Deininger, K., D.A. Ali, and T. Yamano. 2006a. Legal Knowledge and Economic Development: The Case of Land Rights in Uganda. Policy Research Working Paper WPS 3868. Washington, DC: World Bank.

———. 2008. Legal Knowledge and Economic Development: The Case of Land Rights in Uganda. *Land Economics* 84(4): 593–619.

Deininger, K., G. Feder, G. Gordillo de Anda, and P. Munro-Faure. 2003. Land Policy to Facilitate Growth and Poverty Reduction. In *Land Reform, Land Settlement, and Cooperatives.* Special edition, edited by P. Groppo. Washington, DC: World Bank and FAO. ftp://ftp.fao.org/docrep/fao/006/y5026e/y5026e00.pdf. Accessed July 2010.

Deininger, K., and S. Jin. 2006b. Tenure Security and Land-Related Investment: Evidence from Ethiopia. *European Economic Review* 50(5): 1245–77.

Di Falco, S., and E. Bulte. 2009. The Dark Side of Social Capital. Unpublished document. http://www.dec.wur.nl/NR/rdonlyres/A75358CC-E90E-467D-B4DD-0265684643E7/100007/Kinshipandinvestment.pdf. Accessed July 2010.

Gabre-Madhin, E. 2001. Market Institutions, Transaction Costs, and Social Capital in the Ethiopian Grain Market. IFPRI Research Report, no. 124. Washington, DC: International Food Policy Research Institute.

Gebreselassie, M. 2005. Women and Land Rights in Ethiopia. Photocopy. Mekelle, Ethiopia: Relief Society of Tigray and the Development Fund.

———. 2006. Land, Land Policy, and Smallholder Agriculture in Ethiopia: Options and Scenarios. Paper prepared for the Future Agriculture Consortium, Institute of Development Studies, Brighton, UK, March 20–22, 2006.

Ghebru, H., and S.T. Holden. 2008. Factor Market Imperfections and Rural Land Rental Markets in Northern Ethiopian Highlands. In *The Emergence of Land Markets in Africa: Impacts on Poverty and Efficiency*, edited by S. Holden, K. Otsuka, and F. Place. Washington DC: Resources for the Future.

Goheen, M. 1988. Land and the Household Economy: Women Farmers of the Grassfields Today. In *Agriculture, Women and Land: The African Experience*, edited by J. Davison. Boulder, CO, USA: Westview Press.

Heckman, J., H. Ichimura, and P. Todd. 1997. Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme. *Review of Economic Studies* 64(4): 605–654.

Holden, S.T., and M. Bezabih. 2008. Gender and Land Productivity on Rented Land in Ethiopia. In *The Emergence of Land Markets in Africa: Impacts on Poverty, Equity and Efficiency*, edited by S.T. Holden, K. Otsuka, and F. Place. Washington, DC: Resources for the Future.

Holden, S.T., K. Deininger, and H. Ghebru. 2009. Tenure Insecurity, Gender, Low-Cost Land Certification, and Land Rental Market Participation. 2009. Photocopy. Department of Economics, Norwegian University of Life Sciences.

Holden, S.T., B. Shiferaw, and J. Pender. 2001. Market Imperfections and Land Productivity in the Ethiopian Highlands. *Journal of Agricultural Economics* 52(3): 53–70.

Holden, S.T., and H. Yohannes. 2002. Land Redistribution, Tenure Insecurity, and Input Intensity: A Study of Farm Households in Southern Ethiopia. *Land Economics* 78(4): 573–90.

Holden, S.T., J. Xu, and X. Jiang. 2009. Tenure Security and Forest Tenure Reform in China. Photocopy. Department of Economics and Resource Management, Norwegian University of Life Sciences.

Jacoby, H., and B. Minten. 2005. Is Land Titling in Sub-Saharan Africa Cost Effective? Evidence from Madagascar. Photocopy. http://siteresources.worldbank.org/DEC/Resources/LandTitles_Mad.pdf. Accessed July 2010.

Jalan, J., and M. Ravallion. 2003. Does Piped Water Reduce Diarrhea for Children in Rural India? *Journal of Econometrics* 112: 153–73.

Kassie, M., and S.T. Holden. 2007. Sharecropping Efficiency in Ethiopia: Threats of Eviction and Kinship. *Agricultural Economics* 37: 179–85.

Kassie, M., and S.T. Holden. 2008. Kinship, Tenure Insecurity, Input Use, and Land Productivity: The Case of Sharecropping in Ethiopia. In *The Emergence of Land Markets in Africa: Impacts on Poverty and Efficiency,* edited by S.T. Holden, K. Otsuka, and F. Place. Washington, DC: Resources for the Future Press, 197–212.

Kebede, B. 2002. Land Tenure and Common Pool Resources in Rural Ethiopia: A Study Based on Fifteen Sites. *African Development Review* 14(1): 113–49.

———. 2008. Land Reform, Distribution of Land and Institutions in Rural Ethiopia: Analysis of Inequality with Dirty Data. *Journal of African Economies* 17(4): 550–77.

Kevane, M., and L.C. Gray. 1999. A Woman's Field is Made at Night: Gendered Land Rights and Norms in Burkina Faso. *Feminist Economics* 5(3): 1–26.

Khadiagala, L.S. 2001. The Failure of Popular Justice in Uganda: Local Councils and Women's Property Rights. *Development and Change* 32(1): 55–76.

Lastarria-Cornhiel, S. 1997. Impact of Privatization on Gender and Property Rights in Africa. *World Development* 25(8): 1317–33.

Lunduka, R., S.T. Holden, and R. Øygard. 2008. Land Rental Market Participation and Tenure Security in Malawi. In *The Emergence of Land Markets in Africa: Impacts on Poverty and Efficiency*, edited by S.T. Holden, K. Otsuka, and F. Place. Washington, DC: Resources for the Future.

Macours, K. 2004. Ethnic Divisions, Contract Choice, and Search Costs in the Guatemalan Land Rental Market. Unpublished paper.

http://www.econ.kuleuven.be/licos/Seminars/materials/paperMacours.pdf. Accessed July 2010.

Mutimba, J., and E. Bekele. 2002. Searching for a Methodological Approach for Reaching Women Farmers. Proceedings of the 18th Annual Conference of the Association for International Agricultural and Extension Education, Durban, South Africa, May 26–30, 2002.

Nega, B., B. Adnew, and S. GebreSelassie. 2003. Current Land Policy Issues in Ethiopia. In *Land Reform, Land Settlement, and Cooperatives.* Special edition, edited by P. Groppo. Washington, DC: World Bank and FAO (Food and Agriculture Organization).

Okali, C. 1983. *Cocoa and Kinship in Ghana: The Matrilineal Akan of Ghana*. London, Boston, and Melbourne: Kegan Paul International.

Place, F., and S. Migot-Adholla. 1998. The Economic Effects of Land Registration on Smallholder Farms in Kenya: Evidence from Nyeri and Kakamega Districts. *Land Economics* 74(3): 360–73.

Quisumbing, A., and L. Pandolfelli. 2009. Promising Approaches to Address the Needs of Poor Female Farmers Resources: Constraints, and Interventions. IFPRI Discussion Paper 00882. Washington, DC: International Food Policy Research Institute.

Quisumbing, A. 1996. Male-Female Differences in Agricultural Productivity: Methodological Issues and Empirical Evidence. World Development 24(10): 1579–95.

Rashid, M., and R. Townsend. 1993. Targeting Credit and Insurance: Efficiency, Mechanism Design, and Program Evaluation. Photocopy. Washington, DC: World Bank, Population and Human Resources.

Ravallion, M. 2007. Evaluating Anti-Poverty Programs. *Handbook of Development Economics* 4: 3787–3846.

Reid, J.D. 1979. *Sharecropping in American History*. New York: Agricultural Development Council.

Roberts, P. 1988. Rural Women’s Access to Labor in West Africa. In *Patriarchy and Class: African Women in the Home and Workplace,* edited by S. Slichter and J. Parpart. Boulder, CO, USA: Westview Press.

Rosenbaum, P., and D. Rubin. 1983. The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 70: 41–55.

Sadoulet, E, A. de Janvry, and S. Fukui. 1997. The Meaning of Kinship in Sharecropping Contracts. *American Journal of Agricultural Economics* 79: 394–406.

Saito, K., and D. Spurling. 1992. Developing Agricultural Extension for Women Farmers. Washington, DC: World Bank.

Skoufias, E. 1995. Household Resources, Transaction Costs, and Adjustment through Land Tenancy. *Land Economics* 71(1): 42–56.

Slaughter, M. 2001. Trade Liberalization and Per Capita Income Convergence: A Difference-in-Differences Analysis. *Journal of International Economics* 55(1): 203–228.

Smith, J., and P. Todd. 2005. Does Matching Overcome La Londe's Critique of NX Estimators? *Journal of Econometrics* 125(1–2): 305–353.

Sridhar, T. 2008. Gender Differentials in Agricultural Productivity: Evidence from Nepalese Household Data. Trento, Italy: CIFREM, University of Trento.

Sjaastad, E., and Bromley, D.W. 1997. Indigenous Land Rights in Sub-Saharan Africa: Appropriation, Security, and Investment Demand. *World Development* 25: 549–62.

Tadesse, M., Holden, S.T., and R. Øygard. 2008. Contract Choice and Poverty in Southern Highlands of Ethiopia. In *The Emergence of Land Markets in Africa: Impacts on Poverty and Efficiency*, edited by S.T. Holden, K. Otsuka, and F. Place. Washington, DC: Resources for the Future, 112–130.

Teklu, T., and A. Lemi. 2004. Factors Affecting Entry and Intensity in Informal Rental Land Markets in Southern Ethiopian Highlands. *Agricultural Economics* 30(2): 117–28.

Tikabo, M.O. 2003. Land Contract Choice: Poor Landlords and Rich Tenants—Evidence from the Highlands of Eritrea. PhD diss., Agricultural University of Norway.

Tripp, A.M. 2004. Women's Movements, Customary Law, and Land Rights in Africa: The Case of Uganda. *Africa Studies Quarterly* 7(4): 1–19.

Vranken, L., and J. Swinnen. 2006. Land Rental Markets in Transition: Theory and Evidence from Hungary. *World Development* 34(3): 481–500.

Yngstrom, I. 2002. Women, Wives, and Land Rights in Africa: Situating Gender Beyond the Household in the Debate over Land Policy and Changing Tenure Systems. *Oxford Development Studies* 30(1): 22–40.

Udry, C. 1996. Gender, Agricultural Production, and the Theory of the Household. *Journal of Political Economy* 104(5): 1010–46.