Land Certification in Ethiopia: An Illusion or a Solution?

Hosaena H. Ghebru and Stein T. Holden
Department of Economics and Resource Management (IØR)
Norwegian University of Life Sciences (UMB)
P.O.Box 5003, N_1432, Ås, Norway
Email: hosaenag@yahoo.com or hoasena.hagos@umb.no

Abstract

This paper analyses the productivity impacts the Ethiopian land certification program by identifying how the "technological gains" would measure up against the benefits from a resultant improvements in "technical efficiency". For this purpose, we adopted a 'Malmquist-type' productivity index obtained from Data Envelopment Analysis (DEA) models which can be decomposed into: (1) an index for the comparison of within group farm efficiency, evaluating the pure technical efficiency; and (2) an index for the comparison of group frontier productivity, reflecting the longterm investment effects of land certification. We found that farms without land-use certificate are, on aggregate, less productive than those with formalized use rights. We found no evidence to suggest such productivity difference is due to inferior technical efficiency. Rather, the reason is down to 'technological advantages' or favorable investment effect farms with land use certificates enjoy when evaluated against those farms not included in the certificates.

Key words: Land tenure, Land certification, Data envelopment analysis, Malmquist Index, Ethiopia.

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1. Introduction

Intensification of agricultural production, i.e., more frequent use of agricultural land and increased input use associated with introducing high-yielding varieties, has contributed much toward achieving self-sufficiency of food production in the developing world, especially Asia. Governments and international agencies have considered agricultural intensification the primary means for inducing technological change in developing countries that have high population pressure and low agricultural productivity.

However, because of the conventional view that traditional or "customary" land rights impede agricultural development, many developing countries have considered land titling (the formal registration of land that had previously been used without formal title and certificate) to be top priority in their economic development agenda (Atwood, 1990; Holden et al., 2007). On the top of that, poor nations like most sub-Sahara African countries are in a pressing problem of gearing their meager resources (budget) across various competing projects based on their relative expected benefits. It is, therefore, vital and timely for policy makers in LDC's and international financial institutions (like the World Bank and IMF) to clearly understand the persistence and degree of such benefits which can reasonably be expected from the land titling programs.

Taking advantage of a detailed plot level household survey from the northern highlands of Ethiopia, this paper introduces some innovative elements into the pool of studies on efficiency analysis (references). Beyond a mere comparison of relative productivity between farms belonging to different groups or government programs (based on whether they have formalized land use right or a certificate or not), this study adopts a method to decompose such group differences in productivity in to: (1) differences in within-group efficiency spread or individual performances within each group (learning or catching-up effect), and (2) differences in technology (distance between group frontiers). We accomplish this task of analyzing the productivity difference by constructing Malmquist-type productivity index which allows us to compute the difference in productivity between two groups of farms belonging to different government programs or groups (whether they are included in the land certification process or not).

Therefore, comparing the economic (efficiency) performance of group of farms with formalized land use right (certificate) against those without such formal entitlement, this study attempts to answer fundamental questions like: Whether there are any productivity enhancing benefits from land certification or not? What portion of this gain in productivity (if any) is attributable to the investment effects (improvement in farming techniques and a shift in a frontier)? How much of these gains are attributed to an improvement in technical efficiency (within-group efficiency spread)? Therefore, assessing the decomposed effect of land certification by identifying how the "technological gains" would measure up against the benefits from improvement in technical efficiency is the main rationale for this paper. To our knowledge, studies on productivity differences to evaluate group performances of farms belonging to different government programs or specific policy intervention that compares such decomposed effects are completely missing in the literature.

Based on the results from the Malmquist productivity index, it shows that farms belonging to the group without land use certificate are less productive in aggregate terms than those certified ones. It is, however, important to note how the decomposition of this index brought another interesting story in the helm as far as program (group) performance is concerned. Accordingly, even if farms without land use certificate perform poorly or are less productive as compared to the certified farms, this is not due so much to lack of internal technical efficiency where this group performs as good as their titled counterparts. Rather, the reason is down to a technological disadvantage that the former group suffers with respect to those with land use certificate.

This paper is organized as follows. Section 2 reviews the conceptual framework for the economic benefits of land certification. The analytical approach adapted in this study to measure productivity and productivity differences is discussed in section three. Section 4 describes the data sources and variable definition while the last two sections are devoted for the discussion of results and concluding remarks.

2. Literature Review

The economic relevance or importance of government-issued land use certificates are mainly justified through three major sources, namely the effect of formalized land use rights in enhancing tenure security facilitating (1) Technological Change: Long-term investment in land

and (2) smooth functioning of the land (rental) markets that lubricate factor-ratio adjustment, and (3) facilitating access to (informal) credit or informal collateral arrangement (Feder et al., 1988; Feder and Nisho, 1999).

Tenure security: Investment Effect

Farm households' investment in practices that enhance the long-term viability of agricultural production hinges significantly on the expectations regarding the length of time over which the investor (farmers) might enjoy the benefits which mostly are long-term. These expectations depend on the sense of tenure insecurity (whether through ownership of disputes, eviction or expropriation by the government). With titling (ownership officially documented and verified via land certificates), the land holder's sense of tenure security will be enhanced and, therefore, boost incentives to invest in such practices that enhance long-term sustainability of agricultural production (such as land improvements, conservation practices and adoption of new technology) which ultimately may increase farm productivity (Hayes, Roth and Zepeda, 1997; Gavian and Fafchamps, 1996; Gebremedhin and Swinton, 2003; Deininger and Jin, 2006; Deininger et al., 2008; Holden et al., 2008).

Tenure security: Market Efficiency Effect

In addition to its investment enhancing effects, formalization of land titles may, as well, facilitate the smooth functioning of land transactions (land rental markets in the Ethiopian context). This is so as imperfections in such markets (transaction costs and ownership uncertainties) may be more severe when agents of the market lack formal land use rights. From the supply side perspective, for instance, without clear and definite claims to the land, farmers (potential landlords) can be reluctant to transfer ownership (rent/leas out land) to others for the mere fact of fearing to lose the land through administrative redistribution (Ghebru and Holden, 2008; Deininger et al., 2008). In such circumstances, it is possible that the land holder may operate the land by him/herself instead of transferring it even if the productivity of the land is far better under different operator (potential tenant) with better skill and complementary farm inputs. Land titling could, therefore, come to the rescue to reduce such ownership uncertainties and increase land market efficiency. This may ultimately increase farm level efficiency as factor-ratio adjustment can now be channeled through the smoothened land markets.

Access to credit: Interlinked Collateral (indirect tenure insecurity)

Looking for the formal "collateral effects" of land titles to facilitate access to formal credit is irrelevant in the Ethiopian context as collateral use and sales of land is legally prohibited and totally banned where the law only grants land use rights. With a similar fashion, however, due to the high (fixed) transaction cost and information asymmetry (incomplete information about the borrower) in the formal credit markets, it is well established fact that rural farm households are credit constrained and are more reliant on the informal sources (from local money lenders or well-to-do farmers). To make things worse, the risky nature of the agricultural production demands the informal money lenders to look for a "collateral" by titling the land of the borrower in a "land rental-type" guarantee for loan repayment. Therefore, for title-less farmers, getting access to credit (informal credit which is characterized by it small size and short time) is not only an expensive second-best source but may also be missing entirely (rationing-out) due to the lack of guarantee about the ownership of the land that money lenders look for to tie it up (an indirect tenure insecurity passed to a third party - local money lender). A formal land title, thus, could remove such constraints (liquidity constraints) and enable farmers to improve appropriate variable input use which may increase farm level efficiency.

All these three arguments which are forwarded in defense of intensifying the formalization of land titles can be viewed to have a productivity impact through two major channels, namely:

1. Causing a shift in an production frontier (or a change in farming practices and technology adoption) through the "investment effects" from improved tenure security, and
2. An increase in farm level technical efficiency through:
    a. A relative ease in farm factor-ratio adjustment (enabling farms to operate at an optimal scale) facilitated through a reduction in ownership uncertainty and smooth land transactions, and
    b. An improvement in variable input use by reducing the transaction cost of accessing the informal credit market and, thereby, reducing the liquidity constraint.

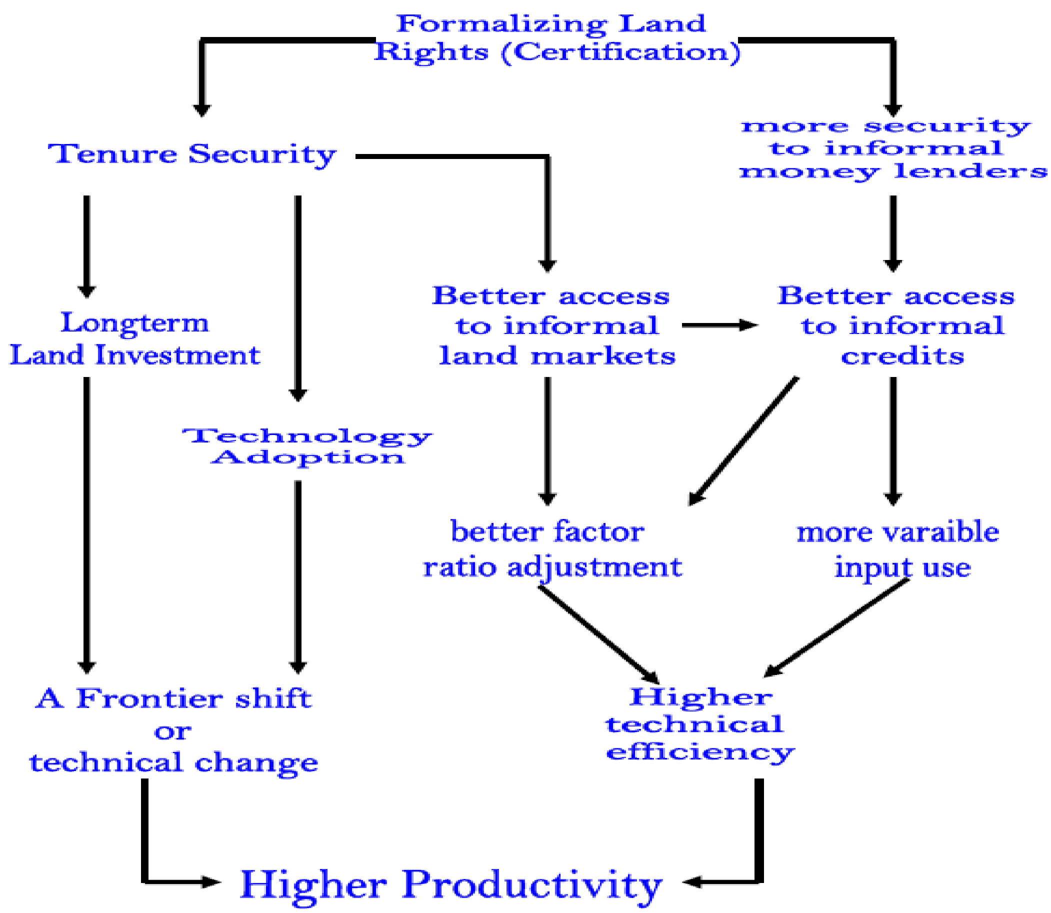

Fig. 1: The Impact of Land Certification on Productivity

The diagram above shows that the technical change (investment effect) and an improvement in pure technical efficiency are the two channels through which land titling program may play an overall farm productivity enhancing role. Though the later goal can be achieved through alternative policy measures like formalization of the tenancy market and improving agricultural extension services, enhancing (on farm) investment incentives through land certification can only be a socially desirable policy measure (as there are arguments against complete privatization of rural land ownership) if it is not the only way to achieve the ultimate target of improving tenure security and thereby productivity.

Because of the conventional view that traditional or "customary" land rights impedes agricultural development, many developing countries has considered land certification (the formal registration and documentation of land that had previously been used without formal land use rights) to be top priority in their economic development agenda (Atwood, 1990; Holden et al., 2007). On the top of that, poor nations like most sub-Sahara African countries are in a pressing problem of gearing their meager resources (budget) across various competing projects based on their relative expected benefits. It is, therefore, vital and timely for policy makers in many LDC's and international agencies (like the World Bank and IMF) to clearly understand the persistence and degree of such benefits which can reasonably expected from the land titling/certification programs.

By comparing the economic (efficiency) performance of group of farms with formalized land use right (certificate) against those without such formal entitlement, this study attempts to answer fundamental questions like: i) Whether there are any productivity enhancing benefits from land certification or not? ii) What portion of this gain in productivity (if any) is attributable to the investment effects (improvement in farming techniques and a shift in a frontier)? iii) How much of these gains are attributed to an improvement in technical efficiency (within-group efficiency spread)? Therefore, assessing the decomposed effect of land certification by identifying how the "technological gains" would measure up against the benefits from improvement in technical efficiency spread is the main rationale for this paper.

As it will be discussed in the next section of this paper, a modified - Malmquist productivity index (an aggregate program performance measurement) is constructed to identify the productivity gains from the land certification program and decomposition of this index benefits our approach of addressing the segregated impact land titling/certification might have up on triggering a shift in a frontier (technology gains) and/or improvement in technical efficiency (within-group efficiency spread). A clear link between the conceptual framework and the analytical approach (see section 3) is shown in bottom part of diagram 1.

3. Method of Analysis

Exogenous factors like government policy interventions or implementation of various development programs may provide rural farm household units with the various types and degrees of opportunities and challenges which ultimately affect their decision making behavior. Most studies, however, conduct the efficiency and productivity analysis entirely based on a method by pooling decision making units together to form a common benchmark frontier which gives less or no notice of the circumstances mentioned above. To our knowledge, studies on productivity differences to evaluate group performances of farms belonging to different government programs or specific policy intervention that compares such decomposed effects are completely missing in the literature.

Attempting to void this gap and characterize the potential productivity differentials among competing programs or groups, this paper adopts new measures of performance evaluation method based on a non-parametric productivity index approach – a Malmquist-type productivity index. Unlike the aforementioned previous studies, the method makes comparisons to group-specific frontiers, without pooling the DMUs together to form a common frontier.

We attempt to study productivity and productivity differences between farm household units that belong to different programs or policy interventions with in the frame work of Data Envelopment Analysis (DEA). DEA is a linear programming technique for constructing a non-parametric piecewise linear envelope to a set of observed output and input data (Coelli et al, 2005). Resent application of DEA method on the estimation and explanation of agricultural efficiency in developing countries include (Dhungana, Nuthall et al. 2004) on Nepal rice farms, (Chavas, Petrie et al. 2005) on Gambia farms, (Shafiq and Rehman 2000) on Pakistan coffee farms.

The Malmquist index was introduced by Caves et al. (1982) and developed further by Fare et al. (1994). The index is normally applied to the measurement of productivity change over time, and can be multiplicatively decomposed into an efficiency change index and a technological change index. Similarly, the 'adopted' Malmquist index (performance index for program evaluation) used in this paper can be multiplicatively decomposed into an index reflecting the efficiency spread among DMUs operating in similar conditions (internal efficiency effect), and an index reflecting the productivity gap between the best-practice frontiers of the two different programs or groups (technology effect). Therefore, unlike the 'original' Malmquist index which measures the productivity change of a DMU between two time periods, it is important to note the distinct feature of the adopted Malmquist index is that it allows a cross sectional comparison between groups of DMU operating in different condition in a static setting, i.e., for a given moment in time.

Technology Characterization: Data Envelopment Analysis (DEA)

Before the derivation and decomposition of the '*adopted*' Malmquist index, it is important to introduce the concept of distance functions as the very idea of the productivity index was originally incepted by a Swedish statistician Sten Malmquist (1953) who had proposed constructing input quantity indices as ratios of distance functions.

Assuming $X^i = (X_1^i, X_2^i, ..., X_M^i) \in \Re_M^+$ denotes the input vector to produce Y^i where i corresponds to a group under which the decision making units (DMUs) operate[1], the feasible production frontier that describes the technology of the farming units can be defined in terms of correspondence between the output vector Y^i and the input requirement set $L^i(Y^i)$ where:

(1) $L^i(Y^i) = \{X^i : (X^i, Y^i) \in T^i(X^i)\}$

The input requirement set $L^i(Y^i)$ provides all the feasible input vectors that can produce the output vector Y^i where $T^i(X^i)$ is the technology set of a group or government program i showing X^i can produce Y^i.

Assuming constant returns to scale, Farrell (1957) proposed a radial measure of technical efficiency in which the efficiency is measured by radial reduction of the levels of inputs relative to the frontier technology holding output level constant[2]. Stated otherwise, Farrell's input-oriented measure of technical efficiency estimates the **minimum** possible expansion of X^i which is given by:

(2) $F^i(X^i, Y^i) = \min\{\varepsilon : \varepsilon X^i \in L^i(Y^i)\}$

As formalized by Fare and Lovell (1978, 1994), Farrell's input-saving efficiency measures are the same as the inverse of Shephard's input distance function which provides the theoretical basis

[1] As the emphasis of the study is to explain the potential productivity differentials with respect to the land use certificate, from this on ward, we adopt two groups: *Group 1*: DMUs or farms with no land use certificate given for and *Group 2*: those which are formalized use rights (certificates).

[2] The input-oriented model implicitly assumes cost-minimizing behavior and the output-oriented DEA, on the other hand assumes revenue maximizing behavior of farmers. In our case, it is thus reasonable to assume that farmers have a budget constraint and thus minimize costs.

for the 'adopted' Malmquist productivity index.[3] Therefore, within the context of input distance function, equation 2 can be rewritten as[4]:

(3) $D^i(X^j, Y^j) = \max_{\mu_{ij}}\{\mu_{ij} : (X^j / \mu_{ij}) \in L^i(Y^i)\}$ i, j = 1, 2

where $D^i(x^j, y^j)$ represents the input distance function for a DMU in program or group *j* with respect to the frontier technology of group *i*, the scalar μ_{ij} is the maximum reduction (contraction) of the input vector of a DMU belonging group or program *j* (X^j), the resulting deflated input vector (X^j / μ_{ij}) and the output vector (Y^i) are on the frontier of the farming system under group or program *i*.

The Malmquist Index

Taking the technology of farming units under group or program '*i*' as reference or base technology to compare potential productivity differentials among the two property right group or programs with C_w farms in group one and C_n farms in group two, the input oriented Malmquist productivity index developed by fare et al. (1994) can be defined as:

(4) $$M_i\left(Y_j^1, Y_j^2, X_j^1, X_j^2\right) = \frac{\left(\prod_{j=1}^{C_n} D^i\left(Y_j^1, X_j^1\right)\right)^{\frac{1}{C_n}}}{\left(\prod_{j=1}^{C_w} D^i\left(Y_j^2, X_j^2\right)\right)^{\frac{1}{C_w}}} = \frac{1/\varepsilon_{i1}}{1/\varepsilon_{i2}} = \frac{\varepsilon_{i2}}{\varepsilon_{i1}},$$ where *i*= 1,2

The above ratio evaluates the distance of the DMUs in each group to a single reference technology *i*. The numerator evaluates the average (geometric mean) distance, relative to group *i*'s frontier, of DMUs or farms from 'group one' while the denominator evaluates the average distance of DMUs from 'group two'[5]. Since we have no reason to prefer either group one frontier (a frontier defined by farms without land certificate) or group two frontier (a frontier

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[3] $F^i(X^j, Y^j) = \text{Min } \varepsilon = [D^i(Y^j, Y^j)]^{-1}$ $i, j = 1, 2$

[4] The expression $D^i(X^j, Y^j)$ is the maximum value by which the input vector can be divided and still produce a given level of output vector y.

[5] Let Group one be group of farms without certificate and Group two be farms with land certificate

from farms with land certificate) as a reference technology, we consider the geometric mean of the two and rewrite the above formulation as:

(5) $$M_{12}\left(Y_j^1, Y_j^2, X_j^1, X_j^2\right) = \left[\frac{\left(\prod_{j=1}^{C_n} D^1\left(Y_j^1, X_j^1\right)\right)^{\frac{1}{C_n}}}{\left(\prod_{j=1}^{C_w} D^1\left(Y_j^2, X_j^2\right)\right)^{\frac{1}{C_w}}} \cdot \frac{\left(\prod_{j=1}^{C_n} D^2\left(Y_j^1, X_j^1\right)\right)^{\frac{1}{C_n}}}{\left(\prod_{j=1}^{C_w} D^2\left(Y_j^2, X_j^2\right)\right)^{\frac{1}{C_w}}}\right]^{\frac{1}{2}}$$

Thus, the two ratios inside the square brackets evaluate the distance of the DMUs to a single reference technology. The first ratio evaluates the average distance, measured relative to group one's frontier, of DMUs or farms from group one divided by the average distance of DMUs from group two. The second ratio is similar quotient taking group two's frontier as reference. Also, when comparing the two groups we consider information from all DMUs to avoid the limitations associated with the definition of an "ideal or representative" DMU to represent each group. Hence, the aggregation of the distances or efficiency scores is done using the geometric mean.

M_{12} greater than one indicates a higher productivity farms cultivated under the second property right group or program (plots with land use certificate) than the first group or program where plots do not have the land certificate. This is so since the maximum reduction of an input vector of a DMU that belongs to group-one necessary to reach the frontier (technology) under group or program *i* is always higher than that of a corresponding DMU belonging to the 2nd group. The vise versa also holds true that M_{12} implies the opposite where DMUs under the first group or program are superior than those which belong to the 2nd.

With particular relevance to the theme of this study, the use of the Malmquist productivity index provides an opportunity to further decompose the global productivity differences between groups M_{12} in to the following two sub-components:

(6) $$M_{12}\left(Y_j^1, Y_j^2, X_j^1, X_j^2\right) = \frac{\left[\prod_{j=1}^{C_n} D^1\left(Y_j^1, X_j^1\right)\right]^{\frac{1}{C_n}}}{\left[\prod_{j=1}^{C_w} D^2\left(Y_j^2, X_j^2\right)\right]^{\frac{1}{C_w}}} \cdot \left[\frac{\left(\prod_{j=1}^{C_n} D^2\left(Y_j^1, X_j^1\right)\right)^{\frac{1}{C_n}}}{\left(\prod_{j=1}^{C_n} D^1\left(Y_j^1, X_j^1\right)\right)^{\frac{1}{C_n}}} \cdot \frac{\left(\prod_{j=1}^{C_w} D^2\left(Y_j^2, X_j^2\right)\right)^{\frac{1}{C_w}}}{\left(\prod_{j=1}^{C_w} D^1\left(Y_j^2, X_j^2\right)\right)^{\frac{1}{C_w}}}\right]^{\frac{1}{2}}$$

$$= \underbrace{\frac{E_{22}}{E_{11}}}_{\textit{Catching-up Effect}} * \underbrace{\left[\frac{E_{11}}{E_{21}} \cdot \frac{E_{12}}{E_{22}}\right]^{\frac{1}{2}}}_{\textit{Frontier-shifter (Technology Gap)}}$$

This feature of the index is very valuable in our case since appropriate policy prescriptions will be different for productivity differences due to catching-up being modest or best, or the difference is due to variation in technology adopted (lack of enough shifters in the frontier)

The catching-up effect (M_{12}^{e})

This component of the Malmquist productivity index compares the difference in internal technical efficiency or within-group efficiency spreads. Its value is given by the ratio of the geometric means of the distance of the DMUs to their group specific frontier or technology, as follows:

(7) $$M_{12}^{e} = \frac{\left[\prod_{j=1}^{C_n} D^1\left(Y_j^1, X_j^1\right)\right]^{\frac{1}{C_n}}}{\left[\prod_{j=1}^{C_w} D^2\left(Y_j^2, X_j^2\right)\right]^{\frac{1}{C_w}}}$$

A value of M_{12}^{e} less than one indicates that the efficiency spread is smaller (that is there is greater consistency in efficiency levels) among DMUs of group-one than in those in group-two. This, in a sense, means, on aggregate terms, farms in group-one seem to catch-up well with the performance of their own best practice farms as compared to those in group-two.

Productivity gap between best practice frontiers (frontier-shifter effect - M_{12}^{f})

This index which measures the distance between the best-practice frontiers of groups one and two is given by:

(8) $$M_{12}^{f}=\left[\frac{\left(\prod_{j=1}^{C_n}D^2\left(Y_j^1,X_j^1\right)\right)^{\frac{1}{C_n}}}{\left(\prod_{j=1}^{C_n}D^1\left(Y_j^1,X_j^1\right)\right)^{\frac{1}{C_n}}}\cdot\frac{\left(\prod_{j=1}^{C_w}D^2\left(Y_j^2,X_j^2\right)\right)^{\frac{1}{C_w}}}{\left(\prod_{j=1}^{C_w}D^1\left(Y_j^2,X_j^2\right)\right)^{\frac{1}{C_w}}}\right]^{\frac{1}{2}}$$

A value of M_{12}^{f} less than one indicates greater productivity (dominance) of the frontier of group-one compared to group-two. If the internal technical efficiency (aggregate efficiency spread) of farming activities in group one and two is the same, the first component of the index M_{12}^{e} is equal to one and the productivity difference represented by the Malmquist index (M_{12}) will be explained only by the distance between the two respective frontiers of the two groups (i.e., . M_{12}^{f}).

Calculating the Malmquist Productivity Index

As shown in the previous section, generating the 'adopted' Malmquist Productivity index requires the computation of four separate input distance function or four Farrell input saving efficiency measures for each farming unit under each of property right groups or programs. To obtain the efficiency scores, we follow Fare et al. (1995) technique of solving a linear programming problem for each farm household unit. Considering a frontier technology of group or program i as reference or benchmark frontier, a linear programming problem for a DMU or farm belonging to group or program *j* can be stated as:

(9) $$[D^{i}(x^{j}, y^{j})]^{-1} = \underset{Z_{ij}}{Min}\ \varepsilon_{ij}$$

s.t

(a) $Y_i z_{ij} \geq y_j$, (b) $X_i z_{ij} \leq x_j \varepsilon_{ij}$, (c) $z_{ij} \geq 0$, and (d) $\sum_j z_{ij} = 1$

Where Y_i is a vector of output in the benchmark sample, X_i is the m x n matrix of inputs in the benchmark sample, and z_{ij} the n x 1 vector of intensity weights indicating the intensity levels which makes the activity of observation (FHU) 'j' compared (expand or contract to construct a piecewise linear technology) to the benchmark FHU (Fare et al., 1994). Note that when the performance FHU 'j' is compared to a frontier generated from a sample excluding FHU 'j', assuming constant returns to scale is sufficient to ensure the existence of a solution to the LP problem in the input saving efficiency case reducing the importance of constraint (d). The introduction of this additional restriction on the sum of weights (constraint'd'), thus, allows us to generalize the problem to the case of variable returns to scale (VRS).

The above LP problem is solved by using data that comprises both group or programs to evaluate the input-output combination under group or program j (x^j, y^j) relative to technology constructed from the second group or program i (x^i, y^i) data. $D^j(x^i, y^i)$ is solved in similar manner, by using data from both group or programs to evaluate (x^i, y^i) input-output combination of group or program 'i' relative to technology constructed from (x^j, y^j) data of FHU's under group or program *j*. $D^i(x^i, y^i)$ is solved for every FHU *i* belonging to group or program 'i'. Finally, $D^j(x^j, y^j)$ is solved for every farm household belonging to group or program *j*. After these four distance functions are calculated for every producer in each group or program, Malmquist productivity indexes can be calculated and decomposed as given by equation 6 on page 16.

4. Data and Descriptive Summary

Data

In an attempt to achieve the theme of the paper, the study used a comprehensive plot-specific household level data from a district from the Tigray regional state of Ethiopia[6] which was identified as a district where a relatively larger portion of farm households are without the land use certificate. All households from four villages of this district were, then, stratified based on whether they have land use certificate or not. An ownership of the land use certificate can be due to an exogenous (administrative) reason of an endogenous (household specific) factor which may ultimately cause Correlation between the certificate variable and the error term of the outcome equation.

A through empirical investigation of the process of registration and certification revealed the following reasons why some households did not have land certificates: (a) some households may have been left out of the registration because they were absent at the time; b) some households did not collect their certificates because they may not have considered them to be

[6] The region is the first region to start a low-cost land certification in ethiopia and Africa

important at that time; c) some households have lost their certificates after they received them or, if there was a change in the head of the household, the new head of the household failed to take over the old certificate or obtain a new one d) administrative failures caused incomplete registration and certification in some communities; e) some households did not receive the certificates because the administration ran out of certificates and failed to obtain additional ones.

The administrative failures (listed as reasons d and e) appear to have affected households and communities quite randomly and are not likely to create any endogeneity bias. However, reasons a), b), and c) above may potentially create bias. A careful measure excluding of households with such reasons for not having the land use certificate has, therefore, been taken before a random selection of 320 farm households (80 farm household units from each of the four villages in the district). Due to administrave problems in the data collection[7], 24 farm household units have been dropped from the study. Of all the 296 households considered by the study, 161 (54.4%) are rural farm households who possess land use certificate while the remaining 135 (45.6%) are households without land certificate. The total number of farms (plots) operated by the sample households was 1356 among which 199 are irrigated and 87 plots are leased-in plots. Due to their very high degree of correlation with the having no land use certificate, plots that are irrigated and leased-in are dropped from the analysis which leaves 1070 plots are considered for the analysis in this paper which consists of 588 and 482 plots with and without certificate, respectively

Descriptive Analysis

Table 1 summarizes some selected characteristics of farm households based on their possession land use certificate (LUC). Signifying the sampling (if not the certification process), farmers with and without certificate have comparable demographic and endowment variables such as the sex and age of household heads, the average size of households, number of male and female adults and key livestock endowment variables like cow and oxen.

Though there seems no significant variation with respect to farm households' access to input markets and ways of income diversification, farm households likelihood of investment in

[7] To no compromise the quality of the data and avoid fed-up problems as far as respondents is concerned, the questionnaire was administered in three separate sections: the household demography, the perception and plot level sections interviewed by separate enumerators at distinct times. Failure to collect data of each section from each respondent ends up dropping out the respondent for incomplete data.

long-term land related investments and adoption of technology (modern input applications) is significantly different as those farm households with land use certificate are compared to their counterparts without the key intervention. Likelihood of own-plot conservation investment is slightly but significantly higher for farm households with land use certificate, at 94.3% compared to 83.9% for those who do not have formalized land use rights. The percentage of those households who considered improving (maintaining) an already existent conservation structure is also significantly higher for those with certificate, 40.7%, compared to only 28.6% by households without land certificate. 62.1 and 57.9 percentage of the households with land use certificate has adopted chemical fertilizer and modern (selected) seed varieties, respectively, which is significantly higher than their counterparts who do not have land certificates (which comprises only 50% and 46.4%, respectively).

A summary of the plot level total output value and level of inputs used both in the stochastic frontier and the non-parametric (DEA) Malmquist index analyses is provided in table 2. As shown in the table, farm plots with land certificate consume slightly higher number of labor and seed costs per *tsimdi* while the average number of oxen days and amount of chemical fertilizer are higher on farm plots without land use certificate.[8] On average, farm plots which appeared to be on the land use certificate also produces slightly higher value of output per *tsimdi* than those without certificate.

An overview of the impact of land certification on long-term land related investments and/or technology adoption (modern farm input application) through which the land certification may have affected productivity is presented in table 3. Consistent with the theoretical justification and empirical evidences from studies that have assessed such impact of tenure security, summary results from table 3 shows a technology (frontier-shift) impact of land certification[9]. Looking at the potential long-term land related investment impact of the land use certificate, a large and significant number of farm plots with land certificate has been conserved with the ratio as high as 56% compared to 51% for plots without land use certificate. Further improvement (maintenance) of an existing conservation structure is also higher in the former (21%) than the later case (15%).

[8] Tsimdi is a local area measurement unit which is equivalent to a quarter of a hectare.
[9] All the variables summarized are in their dummy (dichotomy) form to show a shift or a jump in the frontier which may not be the case had their level form have been considered.

Showing the technology adoption (modern input use application) impact of land use certificate, the summary result also depicts a higher percentage of application of chemical as well as organic fertilizer (53% and 29%, respectively) on plots with land certificate compared to their counterparts without land use certificate (only 46% and 23%, respectively). Consistent with the household level summary results, the ratio of plots with land certificate that applies modern seed varieties is also slightly higher for plots with land certificate than those otherwise. These results are consistent with results of a study by Holden et al. (2008) which was conducted in similar study area.

Due to the productivity enhancing role of those key variables (long-term land related investment and application of modern farm inputs), the dominance of plots with land certificate over those plots without formalized land use rights, therefore, may suggest to consider separate production frontiers for each group in the forthcoming analysis. This strong assumption is more pronounced by a positive and statistically significant certificate variable (where this variable is included as a farm production attribute together with the customary farm inputs) from parametric results of alternative stochastic frontier analyses in the next section.

5. Results and Discussion

In an attempt to achieve the main objective of the study, we adopt the Malmquist productivity index approach to characterize a possible productivity differential between farm plots with formalized land use rights versus those with out it and further decompose the index in to an internal efficiency spread and/or technology gap. The theoretical basis as well as empirical evidences on the technology adoption impact of land certification (and the resultant sense of tenure security) is, however, not straight forwards and, actually, very thin. Hence, an adoption of the Malmquist index, which requires the use of separate group frontiers, to compare productivity differentials between certified plots against plots without land use certificate is not straightforward.

To solve such analytical bottleneck, a parametric approach has been utilized to initially assess if, at all, land certification has a potential productivity (frontier shifting) impact. This is done by pooling the dataset and analyzing a stochastic frontier analysis considering a dummy variable for being a farm plot with land certificate as a production input alongside the customary farm implements (like land oxen, labor, etc). Therefore, the parametric results of structural efficiency comparison of plots is worth discussing before analyzing the non-parametric results of the Malmquist productivity index that explains the source of productivity differentials between the two groups of farm plots.

Structural Efficiency Comparisons: Parametric Approach

The estimated results from the stochastic frontier production function are summarized in tables 4 and 5. As the main aim of this section is to assess whether or not the land use certificate has any technology (frontier-shifting) impact, table 4 summarize results from alternative stochastic frontier production functions. To show the robustness of results, results from the Cobb-Douglas, partial translog and the full translog production functions are presented. A positive and statistically significant (at varying degree) land certificate variable in all the alternative production functions suggest that farm plots with land use certificate are more productive than plots without formalized land use rights.

Using the specifications of the Cobb-Douglas production function where results are interpreted as input specific output elasticities, table 5 shows key comparable results from both groups of farm plots. In both specification (plots with and without land use certificate) output is most responsive to area under cultivation, labor and the value of seeds. Though results from the pooled data in table 4 shows, on average, plots with land use certificate performs better than their counterparts without formalized land use rights, the very high estimates of technical inefficiency in both situations (very low technical efficiency score of 47% and 41% for plots with and without land use certificate, respectively) means the existence of a huge efficiency spread (gap) among farm plots within each group.[10]

Stated otherwise, this result shows, though the overall performance of farm plots is higher for certified plots, plots without land use certificate do not seem to perform so badly in terms of catching-up with the best practice farms since both groups have a very low structural efficiency score. Therefore, efficiency enhancing measures like the intensification of agricultural extension services and better access to credit could be key alternative long-term strategies to be considered.

As the major aim of the study is to characterize and explain the source/cause of productivity differentials between groups of farm plots, further effort has been exerted to

[10] The stochastic frontier analysis use the dataset that considers plots with land use certificate (n=588) and plots without land certificate (n=482) together where the number of observations become 1070.

investigate whether any productivity differential is down to a mere difference in within-group efficiency spread (ability to catch-up with the best practice farms of each respective group) or is due to technology gap (dominance of a frontier over the other) or both utilizing the Malmquist productivity index approach. Therefore, the consistently positive and statistically significant certificate variable in all the alternative models from table 4 together with the mean-comparison results from table 3 are enough to suggest and assume that plots with land use certificate operates on a distinct (higher) production frontier than plots without land use certificate, which is the theoretical basis to proceed with the use of the Malmquist index approach.

Explaining Productivity Differences: Malmquist Index Approach

This section discusses results from a cross-sectional application of the Malmquist index approach so as to analyze group differences in productivity between farm plots with land certificate against plots without formalized land use rights. As shown in section 3, the choice of base technology (reference technology) to facilitate comparison influences the results of the index and, thereby, the interpretation. Therefore, to analyze the group differences in productivity, we have considered one group or government program (certification) as reference at a time. First rows in tables 6, table 7 and table 9, therefore, represent results from equations (6) , (7), and (8), respectively, considering farm plots without land certificate as reference while the respective second rows consider technology of farm plots with land certificate as reference/base technology.

For mere comparison, results of the adopted Malmquist index are presented at arithmetic and geometric averages. Table 6 shows the overall group differences in productivity - the composite Malmquist productivity index as shown in equation (6)while table 7 and 9 shows results of the decomposed sub components of the productivity index: the effect of the within-group efficiency spread (equation (7)); and the technology gap or frontier dominance effect (equation (8)), respectively.

As discussed in section 3 of this paper, values of the Malmquist index smaller than unity corresponding to group i means, on average, group i is more productive (performs better) than the other remaining group. From table 6, the value of the index equal to 1.2367 corresponding to the 'without certificate' group means that, on average, farm plots without land use certificate are less productive than plots with formalized land use rights.

This, as a result, means that plots without land use certificate requires 124% of inputs required by plots with land use certificate so as to be equally productive (be on the same frontier). As results from the second rows of respective tables only mean the reference technology is now defined by plots with certificate, all results below the diagonal of the matrix are the inverse of the values in the upper part of the matrix. Therefore, the above result is more elaborated as the value of the index, in table 6, equal to 0.8086 shows that, on average, the group of farm plots with land use certificate are more productive than their counterparts without land certificate requiring only 80.7% of the inputs required by those without land certificate and still be equally productive (be on the same frontier or produce the same level of output). This result is consistent with the results (the positive and significant certificate variable) from the maximum likelihood estimates of the parametric approach in section 5.1.

We suggest that such evaluation of program performance (group productivity differentials) between the two groups of property right scenarios is more elaborative and meaningful when the decomposed result from Malmquist index is analyzed. As discussed earlier, the two sub-components of the index, namely the catching up effect and the distance in between frontiers or technology effect, can explain what portion of the overall group productivity difference is attributed to a relative within-group efficiency spread and what portion is explained by a potential frontier shift (technology gap), respectively. Table 7 reports the components of the index relating to the comparison within-group efficiency gap or relative internal efficiency (M_{12}^{e})

A greater than one value for the catching up effect (1,0451) shows that farm households belonging to the group without land certificate has, on average, a relatively lower internal efficiency (or higher efficiency spread) than those with land certificate comparing both to their own production frontier. Stated otherwise, those farm plots without land certificate lie relatively far from their own group frontier when compared to their counterparts (group of farms with certificate). This result which shows farms without land certificate fail to catch-up well with their own peers (group frontier) than those farm plots with land use certificate partly explains the results from the overall productivity index (table 6). However, the decomposed results from the arithmetic mean which shows nearly equal to unity (1.0059 or 0.9941) of this component means that there is not too much to differentiate between the two groups based on the 'within-group efficiency spread'. Therefore, it can be asserted that even if farms without land certificate are less productive than those farms with land certificate, they seem to do as good as the later in terms of catching up with their own best practice farms.

As mentioned before, one of the main analytical problems of the non-parametric DEA approach of productivity analysis is the difficulties with testing the statistical significance of such indexes which only results from the ratio of the (arithmetic/geometric) means of group efficiencies (see section 3). In order to obtain some insights, however, relating to the statistical significance of this component of the Malmquist index (catching-up effect), we compared the percentiles of the efficiency distributions in the two groups as shown in table 8. The analysis of the percentiles suggests that the slight difference (gap) between internal efficiencies of the two groups is statistically significant. After eliminating, from each group, farm households with the most extreme efficiency scores (5% of farm households with the highest and lowest efficiency scores) we find that the efficiency range in the group without land certificate is still slightly higher (87%) than the group of farm plots with land certificate (86%).

The result from the second sub-component of the Malmquist index that compares the relative positions (and distance) of the production frontiers of respective groups (technology gap) is shown in table 9. Similar to the interpretations given to the overall Malmquist index in table 6, a value smaller than one means the group considered as a reference or base to define the technology enjoys a superior technology or frontier while the opposite scenario holds for the inferiority or operating in a lower frontier.

Considering the group of farm plots with land use certificate as reference (second row of table 9), the value of the decomposed component equal to 0.8134 means nothing but an input saving parameter by which inputs used by farm plots without land certificate can be multiplied with and still produce the same level of output. This is synonymous as saying, on average, plots with land use certificate enjoys a technological advantage (operates on a higher frontier) as compared to plots without land certificate. This is so since the result (the distance between the two frontiers) shows that, with proper interventions, there is an input saving potential for those plots without land use certificate as compared to those with formalized land use rights.

Note that the similarities of the mean results from the overall Malmquist index (table 6) and the mean results of the second decomposed sub-component (table 9) means that any productivity differences between the two groups is explained more by the positions (dominance/superiority) of the respective efficiency frontiers than the within-group efficiency spread (catching-up ability) of farm plots.

However, due to the formulation of this sub-component of the Malmquist index (see equation (8)), it only provides a summary of the mean (arithmetic/geometric) distances between frontiers of the two groups of farm plots under consideration. Information whether one group frontier (farm plots with land use certificate) completely dominates the other, or intersects each other but remains more productive/superior on average terms must be retrieved by analyzing the two components of the equation vis a vis the ratio of E_{11}/E_{21} on the one hand and the ratio E_{12}/E_{22}, on the other). If the two frontiers intersect (no complete dominance of the with-certificate frontier) not all of the aforementioned individual ratios will be greater than unity. In this case, some ratios will be less than one where the reverse scenario holds where the areas of dominance will be on plots without land use certificate. As information on the input/output mixes associated with the areas of dominance of one group over the other could be relevant for proper policy prescriptions, table 10 reports the summary statistics regarding the distance between frontiers, evaluated at the input/output mix of farm plots in the two groups under evaluation.

The results from the summary statistics show there is no complete dominance of one group over the other (the 'with-certificate' frontier not completely dominating the 'without-certificate' frontier). Unlike the result from table 9 which shows the superiority/dominance of plots with land certificate, it is only the case on average terms as 95 farm plots with land certificate are located in positions with in the production possibility set (PPS) where the 'with-certificate' frontier is less productive than the 'without-certificate' frontier. On the other hand, for most of the farm plots without land use certificate, the 'with-certificate' frontier still remains more productive. As a result, the 361 (out of the 482) farm plots without land use certificate should be targeted for a benchmarking effort (land certification to provide the required land tenure security) towards the 'with-certificate' frontier where it is possible to find farm plots with a similar profile that achieved higher productivity level. From this analysis of individual values of the distance between frontiers we can conclude that farm plots with land use certificate outperforms those without land certificate to a statistically significant degree.

However, contrary to the result (at arithmetic/geometric) from decomposed Malmquist index, 115 farm plots without land use certificate are located in positions with in the PPS where the 'without-certificate' frontier is more productive than the 'with-certificate' frontier. Though on average terms the reverse scenario is the case, the intersections of the frontiers can be detected by the ratios E_{11}/E_{21} less than one reported in the first row of table 10. As mentioned earlier, since the possible benchmarking effort to enhance the productivity level is to provide the required land tenure security through the intensification of the land certification process, explaining those exceptions in terms of possible alternative sources of tenure security may provide proper explanations for the incidence of such reverse scenarios.

Consequently, an attempt has been made to see if those exceptions (115 farm plots) belong to either of the following categories: whether or not they are homestead plots; or they are plots with in five minutes walking distance of the residence of farm households; whether or not the plots are the only one or one of the two plots owned by farm households; or they are plots leased-out by landlords. The summary result from table 11 shows, of all the 115 farm plots, 34 of the cases are farm plots that are homestead while 19 of the farm plots are plots that are located with in five minutes walking distance from the residences of respective farm households. 10 and 4 farm plots are plots that are leased out and plots with tree investment, respectively while 16 plots are the only or one of the two plots that the household cultivates. Studies from SSA by (…) show that households feel more tenure security on parcels that are homestead and with tree investments where as feel more vulnerable to future redistribution/confiscation if they have plots that are located in distant places or they have large number of plots. Therefore, the aforementioned variety of reasons could partly explain for the exceptions.

6. Conclusion and Policy Implications

Based on the results from the Malmquist productivity index, it can be concluded that farms belonging to the group without land use certificate (with untitled land) are less productive than those certified plots. It is, however, important to note how the decomposition of this index brought another interesting story in the helm as far as program (group) performance is concerned. Even if farms without land use certificate perform poorly or are less productive as compared to the titled farms, this is not due to so much lack of internal technical efficiency where this group performs as good as their titled counterparts. Rather, the reason is down to a technological disadvantage (a greater than one value for the frontier component of the index - M_{12}^{f}). The reverse explanation holds true for those farms with titled land where they are more productive than those without land certificate only because they enjoy a technological advantage than their counterparts without land use certificate.

Therefore, it may not be an ill-advised direction or strategy if the government intensifies the formalization of land use rights (land certification) since such policy measure is found to improve the competitiveness and productivity of titled farms when evaluated against title-less farms. However, the titling program by itself may not guarantee the benefit to a desired level unless it is complemented by improvement in the provision of agricultural extension services. This is witnessed from our results as farm plots with land use certificate, like those without land use certifictes, seem to catch-up poorly (badly) with their own best-practice frontier.

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Table 1. Summary Statistics

	Certificate			No certificate			
Variables	**mean**	**(std. Error)**	**N**	**mean**	**(std. Error)**	**N**	**ttest**
HOUSEHOLD RESOURCE ENDOWMENT							
hhsex	0.721	(0.0380)	149	0.750	(0.0411)	124	0.3168
hhage	45.614	(1.1865)	146	45.045	(1.4799)	119	-0.3523
hhsize	5.086	(0.2084)	149	4.830	(0.2261)	122	-0.9528
adumale	1.200	(0.0819)	149	1.080	(0.0852)	122	-1.3598
adufem	1.250	(0.0650)	149	1.143	(0.0681)	122	-1.5627
dependent	1.471	(0.1041)	149	1.598	(0.1116)	122	1.0397
cow	0.936	(0.0825)	149	0.768	(0.0822)	124	-1.4778
oxen	1.164	(0.0933)	149	1.071	(0.0972)	124	-1.0648
draft_animal	0.593	(0.0737)	149	0.357	(0.0738)	124	-2.5441**
ACCESS TO MARKETS							
credit_access	0.536	(0.0501)	149	0.473	(0.0567)	124	-0.5909
cons_credit	0.114	(0.0270)	149	0.063	(0.0230)	124	-0.7473
input_credit	0.421	(0.0419)	149	0.384	(0.0462)	124	-0.6708
invest_credit	0.000	(0.0000)	149	0.027	(0.0153)	124	-1.9150*
resource_mkt_participation_8	0.250	(0.0407)	149	0.339	(0.0467)	124	1.4018
ri_05	0.148	(0.028)	162	0.197	(0.0341)	137	1.1149
ro_05	0.154	(0.028)	162	0.241	(0.0366)	137	1.8909*
lrmp	0.302	(0.0362)	162	0.431	(0.0424)	137	2.312**
INCOME DIVERSIFICATION							
petty_trade_9	0.079	(0.0228)	149	0.045	(0.0196)	124	-0.864
exog_in_10	0.157	(0.0309)	149	0.134	(0.0323)	124	-0.441
saftey_net_3	0.464	(0.0469)	149	0.491	(0.0507)	124	0.579
LONGTERM LAND INVESTMENT AND MODERN INPUT USE							
conserved	0.943	(0.0197)	161	0.839	(0.0349)	135	-2.423**
improved	0.407	(0.0417)	161	0.286	(0.0429)	135	-2.3517**
welmaintai~d	0.571	(0.0420)	161	0.491	(0.0475)	135	-1.0556
maintained	0.071	(0.0218)	161	0.116	(0.0304)	135	1.6577
not_maintained	0.243	(0.0364)	161	0.268	(0.0420)	135	0.4799
fertilizer	0.621	(0.0411)	149	0.500	(0.0475)	124	-2.359**
organic_fert	0.636	(0.0408)	161	0.625	(0.0460)	135	-0.4213
seed_type	0.579	(0.0419)	161	0.464	(0.0473)	135	-1.9295*
INPUT-OUTPUT COMBINATION							
output_value	2079	(130)	161	1458	(106)	135	-3.6246***
area_planted	3.099	(0.1290	161	2.391	(0.1200)	135	-4.5237***

labor	90.793	(5.1879)	161	71.308	(4.1061)	135	-3.6176***
oxen_days	35.653	(2.1093)	161	33.603	(1.9575)	135	-1.1017
seed_cost	271.03	(13.99)	161	192.80	(13.48)	135	-4.4733***
chemical_f	35.229	(2.757)	161	30.621	(3.2268)	135	-1.3302

Table 2. Summary Statistics for Input and Output Data

Variables	Certificate		No Certificate	
	Mean/se	Mean per Tsimdi/se	Mean/se	Mean per Tsimdi/se
Total Value of output (Birr)	502.8	712.81	469.2	675.38
	(22.82)	(22.83)	(17.92)	(21.59)
Land (Tsemdi)	0.7847	-	0.7459	-
	(0.02)		(0.02)	
Labor (No. of Days)	23.44	34.37	21.54	32.89
	(0.86)	(1.00)	(0.70)	(0.99)
Oxen (No. of Days)	8.884	14.33	10.358	17.19
	(0.21)	(0.47)	(0.25)	(0.55)
Seed cost (Birr)	67.29	95.74	62.95	92.50
	(2.49)	(3.26)	(2.67)	(4.77)
Chemical Fertilizer (Kg)	9.262	12.60	9.48	13.56
	(0.58)	(0.78)	(0.63)	(0.88)
Number of Obs.	588		482	

Table 3. Summary Statistics for Key Long-term Land Investment and Modern Input use Variables

	Certificate (N=588)		No Certificate (N=482)		ttest
Variable	Mean	std. Err.	Mean	std. Err.	
Long-term Land Investment	0.56	0.020	0.51	0.023	>*
Improved	0.21	0.017	0.15	0.016	>***
Well-maintained	0.23	0.017	0.25	0.020	n.s.
Just-maintained	0.04	0.008	0.05	0.010	n.s.
Not-maintained	0.10	0.012	0.13	0.015	n.s.
Chemical Fertilizer	0.53	0.021	0.46	0.023	>**
organic Manure/compost	0.29	0.019	0.23	0.019	>**
Seed Type (1=improve, 0=otherwise)	0.22	0.017	0.20	0.018	n.s.
Log of yeild value	5.82	0.053	5.59	0.084	>*

Table 4. Stochastic Production Frontier estimates - Pooled data (n=1070)

Variables	Coefficient (standard error)	
CONSTANT	5.3933	(0.1655)***
lnland (Cultivated area)	0.3658	(0.0542)***
lnlabor (Labor days)	0.2092	(0.0329)***
lnoxen (Oxen days)	0.0624	(0.0307)**
lnseed (Seed cost - Birr)	0.2343	(0.0284)***
lnfert (Fertilizer - Kg)	0.0256	(0.0072)***
Certificate (plot with certificate)	0.1176	(0.0522)**

Table 5. Stochastic Production Frontier estimates of Plots 'with' and 'without' Land Use Certificate

	Without Certificate (n=482)		With Certificate (n=588)	
Variables	Coefficient (std. error)		Coefficient (std. error)	
CONSTANT	5.1009	(0.2312)***	5.8103	(0.2099)***
lnland (Cultivated area)	0.3081	(0.0835)***	0.4179	(0.0676)***
lnlabor (Labor days)	0.272	(0.0790)***	0.2025	(0.0392)***
lnoxen (Oxen days)	0.1019	(0.0859)	0.0266	(0.0359)
lnseed (Seed cost - Birr)	0.2624	(0.0404)***	0.1539	(0.0374)***
lnfert (Fertilizer - Kg)	0.0195	(0.0103)*	0.0276	(0.0094)***
sigma2	4.2082	(0.2963)	2.2778	(0.1562)
lambda	11.5764	(0.0935)	4.1102	(0.0687)
Log-Likelihood	-720.11		-758.44	
Technical efficiency score	0..41		0.47	

Table 6. Malmquist Index for Comparison of Group performance (M_i^{12}) between Farms with and without Land Use Certificate

Groups/Scenarios	Arithmetic Mean		Geometric Mean	
1 \ 2	No Certificate	With Certificate	No Certificate	With Certificate
No Certificate	1	1.2367	1	1.1669
With Certificate	0.8086	1	0.8570	1

Table 7. A Component of the Malmquist Index for Comparison of Within-group efficiency spread (M_{12}^{e}) in Farms with and without Land Use Certificate

Groups/Scenarios (1 \ 2)	Arithmetic Mean: No Certificate	Arithmetic Mean: With Certificate	Geometric Mean: No Certificate	Geometric Mean: With Certificate
No Certificate	1	1.0059	1	1.0451
With Certificate	0.9941	1	0.9568	1

Table 8. Percentiles of the Within-group (program) efficiency distribution of farms with and without certificate

Farm Evaluated	Percentile 5%	Geometric Mean	Percentile 95%	Efficiency Range after eliminating 5% of both extremes
Farms No Certificate (i=1=NC)	0.0615	0.3732	1	0.867
Farms with Certificate (i=2=C)	0.1133	0.39	1	0.864

Table 9. A Component of the Malmquist Index for Comparison of Productivity between the two group frontiers (M_{12}^{f})

Groups/Scenarios (1 \ 2)	Arithmetic Mean: No Certificate	Arithmetic Mean: With Certificate	Geometric Mean: No Certificate	Geometric Mean: With Certificate
No Certificate	1	1.2294	1	1.1165
With Certificate	0.8134	1	0.8957	1

Table 10. Differences between the Two Group Frontiers Evaluated in Points Associated to the input/output mix of farms

$D^2\left(X_j^i,Y_j^i\right)/D^1\left(X_j^i,Y_j^i\right)$ or E_{1i}/E_{2i}	Percentile 5%	Geometric Mean	Percentile 95%	No. Farms with ratio > 1	No. Farms with ratio < 1	Aggregate No. Farms
Farms No Certificate (i=1=NC) E_{11}/E_{21}	0.7625	1.0798	1.8065	361	115	476
Farms with Certificate (i=2=C) E_{12}/E_{22}	0.8205	1.1049	2.8578	471	95	566
All farms (i=1,2 or i=NC, C)	0.7915	1.0924	2.3322	832	210	1042

Table 11. Alternative sources of Farm household tenure security

	Category	Number of cases (farms)
1	Homestead Plots	34
2	farm lands within 5 minutes walking distance	19
3	The only or one of the two plots owned	6
4	Farms with tree investments	4
5	Leased out plots	10
6	Owned by farmers with land certificate	4
	Unexplained farms	38
	Total No. Farms	115