DOES TYPE OF TENURE IMPACT ON TECHNICAL EFFICIENCY OF FARMERS? (A COMPARATIVE ANALYSIS OF OWNER-OPERATORS AND "TENANTS")*

Worku Gebeyehu**

Abstract

This study tries to examine the technical efficiency of farmers and investigate its variation between owner-operators and tenants. A Cobb-Douglas stochastic frontier production function and other econometric tools are employed on a cross-section data of 340 households. Mean technical efficiency of sample households is found to be around 62.8 percent, revealing a considerable potential for output gains under the given technology. Farmers having less than two hectares of land and "literate individual" headed households reported higher efficiency. Wealth, credit, fertilizer and rainfall contributed significantly to increase production. Regardless of tenancy-associated problems, no significant efficiency gap is observed between owner-operators and tenants. Although, it requires further inquiry to have a strong position, encouraging land rent/lease among farmers holding an incompatible resource mix could enhance efficiency. Findings suggested that efforts should be exerted towards providing training and extension services, developing small-scale irrigation schemes and expanding the coverage of credit provision to improve productive use of resources of farmers operating in both tenure systems.

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** Researcher, Ethiopian Economic Association/Ethiopian Economic Policy Research Institute (EEA/EEPRI).

1. INTRODUCTION

Land is a state property, yet it is not accessible to every one. In particular, recently married young people, demobilized soldiers returnees from resettlement areas and similar groups usually suffer from lack of access to land (Dessalegn 1994). On the other hand, some landowners lack indispensable inputs such as oxen, and male labour due to illness, old age, death, or complete absence of male family heads. As many as 30% of all households in the country had no oxen at all and only 8% of farm households had more than one pair of oxen in 1974 (Daniel, et al. 1997). A study on some parts of the Ethiopian highlands indicated that 14% of sample households were female headed, 21.1% had no oxen and 31.4 % had only one ox (Wendwosen 1998). In one study, it was found that women headed as much as 25% of households and almost all of them were either widowed or divorced (Dessalegn 1994). Landless and farmers with insufficient land and landholders with inadequate complementary inputs to complement each other and make use of their inputs the usual way of using idle resource is through tenancy arrangement. For instance, in Mafud district of North Shewa, of the total households who gave land to tenants, 47% did not have a male worker; another 40% had only one worker. Around 65% were without oxen (Ege 1994).

Whether mode of land use could affect the level of efficiency of farmers has been an issue of discussion for many years. In particular, there are opposing views about the impact of tenancy on the use of inputs. Some argue that tenants lack security to invest on assets and conserve the land on the belief that the fruits from such investments are likely to be harvested only in the long run. Tenants might also lack the incentive to maximise output since landowners claim part of the produce. Others argue that tenancy is a mechanism of economically utilizing resources, which are disproportionately available in the hands of different individuals and kept idle otherwise.

The validity of one of the two divergent views could only be confirmed through empirical findings. Given that the issue of land use arrangement and its impact on efficiency is a very sensitive economic and political concern and the empirical findings on Ethiopia are very sparse conducting a study on this area has a paramount importance. The objective of this study is, therefore, to examine factors affecting production levels of farmers and efficiency differentials between own operators and tenants in the case of Ethiopia.

The source of data for this study is the first round Ethiopian Rural Household Survey conducted in 1994/5. The Survey was run by the Department of Economics, Addis Ababa University in collaboration with the Centre for the Study of African Economies, Oxford University (CSAE) and the International Food Policy Research Institute (IFPRI). The study employs descriptive statistics, Maximum Likelihood econometric technique to estimate a stochastic frontier production function and other tests.

Providing empirical evidences on technical efficiency of farmers and assessing factors, including land use arrangements, contributing towards the productive use of resources might help policy makers to invigorate their conceptions of farmers' behaviour and operation in practice and accordingly revitalize their actions. Several studies assessed the efficiency of farmers in Ethiopia, yet no attempt was made to examine efficiency differential of farmers operating into two different land use arrangements as comprehensively as this study does. Gavian and Ehui (1996) and Ahmed et al. (2002) conducted similar studies, yet the focus was only on one of zone in Oromiya region, Arsi. Covering a wider geographical area and addressing the issue in its peculiar way, this study will contribute its share towards building the literature on the subject.

However, the study has its own limitations, in particular with respect to definitions of owner-operators and tenants. The Ethiopian Rural Household Survey does not include those who are absolutely denied of having state land. Nevertheless, it identifies types of farmers; those operating on their own land and those who rented in land in addition to their own small plots. Even in this respect, the survey only provides the size of rented-in land and own land and fails to segregate the input and output magnitudes into two types of land tenure. Thus makes it difficult to make plot level analysis as Gavian and Ehui (1996) did. The average land area for own operators considered in the sample was about 1.93 hectares. On the other hand, those who have their own small plots but acquired a greater percentage from other farmers through rent were operating on about 1.81 hectares. The average share of rented-in land constituted about 60% of the total cultivated land during that particular period. Thus, this paper defines owner-operators as those who work only on their own holdings and "tenants" are those farmers that have their own plots, but the land they rented constitutes more than 50% what is under cultivation during the study period.

2. SURVEY OF LITERATURE

2.1 Theoretical Literature

Volumes of theoretical controversies and empirical evidences are documented in the literature on the impact of land use arrangements on efficiency of farmers. Some scholars argue that tenancy and associated institutional factors impinge on the efficiency of agricultural resources that are utilized, whereas others consider tenancy as a way of utilizing resources in the hands of different parties in a more optimal way.

Some of the major underpinning justifications for considering tenancy as an inefficient institution include the following. A tenant "... will not make long-term investments in his holding unless he is secure in his expectation of reaping the benefits of his investments " (Bruce 1986, p. 28). Owing to a high rate of discount (r) resulting from uncertainties on future benefits, tenants usually tend to invest on marketable assets and/or goods having shorter gestation instead of permanent improvements (Barrows 1973 and Junakar 1976). Tenants also undersupply their variable inputs because of the disincentive effect associated with rental payment. In relation to this, Marshall (1920) argued that tenancy (sharecropping in particular) is an inefficient system and productivity is an inverse function of the rental share. He, therefore, stresses that some sort of government intervention is required either to reduce rent or prohibit this form of arrangement totally in order to safeguard social welfare (Bell 1977). Taslim (1988) argued that landowners interlocked land lease markets with other input markets to extract maximum surplus from their tenants and keep them in perpetual bondage of indebtedness. The inter locking prohibits the liberty of tenants from acquiring inputs from cheaper areas. Other obligations imposed by landowners also share the productive time of tenants and reduce their efficiency. Thus, own-operators and tenants either lie on different production functions or the latter operate less efficiently than otherwise.

Other scholars try to backup their positions with the argument that if the landowner does not own some types of assets, especially types with imperfect or expensively accessed markets (for instance draught power) his net yield from combining labour with other assets may substantially decrease and inspires him to rent out his land. Lipton (1985) argued that "… if a person does not own some types of assets, especially types with imperfect or expensively-accessed markets, that person's net yield from combining his labour with other assts may be substantially reduced. … Lack of owned oxen, in conjunction with imperfect markets in draught-power, may so reduce the return to own-operated farmland as to induce the land owner to rent out". Toutique, (1988) also noted that tenants might own inputs such as knowledge or husbandry skills, land, oxen and finance for which the market is either imperfect or non-existent. Landless and farmers with insufficient land may be forced to consider the opportunity cost of leaving their resources idle and become a wage labourer, with the amount that they are supposed to pay for the land owner if they choose to be a tenant. It is usually the case that cooperation between tenants and landholders benefit both parties than otherwise.

In cases of problems associated with tenancy operation, the landowner could induce efficiency by supervising the application of the desired level of inputs and efforts (Cheung 1969). Another alternative for the landowner is to hire a wage worker. A wage labourer requires intensive supervision by an experienced family member of the land owner who would work with and induce the hired worker to put his maximum effort on the field. Such intensive supervision might not be required for a tenant. A tenant may be less efficient but knows that the effect of his inefficiency would affect his share. There rarely exists the possibility of attaching wage rates with the amount of production and thus, there will be no incentive for a wage labourer to exert his utmost effort. Even if it is possible to supervise a hired labourer effectiveness, easy access to wage labour may not be simple in rain-fed subsistence farming where every farmer could be busy simultaneously.

The insecurity argument against tenancy may not have a strong case in Ethiopia. Ethiopia where the reallocation of land by the government for the benefit of increasing the number of claimants makes 'landholders' themselves insecure. The institutional environment is such that it fails to allow both land owners and tenants to have a vision for long term investment on the land. Hence, no tangible evidence exists that insecurity makes tenancy inferior to ownership on grounds of efficiency. As Lipton (1985) argued, rather tenancy is a means of adjusting different ownership holding sizes towards an operationally optimum land size and utilizing other resources that could have been left idle. This allows operation near to the bottom of the average cost curve, implying maximizing output at given level of inputs. The existence of interlocked markets further facilitates optimal operation. It helps to facilitate the provision of cheap credits in the presence of costly monitoring and moral hazard problems in less developed countries, and tie up land, credit and labour markets to avail inputs at the right time, quantity and quality. While the different arguments have their own rationale and reflect realities on the ground, their validity is confirmed through empirical evidence.

2.2 Empirical Evidence

Like the diverse theoretical views, the empirical findings on the impact of tenure arrangement on efficiency of farmers are mixed. Jabbar (1977) conducted a study on one hundred farmers from three districts of Bangladesh and found owner-operators to be more efficient. He implied from the result that the pattern of resource ownership and property relations was improper for efficient operation of tenancy. Similarly, Ahmed et al. (2002) cameout with a result from their stochastic frontier production function that land transactions such as sharecropping and land gift that restrict tenants' decision making are technically inefficient compared with owner-cultivated or fixed rental tenures.

Junakar (1976) study on Indian agriculture showed that owners were more productive than tenants for large farms, but no significant difference was observed between small farmers.

Based on his review of various empirical works, Lipton (1985) concluded that owner-occupiers within a given village could neither be much more nor much less efficient than tenants (in particular sharecroppers). Huang (1975) also noted yields of tenants to be at least as good as owner operators if not better in a number of countries as it was found by himself in Malaysia, Ras and Malone (1965) in India, Ruttan (1966) in the Philippines, Bray (1963) in the US, Cheung (1968) in China and Hendry (1960) in Vietnam. He further demonstrated that tenants and owner-tenants (those who own and rent land) reported notably higher yields than owner cultivators in particular in the case of Malaysia. Contrary to fears of under supplying inputs, while only 36 % of owner cultivators used fertilisers, 57% of tenants and 69% owner tenants used this input. Hossain (1977) undertook another study on three different areas of Bangladesh and revealed that land productivity was higher for tenants than owner operators.

Studies dealing with the economic impacts of tenancy in Ethiopia are inadequate. Bereket and Croppenstedt (1995) observed an indication that landowners and tenants (specifically sharecroppers) operate in the tenancy market to adjust land holdings to factor endowments such as family size and number of oxen and concluded that “if off - farm employment opportunities are limited, sharecropping helps increase efficiency".

Gavian and Ehui (1996) tried to test the relative efficiency of three different informal and "less" secure land contracts (fixed rent, sharecropping and borrowed) on data collected from 477 plots in Arsi Zone. Although informally contracted farmers applied inputs more intensively, the land was cultivated 7% to 16% less efficiently compared to own-operated farms. They attributed the result to the widespread insecurity of land and suggested a need for more stable and enforceable leases. Insecurity of tenure has its impact on long term investments on areas like land conservation or soil protection whose effect could only be examined through comparing different landholding arrangements over a long period. Thus, it may be unjustifiable to conclusively attribute inefficiency of tenant farmers to insecurity on the basis of a one year cross section data.

3. SPECIFICATION OF MODELS AND DEFINITION OF VARIABLES

3.1 Stochastic Frontier Production Function

There are various ways of measuring efficiency of farmers. Investigating the validity of the position that tenants under supply efforts with a given level of inputs requires a methodology that reveals the extent to which a tenant or for that matter an own-operator deviates from the most efficient way of producing. In this respect, technical efficiency measures the percentage by which the level of production of a tenant or own-operator is less than the frontier (most efficient) level of output.

Aigner and Chu (1968) and later Afriate and Richmond (1974) specified a deterministic frontier to estimate technical efficiency. The model assumes that the amount of output that farmers/firms produce with a given level of resources varies only due to differences in the level of efforts that they exert on optimally utilizing their factor inputs and the influences of external factors which are invariables across farmers/firms. Let the (estimated) frontier and actual level of output be given by equations (1) and (2) as

$$Y^* = F(X_i, \beta) \quad \textbf{(1)}$$

$$Y = F(X_i, \beta)\exp(-\mu_i) \quad \textbf{(2)}$$

where X_i and β are matrices of factors of production and their respective coefficients, and μ_i is an error in operation committed by the farm or firm. Thus, technical efficiency of a farmer, for instance, could be represented as

$$TE_i = Y/Y^* = F(X_i, \beta)\exp(-\mu_i)/ F(X_i, \beta) = \exp(-\mu_i) \quad \textbf{(3)}$$

A farmer is technically efficient if and only if his actual output given the level of inputs is equal to the predicted level of output. Otherwise, there will be a deviation from the frontier level of output by $1\text{-}TE_i$. The inherent assumption of the deterministic model that farmers share similar technology, institutional setting, physical resource endowments, as well as environmental and weather conditions could not hold in the real world. Hence, it may not be practical to fully attribute mismanagement of resources as the only reason for failure to produce the predicted level of output. The stochastic frontier production function specification gives a room for the influences of external factors.

The stochastic frontier production function model assumes the common error term (ε) to be decomposed into two components and specified as:

$$Y = f(X_i, \beta)e^{v-u} \quad \textbf{(4)}$$

or

$$Y = F(X)\exp(v-u)$$

v_i are assumed to be independently and identically distributed as $N(0, \sigma_v^2)$ and the covariance between u_i and v_i to be zero. The maximum production limit (Y) is bounded above by a stochastic quantity $F(X_i; \beta)\exp(v_i)$. The non-negative error term u_i, in exp $(-u_i)$, measure the degree of technical inefficiency, which are assumed to have a non-negative truncation of either half-normal, exponential or gamma distribution with mean and variance, $N(0, \sigma_u{}^2)$ (Battese 1992 p. 190).

Decomposition of the commonly observed error term (ε) into two components in case of estimation is not as simple as its specification. Aigner, Lovell and Schmidt (1977) brought about a procedure called ALS whereby they decomposed the error term into two components:

$$\varepsilon = u + v \tag{5}$$

where v follows the usual normal distribution with constant variance and zero mean: $N(o, \sigma_v^2)$ and *u* follows the truncated normal,

$$F(u) = \frac{2}{\sigma_u \sqrt{2\pi}} \exp\left[\frac{-u^2}{2\sigma_u^2}\right], u \geq 0 \tag{6}$$

(Fishe and Maddala 1994, p. 76). Furthermore, assuming *u* and *v* to be independently distributed,

$$F(\varepsilon) = \frac{2}{\sigma} \phi\left[\frac{\varepsilon}{\sigma}\right]\left[1 - \Phi(\frac{\varepsilon\lambda}{\sigma})\right] \tag{7}$$

where $\sigma^2 = \sigma_u^2 + \sigma_v^2$ **(8)**

$$\lambda = \frac{\sigma_u}{\sigma_v} \tag{9}$$

and $\phi(.)$ and $\Phi(.)$ are density and distribution functions of the standard normal, respectively (Fishe and Maddala 1994, p. 76). From equation 1 above, technical efficiency for each farm is given as:

$$e^{-u} = \frac{Y_i}{\left[f(X_{i,}\beta)e^{v_i}\right]} \tag{10}$$

λ in equation (9) indicates the relative influences of forces that are under the control of farmers and events external to them. A value above unity is an indication of the impact of internal factors on production to outweigh the respective effect of external factors.

Based on the works of Aigner, Lovell and Schmidt (1977), Assefa (1995) provided an estimation procedure in such a way that parameters of the frontier and density functions of the two error terms are estimated through maximising the log-likelihood function, which could be given as:

$$\ln L(Y/\beta,\lambda,\sigma^2) = N\ln\sqrt{\frac{2}{\pi}} + N\ln\frac{1}{\sigma} + \sum\ln\left[1-F(\frac{\phi_i\lambda}{\sigma})\right] - \frac{\sigma^2}{2}\sum\phi_i^2 \qquad \textbf{(11)}$$

Since v_i are not observable, computing efficiency magnitudes for each farm using equation (10) is impossible. Jondrow et al. (1982) estimated farm level technical efficiency as:

$$E\left(u_i/\varepsilon_i\right) = \frac{\sigma_u\sigma_v}{\sigma}\left[\frac{\phi(\varepsilon_i\lambda/\sigma.)}{1-\Phi(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \qquad \textbf{(12)}$$

where $\phi(.)$ and $\Phi(.)$ are standard normal density and distribution functions evaluated at $\frac{\varepsilon_i\lambda}{\sigma}$ and λ is estimated at $\lambda = \frac{\sigma_u}{\sigma_v}$ respectively. Replacing ϕ, σ, λ by their estimates in equation (12), one can drive values of u_i and v_i. Then, technical efficiency indices of individual farmers would be computed as

$$TE_i = \exp\left[-E(u_i/\varepsilon_i)\right] \qquad \textbf{(13)}$$

Following the rules of Ibid, (1982) and Battese and Coelli (1988), the average technical efficiency of all farmers in the sample is given by

$$E(e^{-u_i}) = 2\exp(\sigma_u^2/2)(1-\Phi^*(\sigma_u)) \qquad \textbf{(14)}$$

where Φ^* is the standard normal distribution function (Assefa, 1995).

3.2 Estimation Methods and Testing Procedures

3.2.1 Estimation Methods

Assuming a Cobb-Douglas specification to describe the underlying technology of smallholder agriculture, a stochastic frontier production function is estimated through the Maximum Likelihood Maximum Iteration Method using Limdep 7[1] econometric software. The estimated function is specified as:

$$Y_i = \alpha_0 + \sum \alpha_i X_{ij} + v_i + u_i \qquad \textbf{(15)}$$

where,

Y_i = log of cereal outputs of households,

X_{ij} = Logarithm values of inputs and household specific attributes,

u_i = Technical efficiency parameter assumed non-positive values and a half-normal probability distribution,

v_i = the usual stochastic disturbance term which is normally distributed with $(0, \sigma_v^2)$.

Farm specific and average technical efficiency figures could be estimated using equation (12) and (14).

3.2.2 Econometric Tests

A. Chow Test

Assuming two independent production functions for owner-operators and tenants, the Chow test is specified as[2]

a) $\mu_{1i} \sim N(0, \sigma^2)$ **(16)**

$\mu_{2i} \sim N(0, \sigma^2)$

b) μ_{1i} and μ_{2i} are distributed independently.

[1] Limdep7 (1998) is an Econometrics software written by William H. Greene and Windows interface is made by M.J. Lowe.

[2] For further Discussion of the test please refer Gujarati (1988).

First, a single "pooled" regression, combining both own-operators (*N1)* and tenants *(N2*), is estimated to obtain residual sum of square (s1) with *N1+N2-K* degrees of freedom, where *K* is the total number of estimated parameters. The second step is to run two individual regressions for two groups of farmers and collect the respective residual sum of squares (s2 and s3) with degrees of freedom *N1-K*, and *N2-K*. Using the results for the respective parameters, F-test is applied.

$$F = \frac{[s_1 - (s_2 + s_3]/K}{(s_2 + s_3)/(N_1 + N_2 - 2K)} \qquad \textbf{(17)}$$

with degrees of freedom *(DF) =K, N1+N2-2K*. If the computed F-exceeds the critical F-value, the hypothesis of considering two production functions as the same would be rejected.

B. Wald Test

Assuming a zero covariance between coefficients of production functions for the owner-operator and the tenant, a Wald test is applied to examine elasticity differences for each kind of key factors of production[3]. Under the null hypothesis of no difference, the Wald-test statistics is:

$$W = (\beta_i^{own} - \beta_i^{tent})^2 \big/ [Var(\beta_i^{own}) + Var(\beta_i^{tent}) \sim \chi^2_{(1)} \qquad \textbf{(18)}$$

3.3 Definition of Variables

1. *Output (Y):* Households considered in the study harvested a variety of cereals. However, inputs used were not disaggregated into different types of outputs. In the absence of a clue for segregation of inputs, the only feasible way of comparing outputs with inputs is to aggregate the different cereals into one monetary unit. Production function being a description of functional relationship between physical outputs and corresponding physical inputs, expressing output in monetary terms has its own conceptual problems. Thus, monetary value of a variety of cereals including *teff*, (mixed black and red *teff*), barely, wheat, maize, sorghum and millet produced by sample farmers are aggregated and deflated

[3] Adopted from (Appleton et al, 1994).

through their weighted prices to have a reasonable approximation of "real" output levels of households.

2. *Farm Labour (L)**:*** Labour input constitutes number of working days of a family, hired worker and individuals in self-help labour exchange (like *Debo*) arrangement among neighbours. In the absence of an easy mechanism to take account of heterogeneity, labour is simply assumed to be homogeneous among individuals.
3. *Land (H):* Land is measured in hectares covered under cereal cultivation during the survey. The survey identified the size of rented land by tenants but failed to separately indicate the kind and amount of inputs used and output produced from this plot. Thus, inputs including land and output values for tenants take into account both on their own and rented-in.
4. *Oxen-Bulls (Ob)*: Number of oxen and bulls is considered as an input because of the problem associated with the reliability of information on the number of ploughing days.
5. *Wealth of Households (M):* Wealth of a household is supposed to positively influence production in several ways. It facilitates the acquisition of inputs and can be used as collateral for credit and reflects efforts of farmers. Wealth of households may exist in different forms but measuring these different items is not simple. Thus, the kind of materials used for roofing is taken as a proxy for wealth and a dummy value of 1 is assumed if the roof was made of wood, galvanised iron, stone, bricks or cement, and 0 otherwise.
6. *Fertilizer (F):* The variable stands for all kinds of chemical fertilisers in kilograms. *Intfhs* is an interaction variable capturing the impact of "large" size (2.5 hectares) land on fertilizer application.
7. *Credit (Cr):* Credit is usually associated with increased production. Thus, those farmers who obtained credit in any of the consecutive years (1984 EC, 1985EC, and 1986EC) are given a value 1 and 0 if it was otherwise.
8. *Soil fertility (Lq) and topography of lands (Ls):* Based on respondents' judgment, fertility and topography are given average values for the different plots of households. Quality of land is encoded as 1=*lem (*fertile), 2=*lem-teuf* (semi-fertility) and *3=teuf* (infertile). Topography is encoded as 1=*medda* (flat), 2=*dagath-ama* (semi-flat) and 3=*geddel* (steeply).
9. *Age of household head and its Square (lA2):* is considered as a proxy variable for farmers' experience and 'endurance' given that agricultural activities require strength and long-time practices on activity management and timing (Mulat and Croppenstedt 1998).

10. *Rainfall (R2, R3, and R4):* Timing, magnitude and intensity of rainfall are indispensable variables in modelling agricultural production. Based on respondents' judgement, *R2* takes a value of "1" if there was sufficient rain at the beginning of *Meher* season, and "0" in the case of excess or shortage. *R3* takes a value of "1" if there was sufficient rain during the growing period of cereals, and "0" in the case of excess or shortage and *R4* assumes a value of "1", if the rain stopped on time and 0 otherwise.
11. *Family Size (FS):* Family size, number of persons in a household, is assumed to influence production as a source of labour and trigger for enhanced output for consumption.
12. *Education*: Education has a bearing on accessing and making use of information to improve the production process. The impacts of different education variables are examined.
    i) EDLC takes a value of "1" if the household head obtained a certificate for Adult Literacy Programme or attained a minimum of three years of formal education and "0" otherwise.
    ii) LEDH1 takes "0" if the household head had no formal schooling or adult literacy certificate and "2" if he reads and writes or obtained adult literacy certificate or religious or traditional education. "3", "6", "8", and "12" are values for those who attained primary but failed to complete, completed primary, completed junior secondary and completed high school, respectively.
    iii) EDH is given a value of "1" if there is a member in the household other than the head, who can read and write, and 0 otherwise, with the intention of capturing the influences of literate family members on decision making.

4. EMPIRICAL FINDINGS

4.1 Descriptive Statistics

4.1.1 Source of Data and Over all Feature of the Sample

The first round of Rural Household Survey of Addis Ababa University covered 1477 households from 18 peasant associations (PA) located in 15 w*oredas* of 6 regional states. Observations with erroneous or incredible figures, inconsistent entries, missing and extreme values were excluded in the present analysis. Even though there is not a rule of thumb, households cultivating less than 0.25 hectares of land or who used less than 60 working days and producing less than a quintal in the main agricultural season (*Meher*), were not considered as farmers, hence left out.

Table 1: Regional Distribution of Sample Households

Region	Zone	*Woreda*	Peasant Association (PA)	No. of Households
Amhara	East Gojjam	Enemay	Yetmen	31
Amhara	North Shewa	Debre Berhan	Milki	41
Amhara	North Shewa	Debre Berhan	Kormargefia	28
Amhara	North Shewa	Debre Berhan	Karafino	18
Amhara	North Shewa	Debre Berhan	Fajina Bokafia	19
Amhara	North Shewa	Ankober	Dinki	10
Oromiya	East Shewa	Adda	Sirbana Godeti	61
Oromiya	East Harerge	Kersa	Adele Keke	30
Oromiya	E. Shewa	Spacemen	True Ketchum	53
Oromiya	Arsi	Dodota	Korodegaga	20
SNNP	North Omo	Bolossosore	Gara Goda	16
SNNP	Kembata	Kedia Gemila	Aze Deboa	13
Total				**340**

Source: Own computation

Table 2: Spatial Distribution of Sample Households (HHs) by Land Holding Arrangement

Region	Peasant Association (PA)	Owner-Operators		Tenants/Framers Rented in Land		
		HHs	% Share	HHs	% Share	%Share HHs in PA
Amhara	Yetmen	10	5.1	21	14.6	67.7
Amhara	Milki	21	10.7	20	13.9	48.9
Amhara	Kormargefia	9	4.6	19	13.2	67.9
Amhara	Karafino	10	5.1	8	5.6	44.4
Amhara	Fajina Bokafia	13	6.6	6	4.2	31.6
Amhara	Dinki	6	3.1	4	2.8	40
Oromiya	Sirbana Godeti	46	23.5	15	10.4	24.6
Oromiya	Adele Keke	21	10.7	9	6.3	30
Oromiya	Korodegaga	18	9.2	2	1.4	10
Oromiya	Turufe Ketchema	32	16.3	21	14.6	39.6
SNNP	Gara Goda	6	3.1	10	6.9	62.5
SNNP	Aze Deboa	4	2.0	9	6.3	69.0
Total		**196**	**100**	**144**	**100**	**42.4**

Source: Own computation

Some 196 owner-operators (58%) and 144 tenants (42%), (340 households all together) were considered from twelve different sites of three regional states, the respective shares being 43%, 48% and 9% from Amhara, Oromiya and Southern Nations and Nationalities People (SNNP). From those farmers who rented-in land, Amhara region alone had 54 %, the remaining being distributed between two regions. Tenant farmers relatively dominated in number in Yetmen and Kormargefia of Amhara, and Gara Goda and Aze Deboa of SNNP, while owner-operators concentrated more in other areas.

Among other factors, the type of agro-ecology prevailing and farming technology employed in sample areas have their impact on input-output relationships. Taking account on this, despite some marginal differences, an attempt has been made to consider areas with similar agro-ecology and farming technology. Accordingly, the dominant farming technology is ox-plough among sample areas except that hand hoe is used side by side in Aze Deboa of SNNP. Using or not using of fertilizer has a significant role in determining the kind of technology that farmers employ, and hence the study considers only predominantly fertilised farms. Eight peasant associations, holding about 58 % of the sampled households, cultivated cereal production twice a year; the rest were unimodal with no possibility for *Belg* production. Summing up outputs of two seasons regardless of weather modality might provide deceptive efficiency differentials across places. Thus, only the production of the *Meher* season is considered as annual output across areas. Similarly only the inputs used for the *Meher* season are taken into account.

4.1.2 Own-Operators versus Tenants

About 20% of owner-operator households were female headed, while it was about 8 % in the case of tenants. Female-headed tenant households owned 2.2 oxen and bulls, consisted of 1.75 male adults above 15 years of age and operated on 1.49[4] hectares of land on the average, the corresponding figures for owner-operators being 0.93, 1.15 and 1.52. Except land size, observed differences are statistically significant. Regarding the stock of labour, 5.6 % of owner-operators did not have a male family member above the age of 15 years. For this reason they used hired or under-age farmers. This labour shortage affected only (0.4%) of tenant households.

[4] Of this 1.04 (67percent) hectare was rented in.

The average age of family heads and adult household members who worked on farming and other activities were 48.9 and 36.4 years for owner-operators and 45.1 and 33.5 years for tenants, respectively. Gaps were found to be statistically significant, as it has been the case in many other studies that tenant households had a better stock of younger members. Dependents per household were almost the same, 2.28 for owner-operators and 2.23 for tenants.

With respect to draught power, the difference being statistically significant, owner-operators and tenants on average possessed 1.51 and 1.92 ox-bulls, respectively. Around 28% and 16% of owner-operators reported shortage of oxen and labour, respectively at the right period. The corresponding figures for tenants were 21% and 12%.

Tenant households were found to be relatively wealthier with a statistically significant difference. Around 51% of tenant households resided in houses with a roof made of galvanised iron, bricks, cement or wood, while only 40% own operator households had this opportunity. Educational status and radio possession could be used as a measure for accessing and making use of information on new technologies and marketing. In this respect, nearly 40% of tenant and 32% owner-operator household heads obtained Adult Literacy Program Certificate or attained formal education for 3 years or above. 17% of tenant and 13% of own operator households attended programmes over their own radios.

Table 3: Oxen and Bulls Ownership Status: Owner Operators and Tenants

Number of Oxen and Bulls	Owner-Operators		Tenants/Rented-in Land Farmers	
	% Share	Cumulative %	% Share	Cumulative %
Zero	34	34	23	23
One	28	62	26	49
Two	13	75	22	71
Three and Above	25	100	29	100

Source: Own Computation

The average cultivated land area was 1.93 hectares and for owner-operators and 1.81 hectares for tenants. About 60% of the land operated by tenants was acquired by renting. The quality of land under tenant farmers was slightly inferior, but the difference is not statistically significant. Both groups were operating on similar terrain. Thus, this result does not strongly support the opinion that rented-out holdings are usually inferior in quality. Due to the fact that tenants are found relatively wealthier and well informed, the view that owner-operators rent out their land to unwisely extract surplus from poor renters may not be acceptable, at least in the case of sample households. On the contrary, a tenancy arrangement is found to adjust different landholding sizes with labour, draught power and other complimentary inputs.

The findings do not support either the Marshallian view which assumes tenants to under supply variable inputs. For instance, owner-operators applied 60 kg chemical fertilisers per hectare of land, while it was as much as 75 kg in the case of tenants. Tenants and owner operators spent 181.2 and 136.5 working days per hectare of land and ploughed 13.6 and 9.4 times, respectively. These differences are statistically significant at conventional probability values. A detailed scrutiny revealed that tenants spent more labour time on ploughing and harvesting while owner operators gave more value to weeding.

The observed differences in resource endowment are reflected in output, mean *Meher* cereal production being 12.3 and 13.2 quintals for own-operators and tenants, respectively. However, this gap is not statistically significant.

4.2 Econometric Findings

Visual observation and statistical diagnostic checks through SPSS statistical package were used to clean the data. Normality was checked for non-dummy variables through graphs and variance-covariance matrices. Colinearity is a common problem in most data sets and is accordingly taken care of. For instance, the variance-covariance matrix of age of the household head and its square being singular, Limdep 7 Programme did not entertain the estimation. Ploughing days could have better indicated the contribution of oxen and bulls in the production process rather than the mere number of animals, but it was found highly collinear with the total number of working days (0.91). Indeed, all estimated models in this study were corrected for heteroscedasticity, and the coefficients are standard-error robust estimates.

4.2.1 Production Function and Technical Efficiency: The Whole Sample

A. Production Function Results

OLS and MLE estimates of stochastic frontier Cobb-Douglas production function are presented in Table 4. Most coefficients hold a priori expected signs and were found to be statistically significant. Assuming other factors to be constant, a 1% percent change in the size of land and oxen & bulls could bring about more than 0.32 and 0.26 percent change in output, respectively. The coefficient of labour (L) is significant at 1% and 5% in the OLS and MLE, respectively. The elasticity is relatively low (0.15) perhaps due to less scarcity of labour in rural Ethiopia. Albeit, family size variable is insignificant at conventional probability values, and they might justify the result on the labour input coefficient. Land quality and topography definitely affect both the intensity of farming activities and production. The variable for topography is found to be statistically insignificant as many of the holdings in the sample were by chance flat (*medama*). Quality of land coefficient was found insignificant at 10% degrees of confidence in OLS; and it is statistically different from zero in MLE implying there is a tendency for output to improve as quality of land improves. With respect to direct inputs, more of the variation in output could come from changes in the size of land and draught power as they are relatively scarce.

In the second group, many variables substantially influence the level of production. R2 and R3 are significantly different from zero, confirming the critical importance of rainfall in Ethiopian agriculture. Citrus paribus, if the rain did not come on time with adequate amount at the beginning, it could significantly reduce output. If cereals receive adequate rainfall in the germination and growing periods, it may not be a serious problem at what time the rain stops.

Elasticity of fertilizer with respect to output is around 0.23. This might be low[5] if it is seen in light of farmers' expectations and the responsiveness of land and oxen-bulls. Given its better response than labour and land quality[6], increasing the use of fertiliser is the available feasible way of enhancing production in the face of shortages in the supply of land and oxen & bulls. The interaction variable for fertiliser and land size

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[5] While chemical fertilizer is supposed to substantially enhance the level of production, its effects largely depend on the prevailing weather condition, timely delivery and application [Croppenstedt and Mulat, 1997].
[6] Recall that land quality and topography are encoded in the data set inversely to the impact they are supposed to exert on production.

shows a negative sign with insignificant coefficient. This might, however, have an indication that farmers with relatively small holdings tend to fertilize the larger percentage of their holdings while those farmers having more than 2.5 hectares of land do not proportionally make use of fertilizer.[7]

Table 4: OLS and MLE Estimates of Stochastic Frontier Cobb-Douglas Production Function

Variables	O L S		M L E	
	Coefficients (t-ratios)	**Probability Values**	**Coefficients (t-ratios)**	**Probability Values**
Constant	4.057 (7.19)	0.000	4.614 (7.746)	0.000
L	0.1533 (2.67)	0.008	0.1384 (2.168)	0.03
H	0.3256 (3.315)	0.001	0.3213 (3.13)	0.002
OB	0.262 (3.789)	0.000	0.2597 (3.56)	0.000
M	0.4062 (4.837)	0.000	0.40 (4.6810	0.000
CR	0.2847 (3.004)	0.000	0.2923 (3.377)	0.001
R2	0.560 (4.78)	0.000	0.5354 (4.606)	0.000
R3	0.291 (2.46)	0.01	0.2868 (2.6160	0.009
R4	-0.241 (-0.2)	0.840	-0.3063 (-0.255)	0.799
Lq	-0.103 (-1.57)	0.116	-0.1126 (-1.72)	0.08
Ls	-0.9 (-0.759)	0.45	-0.1017 (-0.799)	0.424
Edh	-0.54 (-2.52)	0.012	-0.5052 (-2.515)	0.01
F	0.2315 (3.71)	0.000	0.2344 (3.79)	0.000
Intfhs	-0.783 (-0.293)	0.76	-0.1149 (-0.374)	0.709
La	0.116 (0.87)	0.38	0.1206 (0.885)	0.376
Ledh1	0.232 (2.19)	0.001	0.2339 (3.39)	0.001
Lfs	-0.125 (-1.343)	0.1793	(-1.255)	0.21

Source: Own computation

[7] The average per hectare fertilizer application for a land size less than 2.5 hectares is 96.16 kg while the respective figure for land size larger than 2.5 hectares is 64.05 kg.

Wealth and credit dummies (M and CR) maintained their expected positive sign with elasticities of 0.40 and 0.28, respectively. Households the roofs whose homes were made of galvanised iron, stone, bricks or cement produced higher levels of output. This might be due to the fact that these farmers could relatively be liquid to acquire the necessary complementary inputs on time. It is also possible to argue that in the Ethiopian context constructing a house with galvanized iron requires producing over and above the customary consumption requisite of the household at least for sometime, which could demonstrate accumulated efforts and experiences on farming. On the other hand, households with grass-made-roofs are forced to waste part of their productive time on housing maintenance, and above all more often than not they are economically less established.

Educational variables revealed that literate farmers are more productive than illiterates owing perhaps to better access to information about the source and use of modern inputs, as well as better commitment in adopting modern farming techniques and management practices.[8] The variable for literate family members other than the head, EDH, came up with a negative sign and became significantly different from zero. A partial correlation between EDH and the variable for adult family members indicated a very weak association[9], implying that many are under “farm-age” with little experience to share and influence the decision of the household head, thus rather compete for limited financial resources and working time in an attempt to take care of them while they are learning.

The variable for age of household head, (Ia), is found to be insignificant. The average age of household heads was more than 45 years, such that there were many “old” family heads. Naturally, two possibly contradictory effects may arise beyond a certain age limit; boosting production through rich experience or losing physical strength/endurance to accomplish day-to-day activities (Croppenstedt and Mulat 1997).

[8] Studies on the area indicated that education is believed to influence after a certain threshold level. However, as descriptive statistics figures indicated educated farmers are rare and discrimination based on education levels may not provide meaningful result. We also learnt from the findings of Abay (1997) on a similar data set that in the Ethiopian peasant agriculture, any level of education for the household has positive contribution to production.

[9] The result shows a negative sign with a partial correlation coefficient of 0.14.

4.2.2 Technical Efficiency

As indicated in Table 4 above, production function estimates through OLS illustrate mean output responses of “all households” for a change in input levels, while MLE, as a stochastic frontier estimator, reveals the same but considers the “best-practising” farmer as a reference. OLS gives no room for impacts of specific household attributes and assumes similar efficiency levels across farmers. Obviously, the value of the constant term in OLS should be lower or equal to the MLE (Assefa 1995). Thus, the values of the constant terms are 4.057 in OLS and 4.614 in MLE, indicating the existence of efficiency difference among farmers due to household controlled “errors in operation”. The difference between the two values measures how far the best-practising farmer operates above the average production line.

Table 5: Estimates of Technical Inefficiency Indicators

Parameters	Coefficients (t-ratios)	Probability Value
σ_μ^2	0.37015	
σ_v^2	0.3399	
σ^2	0.8379 (8.6)	0.00
$\lambda = \sigma_\mu / \sigma_v$	1.056 (2.2)	0.026

Source: Own computation

The effect of household controlled factors on the variation of production levels, σ_μ^2 are found 8.9 percent more compared to the case for exogenous variables σ_v^2. Similarly, the coefficient of λ also indicated that the one-sided error term has statistically significant and higher influences than the conventional error term, implying that factors that are under farmers’ control exert more influence than otherwise. Thus, there exists inefficiency in sampled households due to in-house problems and the extent varies among farmers operating even in a similar technological setting.

Table 6: Technical Efficiency of Farmers by Education Status, Land Size and Regions

Statistics	Whole Sample	Education Status		Land Size		Regional States		
		Literate	Illiterate	Two Ha & below	Above two Ha	Amhara	Oromiya	SNNP
Minimum	0.220	0.307	0.220	0.370	0.220	0.243	0.301	0.220
1st Quartile	0.379	0.439	0.379	0.480	0.379	0.384	0.439	0.314
Mean	0.628	0.639	0.625	0.633	0.627	0.638	0.645	0.426
Median	0.641	0.656	0.631	0.648	0.639	0.654	0.665	0.431
3rd Quartile	0.696	0.703	0.696	0.700	0.696	0.667	0.756	0.500
Maximum	0.855	0.836	0.857	0.855	0.810	0.808	0.855	0.594

Source: Own computation

Mean technical efficiency of all sample households is 62.8% relative to the "best-practicing" farmer. Due to the incapability of optimally utilizing resources under their disposal, households on the average loose about 37.2% of their potential output. About a 63 % difference was observed between the efficient farmer next to the best and the most inefficient one. The first 25% inefficient farmers operated very much below the mean, where as the top 25% farmers performed very much near to the centre. The median, being higher than the mean and the first and third quartiles imply negatively skewed distribution of technical efficiency values. This implies a considerable efficiency difference amongst lower efficiency level operators than the case for relatively "efficient" ones.

Efficiency varies between groups of farmers classified under different attributes. Literate farmers realized higher output per unit of inputs than illiterates and similar variation is also observed in resource endowment and input use. Literate farmers had larger stock of oxen and bulls, applied more fertilizer and obtained more credit[10]. On average, farmers having two or less hectares of land performed more efficiently than those having more than two hectares of land. This might be because of incompatibility of other resource endowments with the size of the cultivated land[11].

[10] While literate farmers on the average used 135.4 kg fertilizer, owned 1.72 ox-bulls and 25% of them acquired credit, the respective figures for illiterate farmers were 118.3, 1.67 and 22%.

[11] Small land farmers spend 99.32 kg chemical fertilizers, 208.44 labour days and 1.2 oxen and bulls per hectare of land while large size farmers use 54.29 kg, 134.53 labour days and 0.86 ox-bulls. In terms of quality of land, the mean

Thus, reallocation of land through tenancy or otherwise has an implication not only on equity but also efficiency gains. Efficiency is also affected by location factors. Farmers of Oromiya were relatively efficient on average than those in Amhara and SNNP, which stood second and third, respectively. Partly this difference was attributable to the magnitude of input utilization and natural conditions.[12] SNNP farmers employed relatively low level of labour, oxen and bulls, and fertilizer and Amhara farmers operated under unfavourable natural conditions in terms of the pattern of rainfall and land quality.

4.3 Efficiency Difference between Owner-Operators and Tenants

Chow-test is used to examine whether or not land ownership leads to different production functions. The required parameter estimates and the respective computed F-value for the test are the following.

Table 7: Chow Test Parameters

Residual Sum of Squares	Number of Observations	F- Statistics
s1= 158.54	N1 = 196	F- computed = 1.56938
s2 = 102.35017	N2 = 144	F (17, 306) at 1% ≈ 2.62
S3 = 43.48569968	K = 17	F (17, 306) at 10% ≈1.74

Source: Own computation

The computed F-value based on equation (17) is lower than the critical F-values at conventional probability magnitudes. Thus, we do not reject the hypothesis that owner-operators and tenants work on the same production function, implying that tenancy related factors such as rent, obligations to be carried out by tenants, land use insecurity, etc., did not have the strength to characterize a different kind of production function. Under such circumstances, comparing efficiency levels between the two groups of households is possible on the basis of a common stochastic frontier production function.

figures are in favour of the small land holders (1.65) compared to the others (1.79). Given the lowest elasticity of land quality variable holds, the main cause of inefficient operation for 'large' lands could be incompatibility of resources.

[12] Details are provided in Appendix No. 4¹

Table 8: Efficiency Comparison between Own-operators and Tenant Farmers

Statistics	Whole Sample	Owner-Operators	Tenants
Minimum	0.22044	0.24255	0.22044
First Quartile	0.3790	0.39558	0.36463
Median	0.64056	0.63926	0.64115
Third Quartile	0.69610	0.70163	0.65301
Maximum	0.85465	0.85465	0.79720
Mean	0.62757	0.629416	0.6251
Mean at 95% Confidence Interval	0.6446	0.6464	0.6423

Source: Own computation

As revealed from Table 8, central tendency measures except the median gauged owner-operators to be relatively more efficient as compared to tenants. Besides, the most efficient and the most inefficient farmers were among own-operators and tenants respectively. However, this gap in efficiency between the two groups of farmers is not statistically different from zero, (F=0.125).

Owner-operator and tenant dummy variables were incorporated into two production functions to examine their associations with output. The coefficient of the dummy variables for owner-operators and tenants became positive and negative, respectively, but statistically insignificant in both cases.[13] Thus, both statistics and econometric findings do not provide a strong support for the view that 'tenants are inefficient because of several institutional constraints'.

The opinion that rental share discourages efficiency of tenants does not adequately consider the opportunity cost of tenant labour at least in the Ethiopian context. In our case, tenants did not meaningfully use hired labour and their non-farm income was very limited[14]. The need for survival in the face of limited opportunities could influence farmers having limited access to land to operate at least with the prevailing input application norms and demonstrated a similar efficiency level with owner operators. In addition to operating in a similar technological setting in terms of using

[13]The coefficient of owner-operator dummy (wn) in OLS with associated t-ratios is found to be 0.774 (0.95) while the respective figures for tenant dummy (tt) are -0.774(-0.95). See Appendix 3

[14] The average non-farm income of households is 19 US Dollars (143.17 *Birr*) per annum.

fertilizer and ox-plough, farmers who rented-in land were relatively better endowed with resources.

To examine possible input specific responsiveness differences, elasticity of labour, land, oxen and bulls, fertilizer and rainfall are estimated for own operators and tenants using MLE and a Wald test is applied.

Table 9: MLE Estimates of Cobb-Douglas Production Functions for Wald Test

Variables	Owner-Operators		Tenants		For the Two Groups		
	Coefficients	Standard Errors	Coefficients	Standard Errors	Sum of β Variances	Square of βs Differences	$\chi^2_{(1)}$
Constant	3.65678*	0.41800	4.005712*	0.39308	0.329241	0.1217	0.37
L	0.18575*	0.088634	0.933352	0.016146	0.012031	0.5589	46.5
H	0.10921	0.113296	0.601790*	0.115578	0.026241	0.24263	8.62
OB	0.25962*	0.094693	0.16979*	0.098892	0.018747	0.00807	0.43
R2	0.58851*	0.0128918	0.813287*	0.128468	0.016674	0.05052	3.03
F	0.34954*	0.0829694	0.321019*	0.802091	0.013623	0.11284	8.28
Ledh1	0.18404*	0.0897825	0.985686	0.780618	0.077425	0.6426	8.23

Source: Own computation *Significant at 5%.

No statistically valid difference is observed between intercepts, the coefficients of oxen and bull, and rainfall variables in the two production functions (as critical value for $\chi^2_{(1)}$ at 5% = 3.84). With respect to other inputs, statistically significant output elasticity differences are noticed. Output fairly responds to fertilizer application in both farms but higher in the production function of owner-operators. Land in owner-operators' and education and labour in tenants production function are found statistically insignificant. This tends to imply that land in owner operators and labour for tenant households' are relatively in abundance, which calls for a sort of adjustment through perhaps tenancy arrangements.

5. CONCLUSION AND POLICY IMPLICATIONS

Mean technical efficiency of sampled households is about 62.8 percent implying that a considerable potential exists for production gain with the given technology. Households with two hectares or less performed better than those having larger farms, possibly because of the fact that those operating on two or more hectares of land may not have adequate complementary resources to make use of the land effectively. Literate farmers were relatively wealthier, more informed and efficient and had better access to credit markets. Wealth of households, credit, oxen and bulls, amount of fertilizer and rainfall significantly contribute to production.

Mode of land holding did not bring about an observable difference in mean technical efficiency between owner-operators and tenants (62.9 percent and 62.3 percent respectively) and both groups operated on a similar production function. Coefficients of dummy variables representing owner operators and tenants, in two alternative cases in a production function, revealed a positive and a negative sign, respectively, but they were statistically insignificant. This consistent outcome from quite different methodologies arose possibly from at least two important factors. Firstly, in the face of limited alternative employment opportunities, tenants may not even contemplate to undersupply inputs and efforts rather than maximizing their share of output. Secondly, land mobility may allow better compatibility of resources for both groups of farmers and this could be witnessed from the fact that those farmers having more than two hectares of land were found less efficient.

From the above findings, the following policy implications could be derived. Efforts towards providing training, education, and extension services for households focusing on optimal use of available inputs should be underpinned. Government should also encourage the establishment and expansion of micro credit institutions and mechanism should be created for the movement of production factors such as oxen and bulls across areas for better economic and social return. Minimizing dependence on rainfall for cereal production calls for a coordinated effort among donors, government and beneficiaries to pool resources and formulate programs to undertake small-scale irrigation schemes.

It has already been observed from the result in this study that rental arrangement of land has been used as a mechanism of adjusting input combinations for their efficient use. Thus, it would be for the mutual benefit of landholders with inadequate complementary inputs, including male labour and oxen, and those who own very small plots or absolutely lack access to state land to continue working together through tenancy arrangements. A thorough study might be required to propose a conclusive recommendation about the impacts of contracts on efficiency, yet as evidenced from past experiences in different countries, the higher the rental shares the more reluctant tenants would be to maximize output. This calls for arrangements that would provide optimal benefits to both parties.

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Annex 1

Descriptive Statistics of Some Key Variables for the Whole Sample

Variables	Mean	Standard Deviation	Minimum	Maximum
Value of Output in Birr	1857.48	1633.77	77.5	13886.0
Land in Hectares	1.88	1.25	0.25	9.25
Labour Days	290.75	322.06	60.0	2253.0
Fertilizer in Kg	124.15	106.52	34.0	800.0
Oxen and Bulls	1.69	1.79	0.0	14
Land Quality	1.69	0.64	1.0	3.0
Land Topography	1.23	0.34	1.0	3.0
Family Size	7.03	3.26	1.0	22
Adults above 15yrs of Age	1.95	1.2	0.0	9
Dependent	2.26	1.63	0.0	11
Age of HH Head	47.3	16.2	18.0	90.0
Age of Adults	35.2	9.7	19.0	85.0
Hired Labour Share	0.13	0.22	0.00	1.0
Exchange Labour Share	0.19	0.23	0.00	0.91
Family Labour Share	0.68	0.29	0.00	1.00
HH Taking Credit	0.23	0.42	0.00	1.00
Female Headed HH	0.15	0.36	0.00	1.0
EDLC	0.34	0.47	0.00	1.0
HH Members Yrs of Schooling	1.33	1.99	0.00	10.0
Credit	0.23	0.42	0.00	1.0
Non-Farm Income	143.17	353.68	0.00	4500.00
HH with Galvanized Iron Sheet Residences	0.45	0.50	0.0	1.0
HHs with Radio	0.15	0.35	0.00	1.00
HHs with Labour Problems	0.14	0.35	0.00	1.00
HHs with Oxen Problems	0.25	0.43	0.00	1.00
Water Acquiring Time in Minutes	15.18	20.27	0.00	300.0
Firewood Acquiring Time in Minutes	39.86	57.86	0.00	420.0

Source: Own computation.

Annex 2

A Comparative Analysis of Mean Values: Owner operators -vis-à-vis- Tenants

Variables	Owner operators	Tenants	F-Value
Age of Household Head	48.9	45.1	4.85
Average Age of Adults (Ag)	36.4	33.5	7.82
Dependents	2.28	2.23	0.17*
Oxen and Bulls	1.51	1.92	4.45
HH with Galvanised Iron Sheet (%)	40	51	4.1
Radio Possession (%)	13	17	1.4*
EDLC (%)	32	38	1.3*
Output in Kg	1229.2	1316.3	0.5058*
Fertiliser in Kg	115.2	136.3	3.26
Land in Hectares	1.93	1.81	1.27*
Labour	263	328	3.38
Credit	0.24	0.34	0.406
Labour for Ploughing	61.1	82.4	5.97
Labour for Harvesting	111.0	164.17	4.42
Labour for Weeding	91.2	81.5	3.35
No. of times (Ploughing)	9.4	13.6	39.4
Share of Family Labour (%)	66	72	3.36
Share of Hired Labour (%)	12.3	12.2	0.002*
Share of Exchange Labour (%)	22	16	4.9
Edh1	1.34	1.33	0.00*
Output per Labour	7.1	6.4	0.9
Output per Oxen and Bulls	713.4	757.8	0.23*
Land in Hectares	1.93	1.81	1.35*
Land Quality	1.65	1.75	1.75
Land Topography	1.23	1.22	0.05*
Female Headed Households (%)	20	8	8.8
No of Adult Farmers	1.95	1.96	0.004*
Family Size	7.2	6.8	1.15*
HHs having Labour Problem at Right Time (%)	16	12	1.1*
HHs having Oxen and Bulls Problem at Right Time (%)	28	21	2.01*

Source: Own computation

Annex 3

1. The Role of Landholding Status in Production- Tenant Dummy as an Explanatory Variable

Limited Dependent Variable Model – Frontier Regression

Ordinary Least Square Regression Weighting Variable = None

Dependent Variable = Y, Mean = 6.7644505, S.D. = 0.9490891482

Model Size: Observations = 340, Parameters = 18, Deg. Fr. = 322

Residuals: Sum of Squares = 158.1004192, Std.Dev. = .70071

Fit: R-squared = .482251, Adjusted R-squared = .45492

Model Test: F[17, 322] = 17.64, Prob value = .0000

Diagnostic: Log-L = -352.2675, Restricted (b = 0) Log-L = -464.1725

LogAmemiyaPrCrt. = -.660, Akaike. Info.Crt = 2.178

Variable	Coefficient	Standard Error	B/St.Er	P[/Z/>z]	Mean of X
Constant	4.126409098	.56877315	7.255	.0000	
L	.1535615947	.57552686E-01	2.668	.0076	5.3046580
H	.3313662366	.98425544E-01	3.367	.0008	.43139455
OB	.2649724730	.69328448E-01	3.822	.0001	.79383793
M	.4135022841	.84339787E-01	4.903	.0000	.45000000
Cr	.2838728559	.93623033E-01	3.032	.0024	.23235294
R2	.568137203	.11740638	4.839	.0000	.36764706
R3	.2790552552	.11892414	2.346	.0190	.35294118
R4	-.2705668449E-01	.12029103	-.225	.8220	.30294118
Lq	-.1001067377	.65626101E-01	-1.525	.1272	1.6933326
Ls	-0.9170590944E-01	.11867592	-.773	.4397	1.2310305
EDH	-0.5423866304E-01	.21514671E-01	-2.521	.0117	1.3340900
F	.2337389606	.62507030E-01	3.739	.0002	4.5338446
Intfhs	-.629271467E-02	.26803113E-01	-.235	.8144	2.3918206
LA	.1016174478	.13422378	.757	.4490	3.7866718
LFS	-.1276985208	.92913398E-01	-1.374	.1693	1.8436391
LEDH1	.2351289870	.72744076E.01	3.232	.0012	.47816286
TT	-.7736025823E-01	.81130687E-01	-.954	.3403	.42352941

Source: Own computation

2. The Role of Landholding Status in Production- Owner operators Dummy as an Explanatory Variable

Limited Dependent Variable Model – Frontier Regression
Ordinary Least Square Regression Weighting Variable = None
Dependent Variable = Y, Mean = 6.7644505, S.D. = 0.9490891482
Model Size: Observations = 340, Parameters = 18, Deg. Fr. = 322
Residuals: Sum of Squares = 158.1004192, Std.Dev. = .70071
Fit: R-squared = .482251, Adjusted R-squared = .45492
Model Test: F[17, 322] = 17.64, Prob value = .0000
Diagnostic: Log-L = -352.2675, Restricted (b = 0) Log-L = -464.1725
LogAmemiyaPrCrt. = -.660, Akaike. Info.Crt = 2.178

Variable	Coefficient	Standard Error	B/St.Er	P[/Z/>z]	Mean of X
Constant	4.049048840	.56416411	7.177	.0000	
L	.1535615947	.57552686E-01	2.668	.0076	5.3046580
H	.3313662366	.98425544E-01	3.367	.0008	.43139455
OB	.2649724730	.69328448E-01	3.822	.0001	.79383793
M	.4135022841	.84339787E-01	4.903	.0000	.45000000
Cr	.2838728559	.93623033E-01	3.032	.0024	.23235294
R2	.568137203	.11740638	4.839	.0000	.36764706
R3	.2790552552	.11892414	2.346	.0190	.35294118
R4	-.2705668449E-01	.12029103	-.225	.8220	.30294118
Lq	-.1001067377	.65626101E-01	-1.525	.1272	1.6933326
Ls	-0.9170590944E-01	.11867592	-.773	.4397	1.2310305
EDH	-0.5423866304E-01	.21514671E-01	-2.521	.0117	1.3340900
F	.2337389606	.62507030E-01	3.739	.0002	4.5338446
Intfhs	-.629271467E-02	.26803113E-01	-.235	.8144	2.3918206
LA	.1016174478	.13422378	.757	.4490	3.7866718
LFS	-.1276985208	.92913398E-01	-1.374	.1693	1.8436391
LEDH1	.2351289870	.72744076E.01	3.232	.0012	.47816286
WN	.7736025823E-01	.81130687E-01	-.954	.3403	.57647059

Source: Own computation

Annex 4

Average Input application and Natural Conditions of Farmers across Regions

Variables	Amhara	Oromiya	SNNP
Labour Days	281.6	323.16	153.7
Oxen and Bulls	2.16	1.40	0.86
Land Quality	1.94	1.46	1.76
Fertilizer in Kg	120.7	139.47	61.54
Rainfall Comes on Time	0.45	0.70	0.63

Source: Own computation