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Productivity and Efficiency of Agriculture in Dhanushadham, Nepal

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Abstract: *This study aims at estimating an output oriented SDF simultaneously with a technical efficiency effects model. Using 450 sample data obtained from a field survey in Janakpurdham, Nepal, the study empirically measures the TE and explores the determinants of the efficiency related to technical inefficiency. The main finding of the study is that a high level of inefficiency is present in the study area. Changes in the quantity of production inputs have a huge effect on the extent of productive efficiency. The inefficiency level is associated to farm specific characteristics. Ownership of land is the key determinant of inefficiency followed by extension service, land quality, access to credit, access to road and education. While the TE among agricultural households differs notably across farm size, medium size farms achieve the highest technical efficiency. The findings are expected to be helpful in improving TE in agriculture which can reduce poverty and inequality.*

Keywords*: technical inefficiency; farm size; stochastic distance function; Nepal*

JEL Classification*: I38; L25; O13; Q12*

1. INTRODUCTION

Agricultural productivity and efficiency is at the focal point of considerable discussions, policies and measures concerning the agriculture based developing countries including Nepal. The 2030 Agenda for Sustainable Development Goals emphasizes the numerous reasons for which extra investigation is needed on measuring productivity and efficiency (UN, 2015). Some of the Sustainable Development Goal (SDG) indicators are interrelated to the level of agricultural productivity and efficiency of the nation concerned. So, many economies around the world, where agriculture is the key economic sector and there is a wide productivity gap between the primary and tertiary sector, have commenced policies to stride out in agricultural productivity and efficiency.

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Improvement in efficiency in agricultural farming reduces poverty through better food security and higher farm incomes. Most developing countries around the world face the main challenge of poverty alleviation which is the most socio–economic development goal set by them. To many development actors such as donors, philanthropic organizations, and policymakers, the expression "make poverty history" has become a common slogan for a long time. In Nepal, land is the fundamental resource on which most poor people are dependent. It is the primary source of earning livelihood for them. However, agricultural land is arguably misallocated endorsing Nepalese society to be greatly hierarchical with regard to production relations.

Nepal faces various problems for implementing strategies that encourage agrarian development and poverty reduction in a sustainable manner. Numerous development practices have been embraced over the years on behalf of economic development and mitigation of poverty and inequality. These past development plans however were not successful to pick up agricultural production and poverty reduction. Although, the overall economic growth increased to some extent, the growth was greater in the rich community as compared to poor ones (CBS, 2011). Similarly, the overall poverty rate decreased to some extent but the reduction in rural areas was slower than in urban areas.

This study mainly aims at estimating an output oriented stochastic distance frontier simultaneously with a technical efficiency effects model in Dhanushadham, Nepal and explore the prospective determinants of productive inefficiency of agriculture to eliminate poverty and inequality and promote equity. However, very limited productivity and efficiency measurement research has been conducted in Nepal. These researches are also concentrating solely on single crop production and covering a small village area. Against this background, the primary hypothesis of this study is that farmers can be economically better off and minimize overall poverty and inequality by raising technical efficiency (TE). To test the hypothesis this study measures the productive efficiency of aggregate farm output in whole Janakpurdham, Nepal using 450 cross-section primary data. Unlike previous studies, the study constructs production variables that integrate all crops and other farm-related products generated by sample households within a whole year, as opposed to previous ones, and analyzes productive efficiency using the stochastic distance function (SDF) model in order to recommend policy implications for increasing TE and thus reducing poverty and inequality. Furthering, this study attempts to explore the determining factors of inefficiency applying Frontier 4.1 econometric software developed by Coelli (1996).

The study is outlined as follows. Section 2 provides a review of the literature. Section 3 offers the study area, data and variables. Section 4 sketches empirical models, while Section 5 reports empirical results and discussion. This study ends with some conclusions and policy implications in Section 6. A list of references and tables are included at the end.

2. LITERATURE REVIEW

The measurement of production efficiency has been a subject of major interest in economic development literature, most likely because of its policy implications. This notion is closely associated with a few problems in developing countries including poverty, inequality, political instability, migration, agricultural stagnation, and natural resource degradation, etc. A number of researches on measuring agricultural productivity have already been carried out worldwide. However, there is a lack of research specifically in addressing the challenges faced by many agriculturally based developing economies (Kelly et al., 1996). Past discussions about the issue were largely motivated by the proposition of farm–size based inverse relationship (IR). The relationship offers important policy implications for more equal size distribution of holdings, with the prospect of improving both efficiency and equity. More importantly, the existence of IR has provided theoretical and logical arguments to land reform measures suggesting that a small farm-oriented development strategy, achieved through breaking up large hired–labour–based farms into smaller family–labour–based ones, would increase agricultural output (Assuncao and Braido, 2007).

A great majority of empirical studies, particularly in developing countries argue that, smaller farms utilize productive resources more efficiently, and produce more output per unit than larger farms. For the first time Chayanov (1926) observed the IR between farm size and productivity relation in Russia. Sen (1962), using Indian farm management survey dataset established an important link with farm size and productivity. He observed that productivity decreases with the increase in land holding. He also argued that small family farms use their labor until the marginal productivity of labor (MPL) becomes zero. On the other hand, big farms employ hired labor until MPL equals market wages. Since this study, several empirical studies have been produced supporting, or rejecting, the finding.

In the 1960s, the finding of this IR became well established, with scholarly recognition that small family farms are more efficient, producing more agricultural output than large ones. The phrase “Small is beautiful” became well known in agricultural development literature (Sharma and Sharma, 2000;

Berry and Cline, 1979). In many countries, including Japan, South Korea and Taiwan, land reform policies were the key factors behind their economic transformation; the creation of an economic surplus, increasing demand and overall stability were essential to sustain rapid industrialization (Heltberg, 1998). However, in the 1970s and 1980s, the process of faster industrialization and urbanization heightened the movement of labor to the urban region, away from rural areas in many Asian countries (Fan and Chan–Kang, 2005). On the one hand, industrialization made modern agricultural inputs (equipment) cheaper, whereas large commercial farming was possible without labor constraints during the peak season. Consequently, small farms were considered a major obstacle to development and a debate against the validity of the IR identified in the 1960s began in agricultural development literature.

In this context, two major arguments have been presented in the literature. The first deals with the issue of omitted variable bias in the regression model, due to unobserved higher quality of land; the other argument deals with resource heterogeneity in different sizes of farmland. The omission of farm heterogeneity in general, and land quality, could lead to biased results in favor of an IR, if these factors are negatively related to farm size (Bhalla and Roy, 1988). The second argument maintains that with the advent of the Green Revolution (GR), agriculture became more capital intensive and the IR either diminished or even reversed (Fan and Chan–Kang, 2005). There exists a perception that large farmers benefit more from the GR with the initial, and fast, adoption of new technology.

The literature suggests among the studies that observed the IR, the majority are based in India (e.g., Sen, 1962; Mazumdar, 1965; Saini, 1971; Bharadwaj, 1974; Talukdar and Banerjee, 1984; Newell, Pandya and Symons, 1997; Banerjee, 1985; Bagi, 1981; Tadesse and Krishnamoorthy, 1997; Sharma and Sharma, 2000; Reddy, 1993; Assunção and Braido, 2007). Relatively few studies of the type done in India have been in other countries such as Gorton and Davidova (2004) in six Central and East European countries; Semos (1997) in EU countries; van Zyl et al. (1996) in Poland; Hossein (1974) in Bangladesh; Moghadam (1982) in Iran; Benjamin (1995) in Java; Byiringiro and Reardon (1996) in Rwanda; Barrett (1996) in Madagascar; Gilligan (1998) in Honduras; Townsend, Kirsten, and Vink (1998) in South Africa; Oduol and Tsuji (2005) in Kenya; Kimhi (2006) in Zambia; Parikh, Ali and Shah (1995) and Heltberg (1998) in Pakistan; Tiwari (1990); and Adhikari (1993) in Nepal.

Some studies (cf. Singh and Patel, 1973; Ghose, 1979; Deolalikar, 1981) observed that the hypothesis of the IR exists where traditional technology is dominant, and not where there is technological advancement. These findings suggested that the superiority of small farm production was merely the results of the technological backwardness. This IR could disappear with the progress in agricultural technology. Some other studies found neither the small nor the large, but the medium size agricultural farm to be more efficient suggesting that productivity/efficiency per unit of land increased up to a certain level and then declined identifying the medium size farm as the more efficient. Mandal (1981) in Bangladesh; Moghadam (1982) in Iran; Haq, Khan, and Ahmad (2002) in Pakistan; Bhuiyan (1987) in Bangladesh are some of such studies.

Some other studies including Johl (1973); and Khan and Maki (1980), in Pakistan; Barnum and Squire (1978) in Malaysia; Dutta (1982) in India; Carter and Wiebe (1990) in Kenya, Lamb (2003), Helfand and Levine (2004) in Brazil; Obasi (2007) in Nigeria were unable to establish any significant relationship between size of the farm and production efficiency or found mixed results including non–linear, U–shaped or inconclusive results. Some evidence particularly from Western countries opposes the hypothesis of IR and demonstrates that bigger farms are technically more efficient (Latruffe et al. 2004; Seckler and Young, 1978; Hall and LeVeen, 1978). These studies argue that large farms benefit from the early adoption of new GR technology and produce more output than small farms. However, the empirical evidence suggests that relative to the total number of sizes–output relationships, there are only few studies which support the positive relationship between size of the farm and production efficiency.

The literature, as reviewed above, suggests that there has been a long debate concerning the optimal farm size in terms of agricultural production. In the context of many developing countries including Nepal, the inverse hypothesis has continued to centre on the economic grounds and remains pertinent for policy implications with land management and scientific land reforms (Schmitt, 1991; Bharadwaj, 1974; Cornia, 1985). This issue is likely to continue to play an important role. However, relative to the total number of recent frontier studies measuring TE in agriculture, there has been very little research linking TE with farm size. Unlike other studies, this study integrates all yields produced by farmers within a year in three broad output variables and all inputs used in six broad input variables. Further, this utilizes a single step method to get consistent parameter estimates for the stochastic distance frontier (SDF) and the inefficiency equation and try to link farm size and efficiency to fill the research gap.

3. THE STUDY AREA, DATA AND VARIABLES

The study area for this research is Janakpurdham which is in Province 3 of Nepal. The land is plain, soil is alluvial and moist most suitable for cultivation of varieties of crops and other food items.

This study uses cross sectional data collected from primary sources using a personal interview method. Janakpurdham was selected purposively for data collection largely for two reasons: (i) author's familiarity with the area and (ii) Janakpurdham is highly appropriate for agricultural productive analysis and may represent the whole country for land policy implications.

Taking the whole Janakpurdham area as a population, sample units were chosen from the area using a two-stage area sampling method. In the first-stage three ward numbers namely ward number 4, 21 and 25 were chosen randomly among the total 25 wards. A total of 150 samples from each ward were selected randomly in the next stage. The unit of information was family heads who were interviewed to obtain necessary information. In this manner, while the study area was purposively chosen, participants were randomly selected.

Three output variables namely cereal crops (q1), cash crops (q2) and other outputs (q3) are constructed to estimate the SDF model. Each output variable is measured in monetary terms (Nepalese rupees) and is obtained by multiplying the physical quantity by its respective average price. Consistent with the literature on production economics, six production variables, viz, farmed land in hectare (x1), human labour (x2), farmyard manure (FYM) (x3), capital service (X4), purchased inputs (x5) and other costs (x6) are included in the econometric model.

Nine farm specific attributes are specified in the inefficiency impact model. These variables are ownership dummy (Z1)– a value is equal to 1 if the household has 50% or more ownership of the cultivated land, 0 otherwise; value of land per bigha (Z2)– measured as the market value of land as (a proxy of land quality); extension service (Z3)– an extension agent's visit time to the agricultural farming during the last year; age (Z4)– household head (HHH) age; HHH education (Z5)– years of HHH education; gender dummy (Z6); HH size (Z7)– number of family members; credit dummy (Z8); access to road in Km (Z9)– distance from residence to a vehicle passable road.

To account for potential location-fixed effects, three dummy variables are used as follows: ward number 4 is treated as a reference and two location dummies are ward 21 dummy (Z10) and ward 25 dummy (Z11). Based on the World Bank (2006) classification, farm sizes are categorized as follows:

small (less than 1.00 hectare), medium (1.00 hectare to 2.00 hectare) and large (2.00 hectare or more).

4. THE EMPIRICAL MODEL

The 'poor but efficient hypothesis' advanced by Schultz (1964) generated several empirical works on the efficiency of agricultural farms. Latest research applying the DFA technique have utilized the transcendental logarithmic functional form on the grounds that imposing linear homogeneity in output is almost impossible for the other functional forms (Paul and Nehring, 2005; O'Donnell and Coelli, 2005). Following these research works, the distance function model in this study is specified by applying a transcendental logarithmic production frontier. Equation (1) below specifies the transcendental logarithmic output oriental distance function model for '*M* 'outputs and '*P*' inputs.

$$\ln D = a_0 + \sum_{m=1}^{M} a_m \ln q_m + 0.5\sum_{m=1}^{M}\sum_{n=1}^{M} a_{mn} \ln q_m \ln q_n + \sum_{p=1}^{P} b_p \ln x_p + 0.5 \sum_{p=1}^{P}\sum_{j=1}^{P} b_{pj} \ln x_p \ln x_j + \sum_{p=1}^{P}\sum_{m=1}^{M} g_{pm} \ln x_p \ln q_m \quad (1)$$

In this equation, the subscript '*i'* denotes the *i*th sample observation in the data set (*i*=1, 2, … 450), the $a_{o,}$ a_m, a_{mn}, b_p, b_{pj}, and g_{pm} are unknown parameters and *ln* indicates the natural logarithm. The '*M* 'outputs and '*P*' inputs are defined in Section 3. From Euler's theorem the homogeneity of degree 1 in outputs implies as follows:

$$\sum_{m=1}^{M} a_m + \sum_{m=1}^{M}\sum_{n=1}^{M} a_{mn} \ln q_n + \sum_{p=1}^{P}\sum_{m=1}^{M} g_{pm} \ln x_p = 1, \quad (2)$$

that is satisfied if and only if

$$\sum_{m=1}^{M} a_m = 1, \sum_{m=1}^{M} a_{mn} = 0 \quad \text{for all n, and} \quad \sum_{m=1}^{M} g_{pm} = 0 \quad \text{for all p} \quad (3)$$

and the symmetry restrictions require $a_{mn} = a_{nm}$ and $b_{pj} = b_{jp}$ for all *m, n, j* and *p*. The homogeneity constraint in the model is imposed as Lovell *et al.* (1994). "Substituting these constraints into the distance function is equivalent to normalising by one of the outputs" **(**O'Donnell and Coelli, 2005; 499). If output '*M'* is chosen to normalise, equation (1) becomes:

$$\ln D/q_M = a_0 + \sum_{m=1}^{M-1} a_m \ln q_m^* + 0.5\sum_{m=1}^{M-1}\sum_{n=1}^{M-1} a_{mn} \ln q_m^* \ln q_n^* + \sum_{p=1}^{P} b_p \ln x_p +$$

$$0.5\sum_{p=1}^{P}\sum_{j=1}^{P} b_{pj} \ln x_p \ln x_j + \sum_{p=1}^{P}\sum_{m=1}^{M-1} g_{pm} \ln x_p \ln q_m^*, \quad (4)$$

where $q_m^* = q_m/q_{M.}$ Equation (4) can be written in more compacted form as

$ln\ (D/q_M) = TL\ (x,\ q/q_M,\beta),$ (5)

or

$ln(D)–ln(q_M) = TL(x,\ q/q_M,\beta)$ (6)

In this equation *TL (.)* denotes the transcendental logarithmic function and β is the vectors of *a*, *b* and *g* parameters. Specifying equation (6) by substituting *–ln (D) = –u* as a one-sided error term, captures the inefficiency effects as follows:

$–lnq_M = TL(x,\ q/q_M,\beta) –u$ (7)

An error term, *v*, can be included in this specification to represent the effects of random errors. The transcendental logarithmic SDF model becomes as follows:

$–ln\ q_M = TL(x,\ q/q_M,\beta)–u+ v$ (8)

Applying maximum likelihood method, the parameters of this equation can be estimated. Here, '*u'* is to be assumed a non–positive random variable independently distributed as truncations at zero of $N(0,\sigma_u^2)$. Similarly, '*v*' is an independently and identically distributed random variable which is $N(0,\sigma_v^2)$. Rewritten Equation (8) becomes as:

$ln\ q_M = TL(x,\ q/q_M,\ \beta) – u+ v$ (9)

This transcendental logarithmic model has two error terms: the '*u*' is the deviation from the frontier which represents the technical inefficiency distribution parameter and '*v*' is a random error. The model can also be specified as:

$ln\ (q_M^*) = TL(x,\ q/q_M,\ \beta)+ v$ (10)

Equation (9) can be specified using equation (7)

$ln\ q_M = ln\, q_M^* –u$ (11)

or

$$\ln\left(\frac{q_M}{q_M^*}\right) = (\text{-u}) \tag{12}$$

As definition, Equation (12) obviously shows that the technical efficiency of a production unit is the ratio of its mean (average) production to the corresponding mean production if the producer used its available factors of production most efficiently (Battese and Coelli, 1988), i.e.:

$$TE = \frac{q_M}{q_M^*} = \exp(-u) \tag{13}$$

In this model *TE* takes values between 0 and 1. If *TE = 1*, it indicates that the production unit (farm or household) is fully efficient and *vice versa*. It is clear that the difference between q_M and q_M^* is embedded in *u*. If *u = 0*, then q_M equals to q_M^*. It means that the farm lies on the production possibility curve and the farm is said to be technically efficient. On the other hand, if $u > 0$, the farm lies below the curve, indicating that the production unit is technically inefficient. The '*u*' is a function of various farm specific variables. It can be specified as follows:

$$u_i = \delta_0 + \sum_{p=1}^{10} \delta_p z_{pi} + w_i \tag{14}$$

In this equation, Z_i is a $1\times p$ vector of farm specific variables as defined in Section 3 that may influence efficiency of a production unit. The parameter δ is a set of parameters to be estimated. The w_i*'s* are the random variables assumed truncation of the normal distribution with mean *0* and variance σ_u^2 (Battese and Coelli, 1995). The point of truncation is $-z_i\delta$ i.e., $w_i \geq -z_i\delta$, with u_i being a nonnegative truncation of the $N(Z_i\delta, \sigma_u^2)$ distribution.

5. EMPIRICAL RESULTS AND DISCUSSION

5.1 Test of the Model Specification

The first test carried out about model specification is the technical inefficiency effects test. The null hypothesis in this point is $H_0: \gamma = 0$, whereas the alternative hypothesis is $H_1 : \gamma > 0$. As the model is estimated applying maximum likelihood method, the hypothesis for inefficiency effects can be tested using Wald, Lagrangian Multiplier or Likelihood Ratio tests. The test statistic in this model is more than the 5% critical value and therefore the null hypothesis of no inefficiency effects is rejected. This confirms that inefficiency is present in the study area of farming practices and that the frontier model is valid.

The next hypothesis tested in the basic model is the choice of the functional form between Cobb–Douglas vs. transcendental logarithmic. Removing the second order and the interaction terms from the model and estimating the model, the H_0: (Cobb–Douglas) is imposed as $a_{mn}=b_{pj}=g_{pm}=0$ in equation 4. The generalised likelihood–ratio test statistic (λ) is equal to 253.40. The statistic is higher than the 99% critical value for χ^2 distribution with 19 degrees of freedom indicating that the H_0 is rejected at the 1% significant level. This implies that the transcendental logarithmic functional form gives a better fit than a Cobb–Douglas function and also adequately captures the productive technology in the study area.

The parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$ in the SDF model stand for the variances of the random variables v_i and u_i. The value of γ in the SDF model is 0.944 with the standard error 0.031, which is statistically different from zero indicating that 94% of the variation in the composite error term is due to the inefficiency component. This implies that the random part of the SDF model is statistically well-founded.

5.2 Production Elasticity

The partial derivative of each output with respect to m^{th} output in the output oriented SDF model represents the slope of the production possibility curve. In other words, it is the marginal rate of transformation between q_M and q_m. When the function is monotonically increasing and concave in input quantities the model is said better fit (Kumbhakar, 1994). Monotonicity refers positive coefficients of inputs within the data range. Table 1 reports the full regression results of the SDF model.

As Table 1(i) in Appendix shows, the first order and the second order output coefficients have corrected (negative) signs. This implies that the transformation curve has a concave shape. All first and second order coefficients and the cross (apart from cereal and others) and squared output terms are statistically significant. The second order coefficients refer that there is a room for substitution among output variables.

The output coefficient for an input estimates the proportional variation in overall output from a one percent change in an individual input, keeping all other inputs and all output ratios unchanged (Paul and Nehring, 2005). The estimated first–order coefficients of outputs with respect to all inputs are reported in Table 1(ii) in Appendix. The estimated first-order output coefficients for all inputs have expected positive signs and all coefficients are significantly different from zero. This result obviously points out that households can improve output by applying additional input quantities.

Farmed land possesses the higher coefficient (0.214) followed by FYM (0.185), human labour (0.162) and capital service (0.122). Higher the coefficient value, the more important the input is. The estimated coefficients for purchased inputs (0.053) and other input (0.042) have relatively small value but they are statistically significant. This implies that an increase in the amount of these inputs also adds a bit to the total output. Table 1(iii) in Appendix also shows that five squared terms are statistically significant and one of them is not significant.

The second–order elasticities present further insights into the production systems which can be used to evaluate complementarity and/or substitutability. If the sign of the parameter is positive there, those variables concerned are complementarity. This means that if the value of one variable is increased, it also increases the impact of another variable on total output. Correspondingly, a negative sign on the elasticity implies substitution between variables. Table 1(iv) in Appendix shows the cross output–input distance–function regression results. Out of the total 20 cross *q*–*x* terms 14 are statistically insignificant.

5.3 Returns to Scale

In an output oriented transcendental logarithmic SDF model the sum of first order input coefficients measures SDF based scale economy (Paul and Nehring, 2005). This measures the percentage change in output if all factors of production were changed at the same ratio. In other words, it measures the degree of increment of total output with a 1% increase in all factors of production. If the estimated value equals to 1, it indicates that constant returns to scale is present in the production system. Under this situation doubling the inputs would double the output and *vice versa*. If the sum is less than 1, then, the returns to scale are decreasing. Similarly, if the sum is greater than 1 there is increasing returns to scale. The sum of input coefficients in this study is equal to 0.78, which is evidently less than 1. This illustrates that decreasing returns to scale is prevailing at the average. The decreasing returns to scale also suggest that productive efficiency and aggregate output will be increased with minimizing the size of the larger farm (Gilligan, 1998).

5.4 Technical Efficiency

As discussed earlier, the technical efficiency of the farm is the ratio of its mean production to the corresponding mean production if the farm utilised its levels of inputs efficiently. The technical efficiency for each farm can be defined as $TE = exp(u_i)$, where *exp* denotes the exponential operator (Battese and Coelli, 1988).

Table 2 in Appendix reports the mean TE, its distribution between different classification and farm size. The estimated TE scores in this transcendental logarithmic SDF model extend broadly from 0.12 to 0.98, with an average TE of 0.74. The result illustrates that a high level of technical inefficiency exists in the production system. This demonstrates that a huge number of production units are operating far away from the efficient frontier. This suggests that there is a significant room for increasing TE by applying the present level of production technology and resources more efficiently. Therefore, the mean efficiency level of 0.74 in this study obviously demonstrates that typical households in the study area can raise agrarian output by 26% with the adoption of the technology and the techniques utilized by the best practiced households. Interpreting differently, on average, there is the possibility to attain the present level of output by reducing 26% of production inputs.

Frequency distribution of the estimated TE scores as reported in Table 2 shows that only 4.22 % of households have an efficiency index of higher than 90% and 30.21 % of households are working below than 50% range. The highest relative frequency of the TE index exists between the 51–60% range, followed by 61–70%, 71–80% and 41–50% range.

5.5 Technical Efficiency and Farm Size

Table 2 also demonstrates that 4.93% of medium households are working at more than 90% level, followed by small 4.46% and large 2.22%. The frequency distribution of households working in the less than 50% range of technical efficiency are 32.48%, 20.39%, and 36.67% in small-size, medium-size, and large-size farms, respectively. This proves the fact that high proportion of inefficient farms exists in the large farm size group followed by small and medium sized farms. The mean TE of 74% in the present study is similar with many other earlier studies based on cross sectional data using stochastic frontier analysis (Bravo–Ureta and Pinheiro, 1993).

The above analysis suggests that the Government of Nepal must recognize that there is a high level of technical inefficiency existing in the method of production. If technical inefficiency is minimized, inefficient farms can have a surplus of some resources. These surplus resources can be utilized to create extra earnings to boost family wellbeing. For example, extra human resources from agriculture can be withdrawn and mobilized to secondary and tertiary employment where an opportunity is present. Farms can use the surplus earnings to obtain latest technologies and land upgrading. Formulating and implementing such policies and strategies by the government will help to improve in technical efficiency and family welfare which may ultimately help in reducing poverty and promoting equity.

5.6 Sources of Inefficiency

Table 1 (v) reports the regression results as defined in Equation (14). The variables Z_1 to Z_{11} are selected as the prospective sources of technical inefficiency in the study area. The sign and estimated parameters, and level of significance depend largely in the contextual settings of the study area. As the dependent variable in the transcendental logarithmic SDF model is technical inefficiency (not TE), a negative sign of the parameter of each independent variable refers to a decrease in technical inefficiency vis–à–vis an increase in technical efficiency.

The regression results report that as expected, the coefficient for ownership of land variable (Z_1) has a negative sign and therefore it impacts on inefficiency negatively or it impacts positively on efficiency). The higher value of coefficient for ownership of land compared to other parameters also implies that this can be the major determinant for inefficiency. The positive impact on efficiency implies that a household who possesses ownership of land has high motivation to farming and undeniably less inefficient.

The parameter for the value of land per bigha (Z_2) has an expected negative sign. This variable is included in the model to capture the fixed effect of land quality. A higher value of land may represent more superiority of land quality. From the point of efficiency aspect, a household with higher quality land are less inefficient compared to those having lower quality of land. The coefficient for extension dummy (Z_3) represents the effect of the extension services provided by the extension agent. By and large, availability of extension services in agriculture is expected to encourage efficiency. The negative sign of the regression result for extension variable signifies that it has negative impact on inefficiency.

The coefficient for the age of the HHH (Z_4) variable has a positive sign. It indicates that age of the HHH has positive impact on inefficiency, but the estimated parameter is not statistically different from zero. As expected, the algebraic sign of family head’s education (Z_5) variable has a negative sign, and the coefficient is statistically significant. This indicates a positive relationship between HHH's education and technical efficiency. In other words, higher the year of education, higher will be the efficiency among households. The sign of gender (Z_6) has negative and the size of HH (Z_7) has positive sign. This signifies that a male HHH is efficient, but a bigger or joint family is inefficient. However, the coefficients of both variables are not statistically significant.

As expected, the coefficient for access to credit (Z_8) has a negative sign and the coefficient is statistically significant. The result indicates that bank credit has significantly positive impact on efficiency or negative impact on inefficiency. Consequently, households with more access to agricultural credit facility are more efficient than households who do not have such facility. As expected, the sign of the coefficient for the access to road (Z_9) is positive. The coefficient is statistically significant too. This indicates that the shorter the road access, the more efficient the household is and vice versa.

The ward 21 dummy and ward 25 dummy have a negative sign. This suggests that these two wards have negative impact on efficiency. The negative sign of ward 21 dummy and ward 25 dummy implies that ward 4 dummy has a positive impact on efficiency. In other words, households who live in ward 4 are relatively efficient as compared to ward 21 and ward 25 households.

The above analysis observed that a high degree of technical inefficiency exists in the agricultural production system of study are. This obviously implies that a large portion of farms operate far below their efficient level. It justifies the hypothesis set out earlier in Section 1 that by raising technically efficiency, households could be better off and minimize overall poverty and inequality. The analysis is also successful to fulfil the research objective of the study by measuring the level of productive efficiency of agricultural production in the study area and exploring the potential determinants of inefficiency in the way of eliminating poverty and inequality and promoting equity. In a nutshell, households with ownership of farming land, more educated, availability of credit, extension facility, high quality of land and who live in ward 4 have a higher level of technical efficiency than the households who do not possess these features.

6. CONCLUSIONS AND POLICY IMPLICATIONS

The empirical results demonstrate that there is a higher level of technical inefficiency in the farming systems in Nepal. Changes in the factors of production can have a meaningful effect in the agricultural production. There is a linkage between technical inefficiency and farm related variables. Ownership of farming land is the most important factor related to inefficiency followed by extension services, quality of land, accessibility of credit, accessibility of road and educational facility.

The empirical findings explicitly reveal that the degree of technical inefficiency vary extensively among different farm size groups. Farms of medium size are enjoying relatively high level of technical efficiency as compared to other sizes. The result of decreasing returns to scale implies that a higher degree of productive efficiency can be accomplished by lessening the size of bigger farming units.

Unlike previous studies, the study constructing production variables integrating all crops and other farm-related products generated by sample households within a whole year analyzed the productive efficiency using the stochastic distance function model to recommend policy implications for increasing technical efficiency and thus reducing poverty and inequality. This study also identified that the level of technical efficiency among agricultural households differs significantly across farm sizes. This study also explored the determining factors of inefficiency in the path of elevating poverty and inequality as well as promoting equity. These findings are the novelty of this study and main contributions to the existing literature. Based on the transcendental logarithmic SDF results the following policy implications can be recommended to enhance productive efficiency to reduce poverty and encourage equity.

- ❖ Given the inadequate agricultural land and availability of other resources, fulfilling the constantly increasing demand for foodstuff has to be satisfied through enhancement in productivity from technological advancement or increases in technical efficiency. Considering the present technological knowledge in the country, there is limited scope of technical improvement. In this context, The Government of Nepal has to recognize that raising the degree of technical efficiency is comparatively cost effective. So, development strategy and policies ought to be coordinated towards this fact.
- ❖ Agricultural farming has a prospect for improving productive efficiency with the use of additional quantity of inputs including ownership of land and land quality, access to extension service, agricultural credits, FYM and education. In economic terminology, these inputs are known as the shifting factors of the production. So, state policy and plan should facilitate the supply of and access to these inputs in the required amount.
- ❖ The technical efficiency results show that the size of medium farming is relatively more efficient as compared to other farm sizes suggesting that rearranging medium sized farming would enhance productivity and efficiency. So, strategy and approach focused on maintaining medium–

sized farms might have better option with regard to reduce poverty and encourage equity.

- ❖ The presence of a higher level of inefficiency among farm households implies that decision made by individual farmers vary substantially. In this setting, introducing households' communication system and producers' organizations can enhance productivity and efficiency. Therefore, state policy should be devised in providing such facilities and empowering households to participate in such activities.
- ❖ Technical efficiency differs greatly among different farm-size holders. The usefulness of new policy plans intended to enhance productive efficiency relies basically upon the extent to which such variations are identified. Government plans and strategies implemented to enhance productivity and efficiency should be adaptable to accommodate these facts. So, strategies focused on different clusters of households, rather than 'one size fits all', would be a blooming technique in order to enhance productive efficiency. Similarly, identifying households who are inefficient in utilizing certain factors of production would be beneficial in behaving them separately for intercession objectives.

Productive efficiency can also be measured using allocative and economic efficiency. This study, however, is limited to TE due to the lack of prices data. Depending on appropriate models and data being available in the future, it would be interesting to undertake the above-mentioned aspects of efficiencies to verify the empirical results.

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Table 1: Stochastic Distance Function Results

Variables	Coeff.	St.Err	t–ratio		Variables	Coeff.	St. Err	t–ratio
(i) Output and interaction Coefficient					Pur Inp×Pur Inp	0.046	0.008	5.75
Constant	1.421	0.044	32.295		Other Cost×Other Cost	0.049	0.059	0.831
Cereal Crops (q_1)	–0.488	0.013	–37.538		**(iv) Input-Output Interaction Coefficients**			
Cash Crops (q_2)	–0.294	0.013	–22.615		Land×Cereal Crop	–0.018	0.009	–2.012
Other Output (q_3)	–0.218	0.014	–15.571		Labor×Cereal Crop	0.019	0.004	4.751
Cereal×Cash (nm_{12})	–0.005	0.002	–2.232		FYM×Cereal Crop	0.003	0.004	0.753
Cereal×Other (nm_{13})	–0.009	0.016	–0.563		Cap Ser×Cereal Crop	–0.012	0.003	–4.014
Cash×Other (mn_{23})	–0.006	0.003	–2.069		Pur Inp×Cereal Crop	0.002	0.002	1.002
Cereal×Cereal (nm_{11})	–0.004	0.002	–2.294		Other Cost×Cereal Crop	–0.003	0.002	–1.501
Cash × Cash (mn_{22})	–0.006	0.003	–2.336		Land×Cash Crop	0.014	0.011	1.282
Other×Other (mn_{33})	–0.009	0.004	–2.116		Labor×Cash Crop	–0.015	0.007	–2.354
(ii) Output Coeff. wrt Inputs					FYM×Cash Crop	–0.011	0.013	–0.872
Farmed Land (x_1)	0.214	0.011	18.772		Cap Ser×Cash Crop	–0.013	0.018	–0.692
Labor (x_2)	0.162	0.012	13.908		Pur Inp×Cash Crop	–0.005	0.011	–0.411
FYM (x_3)	0.185	0.015	12.278		Other Cost×Cash Crop	0.004	0.003	1.312
Cap Service (x_4)	0.122	0.018	6.843		Land×Other Output	0.006	0.007	0.757
Pur. Inp. (x_5)	0.053	0.011	4.699		Labor×Other Output	0.004	0.008	0.452
Other Costs (x_6)	0.042	0.016	2.625		FYM×Other Output	0.006	0.01	0.616
(iii) Input Interaction Coefficients					Cap Ser×Other Output	0.003	0.002	2.133
Land×Labor	–0.017	0.038	–0.447		Pur Inp×Other Output	0.005	0.004	1.071
Land×FYM	–0.024	0.017	–1.412		Other Cost×Other Output	–0.002	0.002	–1.558
Land×Cap Ser	0.024	0.016	1.521		**(v) Factors Affecting Technical Ineff.**			
Land×Pur Inp	–0.016	0.012	–1.333		Constant (Z_0)	–1.728	0.522	–3.314
Land×Other Cost	–0.018	0.012	–1.501		Ownership (Z_1)	–0.452	0.214	–2.112
Labor×FYM	0.024	0.007	3.429		Value of Land (Z_2)	–0.321	0.081	–3.963
Labor×Cap Ser	–0.018	0.016	–1.125		Extension Service (Z_3)	–0.438	0.211	–2.076
Labor×Pur Inp	–0.012	0.016	–0.751		Age of HH (Z_4)	0.124	0.115	1.078
Labor×Other Cost	0.013	0.006	2.167		Education of HH (Z_5)	–0.112	0.052	–2.154
FYM×Cap Ser	0.008	0.949	0.008		Gender (Z_6)	–0.245	0.182	–1.346
FYM×Pur Inp	–0.007	0.004	–1.754		Household size (Z_7)	0.052	0.048	1.083
FYM×Other Cost	0.003	0.948	0.003		Access to Credit (Z_8)	–0.077	0.028	–2.708
Cap Ser×Pur Inp	–0.007	0.004	–1.753		Access to Road (Z_9)	0.021	0.027	0.778
Cap Ser×Other Cost	–0.004	0.005	–0.811		Location (Z_{10})	0.277	0.128	2.157
Land×Land	0.059	0.056	1.054		Location (Z_{11})	0.166	0.081	2.043
Labor×Labor	0.063	0.025	2.52		**(vi) Test Statistic**			
FYM×FYM	0.067	0.014	4.786		sigma–squared	4.126	1.132	3.645
Cap Ser×Cap Ser	0.029	0.007	4.143		Gamma	0.944	0.031	30.458

Source: Author's Calculation

Table 2: Distribution of te by Farm Size

TE (%) Category	Small Farm		Medium Farm		Large Farm		All Farm	
	Number	%	Number	%	Number	%	Number	%
< 10	0	0	0	0	0	0	0	0
20–Nov	3	1.91	4	1.97	2	2.22	9	2
21–30	8	5.1	12	5.91	4	4.44	24	5.33
31–40	14	8.92	15	7.39	9	10	38	8.44
41–50	26	16.56	21	10.34	18	20	65	14.44
51–60	42	26.75	44	21.67	24	26.67	110	24.44
61–70	24	15.29	41	20.2	15	16.67	80	17.78
71–80	21	13.38	36	17.73	12	13.33	69	15.33
81–90	12	7.64	20	9.85	4	4.44	36	8
>90	7	4.46	10	4.93	2	2.22	19	4.22
Total Farm	**157**	**100**	**203**	**100**	**90**	**100**	**450**	**100**
Mean TE	0.73		0.77		0.71		0.74	

Source: Author's Calculation