Cost efficiency estimates of maize production in Nepal: a case study of the Chitwan district

Odhad efektivnosti nákladů na pěstování kukuřice v Nepálu: případová studie regionu Chitwan

P. Paudel[1], A. Matsuoka[2]

[1]*The United Graduate School of Agricultural Sciences, Ehime University, Ehime, Japan*
[2]*Faculty of Agriculture, Ehime University, Ehime, Japan*

Abstract: This study was carried out to analyze the cost efficiency of maize production in the Chitwan district, Nepal with a view to predict economic efficiencies using stochastic frontier cost function. The primary data were collected from 180 maize farmers representing 12 village development committees (VDCs) including one municipality of the district during May–June 2005 for the cropping year 2004–2005. Among various factors, use of manure accounted the highest share in the production cost followed by labour and tractor costs. The maximum-likelihood (ML) estimates of the parameters revealed that estimated coefficients of cost of tractor, animal power, labour, fertilizer, manure, seed and maize output gave positive coefficients and were significant at 5% level. Further, quantitative estimates obtained from the cost function shows the mean cost efficiency of 1.634 indicating that an average maize farms from the study incurred about 63% costs above the frontier cost-an indication of inefficiency. Also, the significant years of schooling of the household head and maize area in the inefficiency model indicated the positive effect of these factors on cost efficiency of the farms. From the analysis of scale effect among maize farms, it was revealed that the maize farms experienced an increasing return to scale, that is, the output increased more proportionately than the total production cost.

Key words: *Zea mays* L, stochastic frontier model, cost efficiency, economies of scale

Abstrakt: Studie je zaměřena na analýzu nákladové efektivnosti pěstování kukuřice v regionu Chitwan v Nepálu, s cílem predikovat ekonomickou efektivnost stochastické mezní nákladové funkce. Primární údaje byly získány od 180 farmářů pěstujících kukuřici, reprezentovaných 12 vesnickými rozvojovými radami (VDC) včetně jednoho města v dané oblasti za období květen–červen 2005 za hospodářský rok 2004–2005. Nejvyšší podíl z faktorů ovlivňujících náklady na produkci kukuřice měly náklady na statková hnojiva, následované pracovními náklady a náklady na využití traktorů. Odhady maximální pravděpodobnosti jednotlivých parametrů (ML) ukázaly, že odhadované nákladové koeficienty pro práci traktorů, práci zvířat, pracovní náklady, průmyslová hnojiva, statková hnojiva, osiva a produkci kukuřice byly kladné a vykazovaly míru významnosti 5 %. Kvantitativní odhady získané z nákladových funkcí vykazovaly průměrnou efektivnost nákladů 1,634, což naznačuje, že průměrná farma pěstující kukuřici vykazuje 63 % nákladů nad hranicí nákladové neefektivnosti. Ukazuje se rovněž, že v letech, kdy byli farmáři školeni o modelu neefektivnosti, se projevil pozitivní efekt těchto faktorů na nákladovou efektivnost. Analýza efektu rozsahu odhalila, že farmy pěstující kukuřici vykazují zvýšenou návratnost, výnosy se zvyšovaly více než náklady.

Klíčová slova: *Zea mays* L, stochastický mezní model, efektivnost nákladů, ekonomika z rozsahu

Maize (*Zea mays* L.) ranks the second foremost staple food crop after paddy in Nepal covering 0.834 million hectares with an average productivity of 1.90 t/ha contributing approximately by 22.60% to the total cereal requirement (MOAC 2005; Serchan 2004). This crop is cultivated mainly for food, feed and fodder purpose on both the irrigated as well as non-irrigated land across the different agro-climatic condition of the country (Paudyal, Poudel 2001).

The utilization statistics indicates that the chief use of maize is as food, i.e. 70% while the proportion for feed purpose accounts 20% and other uses mainly as inputs in several industries and seed as 10% (Paudyal et al. 2001). Specifically, it is subsistence staple food crop for hill people whereas in Terai and Inner Terai (the plain area), maize is largely produced as income generating feed crop, where more than 90% of maize production is consumed as animal feed. The demand for maize is increasing due to the upsurge in human population (2.25% per annum – CBS 2004) and also due to the inflated animal and poultry feed industry, particularly in the Terai and Inner Terai regions of Nepal (Upadhyay 2004).

Moreover, in the recent year, there is a gradual shift regarding its utilization as a food as well as a feed. It has been reported that the annual growth rate in the year 1991–1999 for food to feed is –2.2% and 45.10% respectively (Gerpacio 2001). As a consequence, this crop has become an important source of cash especially for small holders either directly through its sale to millers or indirectly through the sale of animals that are fed with maize grain (Serchan 2004).

It has been suggested that, over the next 20 years, the overall demand for maize is expected to grow by 4–6% per annum (Paudyal et al. 2001; Pathik 2002). In order to meet the growing demand for maize resulting from increasing population and flourishing feed industries in Nepal, maize output has to be significantly improved, which would be pivotal to improve the food security situation in Nepal.

In such case, Nepal will have to resort to the import of maize if productivity of maize is not increased substantially (Koirala 2004). On the other hand, bulk of the country's farm is dependent on subsistence agriculture with the rudimentary farming system, low capitalization and a low yield per hectare. As a consequence, the productivity of maize has either remained stagnant or increased at a very slow rate (Kaini 2004). The average productivity of maize in many countries is more than 4 t/ha, which is relatively much higher than in Nepal. However, it is possible to increase its productivity as there is a big gap in yield at the research stations and the farmers field (Dhami 2004). Numerous factors are held responsible with the lower productivity of maize crop in Nepal. The slow and limited adoption of production technology related to the application of a lower level of fertilizers, a lower rate of seed replacement, the unavailability of quality seed, the lack of irrigation facilities in the dry season as well as declining soil fertility are some of the major factors responsible for the lower yield per unit area (Kaini 2004). In order to alleviate poverty and to achieve the food security situation in Nepal, it is imperative to recognize the factors that hinder farmer's efficiency in maize production and further quantify the extent to which they limit the efficiency of maize farm. An improvement in the understanding of the level of cost efficiency and its relationship with the maize farmers can greatly aid policy makers in creating efficiency enhancing policies as well as in judging the efficiency of the present and past reforms (Ogundari et al. 2006).

According to the Ministry of Agriculture and Cooperatives, Nepal (2005), Chitwan ranks the second position among 75 districts of Nepal with respect to the area and production of maize. Further, in the year 2003–2004, the area under maize cultivation in this district was 27 170 ha with the average productivity of 2.23 t/ha. Maize production is one of the important constituents of the farming system in this district regarding the agroclimatic suitability, road access for the product supply and the expansion of poultry enterprise. However, maize farming in Chitwan district is confronted with several technical as well as socio-economic efficiency factors. The production efficiency of small holder farms has been reported to have an important implication for the development strategies in most developing countries (Ogundari et al. 2006). The studies to identify the factors of efficiency and to suggest the policy intervention to improve the productivity and technical efficiency of maize production have been conducted in the past in the hills of Nepal as well as other countries (Paudyal, Ransom 2002; Ogundari et al. 2006). However, no systematic study has been conducted so far to assess the cost efficiency of maize farms in the Chitwan district of Nepal.

Taking into consideration the aforementioned facts, this study was conducted with the view of better understanding the maize farms cost efficiency and predicting the allocative efficiencies of maize farmers in the Chitwan district of Nepal. This paper therefore analyses the productivity and cost efficiency of maize farmers to identify the importance of each factor and to detect if there is the presence of cost inefficiency of maize production using the stochastic frontier cost function. This study will help to introduce a new dimension to farmers and policy makers on how to increase maize production by determining the extent to which it is possible to raise the efficiency of maize farms with the existing resources base and the available technology in order to tackle the food insufficiency problems in Nepal.

MATERIALS AND METHODS

Study area

The data used in this study were based on the farm level study of maize farmers in the Chitwan district, Inner Terai, of Nepal. This district lies at 27° 21'45" to 27° 52'30'' North latitude and 83° 54'45'' to 84° 48'15'' East longitudes. It occupies the area of 2 205.90 square kilometres, which is about 1.49% of the total land area of Nepal. There are altogether 36 Village Development Committees (VDCs) and 2 municipalities in this district. As per population census dated 2001, the population of this district was 472 048 (CBS 2004) which was 2.03% of the total population of Nepal. In this district, 26% (57 353 ha) of land is suitable for cultivation. Of that total arable land, only about 78% of land is being utilized for cultivation. Thus, there is the potential to expand the area for cultivation (Anonymous 2002). This district experiences the subtropical monsoon with a hot and humid summer and cool and dry winters. Over 75 percent of the annual rainfall concentrates during the monsoon from June through September and a very low rainfall occurs during the month from January to April with the annual average rainfall of 2 318 mm (Anonymous 2002). The population consists predominantly of peasant farmers cultivating mainly food and cash crops such as rice, maize, wheat, beans, lentil, mustard, vegetables and fruit crops for family consumption as well as for cash income.

Data collection

For this study, primary data were collected from 180 maize farmers selected from 11 village development committees (VDCs) and one municipality of the Chitwan district of Nepal. The selected VDCs for study were Padampur, Chainpur, Jutepani, Bachhauli, Pithuwa, Phulbari, Parbatipur, Saradanagar, Gunjanagar, Shivanagar and Sukranagar, while the municipality was Bharatpur. The data were collected during the May–June 2005 for the cropping year 2004–2005. Fifteen farmers from each VDCs/Municipality were randomly selected for interview. The sampled farmers were interviewed by administrating a pre-structured questionnaire designed to collect the information on output, input, and some major socio-economic characteristics of the farmers as well as the prices of input which serve as the basis for computing the costs of materials used in the course of production. The input data include the costs of tractor, animal power, human labour, fertilizer, pesticides and seed required to calculate the total cost of production. Data were collected also on the socio-economic variables such as family members, the age of the household, the schooling year and the maize area of the sampled farmers to explore their influence on the estimated cost efficiencies of the maize farms. Secondary information was acquired from the publications of various governmental and non- governmental organizations. The collected data were converted from local to standard units.

Stochastic frontier model

Aigner, Lovell and Schmidt (1977), Meeusen and van den Broeck (1977) independently introduced the stochastic production or cost frontier models. Frontier fits three stochastic frontier models with distinct parameterizations of the inefficiency term and can fit the stochastic production or cost frontier models.

Suppose that a producer has a production function $f(z_i, \beta)$. In the production characterized by efficiency, the i^{th} firm would produce

$$q_i = f(z_i, \beta) \quad (1)$$

where q_i is the scalar output of producer i, z_i is the vector of N inputs used by producer i, $f(z_i, \beta)$ is the production frontier and β is the vector of technology parameters to be estimated.

Stochastic frontier analysis assumes that each firm potentially produces less than it might due to the degree of inefficiency. Specifically, we can write the above equation as

$$q_i = f(z_i, \beta)\varepsilon_i \quad (2)$$

where ε_i is the level of efficiency for firm i; ε_i must be in the interval (0, 1). If $\varepsilon_i = 1$, the firm is achieving the optimal output with the technology embodied in the production function $f(z_i, \beta)$. When $\varepsilon_i \prec 1$, the firm is not making the most of the inputs z_i given the technology embodied in the production function $f(z_i, \beta)$. Since the output is assumed to be strictly positiv $(\text{i.e.}, q_i \succ 0)$, the degree of technical efficiency is assumed to be strictly positive $(\text{i.e.}, \varepsilon_i \succ 0)$.

Output is also assumed to be subject to random shocks, implying that

$$q_i = f(z_i, \beta)\varepsilon_i \exp(u_i) \quad (3)$$

where: u_i is the one-sided disturbance form used to represent cost inefficiency.

Taking the natural logarithm for equation 3 of both sides yields

$$\ln(q_i) = \ln\{f(z_i, \beta)\} + \ln(\varepsilon_i) + u_i \quad (4)$$

Assuming that there are k inputs and that the production function is linear in logs, defining $u_i = -\ln(\varepsilon_i)$ yields can be expressed as

$$\ln(q_i = \beta_0) + \sum_{j=1}^{k} \beta_j \ln(z_{ji}) + v_i - u_i \tag{5}$$

Since u_i is subtracted from $\ln(q_i)$, restricting $u_i \geq 0$ implies that $0 \prec \varepsilon_i \leq 1$, as specified above.

Further, Kumbhakar and Lovell (2000) provide a detailed version of the above derivation, and they show that performing an analogous derivation in the dual cost function problem allows us to specify the problem as

$$\ln(c_i) = \beta_0 + \beta_q \ln(q_i) + \sum_{j=1}^{k} \beta_j \ln(p_{ji}) + \nu_i + u_i \tag{6}$$

where q_i is output, z_{ji} are input quantities, c_i is cost and p_{ji} are input prices.

Analytical framework

To analyze the data, both the statistical and tabular methods were employed. For the purpose of the statistical analysis, Battese and Coelli (1995) model was used to specify a stochastic frontier cost function with the behaviour inefficiency component and to estimate all parameters together in the one step maximum likelihood estimation. This model is implicitly expressed as:

$$\ln C_i = g(P_i, Y_i; \alpha) + (V_i + U_i) \tag{7}$$

where C_i represents the total cost of production, g is a suitable functional form such as the Cobb-Douglas; P_i is the vector variable of input prices such as machinery, animal power, labour, chemical fertilizers, manure, pesticides and seed. Y_i is the value of maize produced in kg, α is the parameter to be estimated. The systematic component V_i represents the random disturbance costs due to the factors outside the scope of farmers. It is assumed to be identically and normally distributed mean zero and constant variance as $N(0, \sigma^2 v)$. U_i is the one-sided disturbance form used to represent cost inefficiency and is independent of V_i. Thus, $U_i = 0$ for a farm whose costs lie on the frontier, $U_i \succ 0$ for farms whose cost is above the frontier, $U_i \prec 0$ for farm identically and independently distributed as $N(0, \sigma^2 v)$. The two error terms are proceeded by positive signs because inefficiencies are always assumed to increase cost.

Furthermore, the cost efficiency of an individual maize farm is defined in the terms of the ratio of the observed cost (C^b) to the corresponding minimum cost ($C^{\min}$) given the available technology is expressed as:

Cost Efficiency (C_{EE})

$$\frac{c^b}{C^{\min}} = \frac{g(P_{i,} Y_i; \alpha) + (V_i + U_i)}{g(P_i, Y_i; \alpha) + (V_i)} = \exp(U_i) \tag{8}$$

where the observed cost (C^b) represents the actual production cost whereas the minimum cost ($C^{\min}$) represents the frontier total production cost or the least total production cost level. C_{EE} takes the values between 1 or higher with 1 defining cost efficient farm (Ogundari et al. 2006).

The inefficiency model (U_i) is defined as:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} \tag{9}$$

where Z_1, Z_2, Z_3 and Z_4 represent the family size, age of the farmer, the educational level and the maize area of the respondent farmer. The socio-economic variables are included in the model to indicate their possible influence on the cost efficiency of the maize farms. The variance of the random error $\sigma^2 v$ and that of the cost inefficiency effects $\sigma^2 u$ and the overall variance of the model σ^2 are related as: $\gamma = \sigma^2 u / \sigma^2 v + \sigma^2 u$, where γ measures the total variation of the total cost of production from the frontier cost which can be attributed to cost inefficiency (Battese, Corra 1977).

Hence, following the adoption of Battese and Coelli (1995) framework for the analysis of the data, the explicit Cobb-Douglas functional for the maize farms in the study area is therefore specified as:

$$\ln C_i = \alpha_0 + \alpha_1 \ln P_{1i} + \alpha_2 \ln P_{2i} + \alpha_3 \ln P_{3i} + \alpha_4 \ln P_{4i} + \\ + \alpha_5 \ln P_{5i} + \alpha_6 \ln P_{6i} + \alpha_7 \ln P + \alpha_8 \ln Y_i + (V_i + U_i) \tag{10}$$

where C_i represents the total production cost in Nepalese Rupees (Rs) per ha; P_1 represents the cost of tractor Rs/ha; P_2 represents the cost of animal power Rs/ha; P_3 represents the cost of labour Rs/ha; P_4 represents the cost of fertilizers Rs/ha; P_5 represents the cost of manure Rs/ha; P_6 represents the cost of pesticides Rs/ha; P_7 represents the cost of seed Rs/ha and Y_i represents the output of maize in kg/ha. The choice of the Cobb-Douglas is based on the fact that the methodology requires that the function be self dual as in the case of cost function which this analysis is based on.

Scale Effect (SE) is mathematically defined as inverse of the sum of all cost elasticities with respect to all output included in the regression. The cost function parameter estimated most especially the coefficients of the output for the Cobb-Douglas model suggests the presence of scale effects (SE) in the production process. Positive economies of scale (ES_p) prevail, if the SE is greater than 1 (ESp is defined as the reduction in cost of production of the given output level while holding all other input prices constant) and, conversely, the diseconomies of scale (DS) when the SE is less than 1. The return-to-scale and scale effects are equivalent measures if and only if the product is homothetic, an assumption that applies to and is implicit in the Cobb-Douglas function structures (Chambers 1988). If costs increase proportionately with output, there are no economies of scale meaning that there is a constant return-to-scale. If costs increase by a greater amount than output, there are diseconomies of scale meaning that there is a decreasing return-to-scale if costs increase by a lesser amount than the output, there are positive economies of scale which is sometimes referred to simply as economies of scale meaning increasing return-to-scale. Here, since the Cobb-Douglas function was used, this assumption is imposed.

The estimate for all the parameters of the stochastic frontier cost function and the inefficiency model are simultaneously obtained using the computer program STATA.

RESULTS AND DISCUSSION

Summary statistics

The summary statistics of variables used in the stochastic frontier model is presented in Table 1. The mean and standard deviation of each of the variables along with their contribution to the total cost of production are depicted in this table. The cost of production is calculated in Nepalese currency as rupees per ha for each of the variables for the crop production year 2004–2005. The total cost of Rs. 14 651.58 was required to produce 2 235.93 kg/ha of maize with the standard deviation of Rs. 5 697.41. The smaller standard deviation denotes the reality that most of the farm operates at the similar level of cost of production.

Among the various factors of production, the cost of manure accounted for the highest share (44.23%) followed by the cost incurred on labour and machinery used in the production. The application of manure is the traditional and dominant method of maintaining soil fertility in the study area. The cost of labour accounts for 21.07% of the total cost of production that may be due to the higher use of family labour for maize cultivation. Most farmers in the study area were of the small scale, did not have enough capital to hire labour and as a consequence, they relied on family labour for most of the operations. Of the total labour used for maize production, about 51% of the labour is fulfilled by their own family labour. The cost of tractor to plough land accounts for 18.53% of the total cost of production. In the study area, about 97% of the total maize farmers use tractors for land preparation and it is the third most important cost factor among the cost variables. The cost of fertilizer accounts to just a mere 6.46% of the total cost of production and only 42% farmers apply fertilizers during maize cultivation which shows that the farmers are adopting the comparatively traditional technology like a higher reliance on the use of manure for the maize production. The cost of animal power denotes the payment meant for the bullock for land prepara-

Table 1. Summary statistics of the variables in stochastic frontier model Chitwan, Nepal, 2005

Variables	Mean	Std. deviation	% of total cost
Maize output (kg/ha)	2 235.93	1 125.46	
Total cost of production (NRs./ha)	14 651.58	5 697.41	
Cost of tractor (NRs./ha)	2 715.18	1 437.43	18.53
Cost of animal power (NRs./ha)	535.42	895.95	3.66
Cost of labor (NRs./ha)	3 087.17	2 567.25	21.07
Cost of fertilizer (NRs./ha)	946.13	1 605.79	6.46
Cost of pesticides (NRs./ha)	70.52	253.02	0.48
Cost of manure (NRs./ha)	6 480.51	3 908.76	44.23
Cost of seed (NRs./ha)	816.66	493.58	5.57
Family members (persons)	6.22	2.88	
Age of farmers (years)	44.95	12.52	
Education level (number of schooling yearss)	4.78	5.84	
Maize area (ha)	0.65	0.56	

tion as well as weeding and it accounts for 3.66% of the total cost of production. In the study area, about 50% of the farmers were reported to use bullock for maize cultivation. Similarly, the cost of pesticides accounts for 0.48%, while the cost of seed accounts for 5.57% of the total cost of producing maize in the study area.

The socio-economic and demographic characteristics of the respondent farmers are also presented in the Table 1. It includes the number of the economically active family members, the age and the educational level (schooling year) of the household head as well as the area under maize cultivation. The mean size of the family of the respondent farmers was recorded as 6.22 people per family with the standard deviation of 2.88. The mean age of the household head was observed as 44.95 years with the standard deviation of 12.52. The educational level of the farmers denotes the mean value of the years of schooling of the household head which was 4.78 years with the standard deviation of 5.84, implies that the education level of the respondent farmers was low. The mean maize area of the households was 0.65 hectare per farmer and it indicates that most of the farmers have operated a small-scale of land.

Estimates of the stochastic frontier cost function parameters

The maximum-likelihood (ML) estimates of the parameters of the stochastic cost frontier models were obtained using the computer program STATA. These results are presented in Table 2. The result revealed that all independent variables confirm with a prior expectation as all the estimated coefficients of the cost of tractor, animal power, labour, fertilizer, manure, seed and maize output gave the positive coefficients suggesting the conformity with the assumption that the cost function monotonically increases with the input prices. The parameter estimates of the frontier cost function as reported in Table 2 show the statisti-

Table 2. Maximum-likelihood estimates of parameters of the Cobb-Douglas frontier function for maize farmers, Chitwan, Nepal, 2005

Variable	Parameters	Estimates
General Model		
Constant	α_0	5.295 (11.05)
Cost of tractor	α_1	0.065* (3.72)
Cost of animal power	α_2	0.016* (2.57)
Cost of labor	α_3	0.027* (4.11)
Cost of fertilizer	α_4	0.015* (2.47)
Cost of pesticides	α_5	0.014 (1.24)
Cost of manure	α_6	0.092* (5.56)
Cost of seed	α_7	0.130* (2.69)
Maize output	α_8	0.210* (4.00)
Inefficiency Model		
Constant	δ_0	–1.293 (–1.83)
Family size	δ_1	–0.101 (–1.83)
Age of household head	δ_2	0.014 (1.07)
Education	δ_3	–0.006* (–2.26)
Maize area	δ_4	–0.077* (–2.33)
Diagnostic statistics		
χ^2 statistic		138.210*
Log likelihood function		–12.625*
Sigma-square	$(\sigma^2) = \sigma^2 v + \sigma^2 u$	0.116* (4.11)
Gamma	$\gamma = \sigma^2 u / \sigma^2 v + \sigma^2 u$	0.448* (18.24)

*Estimates are significant at 5% level of significance; figures in parenthesis are *t*-ratio cal significance at 5% level on all coefficients except the cost of pesticides. Hence these variables are the important determinants of maize production in the study area. The reason for the cost of pesticides being an insignificant factor might be due to its lesser contribution to the total cost of maize production (Table 1). Since the cost function is a function of all input prices, the percentage increase in the total production is based on the interpretation of the coefficient of the Cobb-Douglas function as the elasticity of production. In this case, the coefficients of the cost function serve as the cost elasticity of the production. Hence, 1% increase in the cost of machinery will increase the total production cost by approximately 0.07%, 1% increase in the cost of animal power will increase the total production cost by approximately 0.02%, 1% increase in the cost of labour will increase the total production cost by approximately 0.03%, 1% increase in the cost of fertilizer will increase the production cost by approximately 0.02%. Similarly, 1% increase in the cost of pesticides will increase the total production cost by 0.01%, 1% increase in the cost of manure will increase the total production cost by 0.09%, 1% increase in the cost of seed will increase the total production cost by 0.13% and 1% increase in the maize output will increase the total production cost by 0.21%.

Table 3. Cost efficiencies of the maize farms, Chitwan, Nepal, 2005

Efficiency level	Frequency	Relative efficiency (%)
1.0–1.1	19	10.56
1.2–1.3	55	30.56
1.4–1.5	36	20
1.6–1.7	26	14.44
1.8–1.9	18	10.00
2.0–2.1	5	2.78
2.2–2.3	6	3.33
2.5–2.6	4	2.22
2.8–2.9	2	1.11
3.0–3.1	2	1.11
3.8–3.9	2	1.11
4.0–4.1	2	1.11
4.5–4.6	2	1.11
7.0–7.1	1	0.56
Total	180	100.00
Mean	1.634	
Std. deviation	0.744	
Minimum	1.053	
Maximum	7.015	

Cost efficiency analysis

The main purpose of this model is to analyze the cost efficiency of the maize farms in the study area. So, the model is assumed to be the representation of the data for considering its highly significant chi-square value as well as the Log Likelihood function under the half-normal distribution assumed with the maximum likelihood techniques. The cost efficiency analysis of maize farmers in the study area revealed that there was the presence of cost inefficiency effects in maize production as confirmed by the significance gamma value of 0.448 significant at 5% level (Table 2). This implies that about 45% of the variation in the total cost of production among the sampled farmers was due to the differences in their cost efficiencies.

Cost efficiency scores for the maize farms in the study area are presented in Table 3. The predicted cost efficiencies (C_{EE}) ranged from 1.0 to 7.1. The mean cost efficiency of an average maize farm was estimated as 1.634, meaning that an average maize farms in the study area incurred costs that are about 63% above the minimum cost defined by the frontier. That is, over 63% of the maize farms costs are wasted in comparison to the best practice firms producing the same output and facing the same technology. The higher value of cost efficiency represents the more inefficient farm during the course of maize production in the study area. The frequencies of the cost efficiency scores range between 1.0 and 1.1 representing about 11% of the sampled farms, implying that very few farmers are fairly efficient in producing at the given level of output using the cost minimizing input ratios. This indicates that the majority of farms in the study area need to minimize the waste of resources associated with maize production process. Earlier, Ogundari et al. (2006), while analyzing the small scale maize production in Nigeria, obtained the result that a relatively larger proportion of farms were fairly efficient to minimize the resource wastage associated with the production process. That might have resulted from a higher level of education of the farmers in that study area as compared to the present study site.

Cost inefficiency analysis

The analysis of the inefficiency model is depicted in the Table 2. The explanatory variables in the model show that the signs and significance of the estimated coefficients in the inefficiency model have important implications on the cost efficiency of the maize production in the study area. The positive coefficient of the age of the household head implies that farmers of older age tend to be less cost efficient i.e. the decrease in cost efficiency tends to increase with the household head age for maize production in the study area. This is in conformity with the assumption that the households of younger age have a greater access to the extension services and have a better knowledge about the cost of production since they are comparatively more educated than the households of older age. This finding is in harmony with the report of Ojo (2003). However, this variable is not significant in influencing the level of cost efficiency.

The negative coefficient for family size with the working age members implies that cost efficiency increases with the increase in family size. This is due to the fact that the farmers with a lager family size rely on family labour and subsequently reduce the cost inefficiency for maize production in the study area. However, this variable is not significant in influencing the level of cost efficiency in the study area. Similarly, the negative and significant coefficient for the education of the household head implies that the higher is the number of the years of schooling; the lower is the cost inefficiency of the maize farmer. The positive relation indicates that farmers with more years of education are more economically efficient. The prior expectation is that cost efficiency should increase with the increase in the years of schooling since education is expected to be positively correlated with the adoption of the improved technology and techniques of production (Ojo, Ajibefun 2000). In the study area, an increase in the years of schooling may enhance the knowledge, skill and attitude to adopt the more efficient technology and to allocate the inputs of production of the farms more efficiently. Moreover, the negative and significant coefficient for maize area which also represents the scale of operation indicates that as the maize area increases, the farmers become more cost efficient in the allocation of resources. This is an indication that the level of cost inefficiency of an average maize farmer in the sampled farmers tends to decrease as the maize area moved from a small to a large area thereby making the maize farmers to enjoy the economics of scale as the cost per unit output decrease in the long run. Earlier, Iraizoz et al. (2003) also found the positive and significant effect of farm size while analyzing the technical efficiency of tomato production in Navarra, Spain.

Scale Effects (SE)

The scale effect among the maize farms in the study area was computed as the inverse coefficient of cost elasticities with respect to the maize output in kg as the only output in the analysis that shows that scale effects among the sampled farmers. This is because the computed value of the SE is 4.76 (i.e., 1/0.210 = 4.76) which confirms that there is a positive economy of scale. The computed value of the SE is greater than one, meaning that 1% increase in the total production costs increased the total maize production by 4.76% during the course of maize production. The result obtained is an indication that there are positive economies of scale (SE_p) meaning that an average maize farmer in the sampled area experiences a decrease in the total production cost in the course of production irrespective of the area of maize production. It indicates that maize farmers are experiencing an increasing return to scale, which is the stage I of the production surface and this is in conformity with the earlier findings in this study under the analysis of the inefficiency model. According to Reddy et al. (2004), the stage I of production can be regarded as the sub-optimal stage where the fixed resources are abundant relative to the variable resources.

CONCLUSION AND RECOMMENDATION

This paper employs the stochastic frontier analysis to observe productive efficiency among the maize farmers in the Chitwan district of Nepal from the cost perspective. A Cobb-Douglas functional form was used to impose the assumption of cost elasticity and economies of scale.

The estimated coefficients of the cost of various inputs like tractor, animal power, labour, chemical fertilizer, manure and seed as well as maize output gave the positive coefficients meaning that as these factors increased, the total cost of maize production increased in the study area. Among the various factors of production, the cost of manure accounted the highest share (44.23%) in maize production and 1% increase in the cost of manure will increase the total production cost by 0.09%. The mean cost efficiency from the stochastic frontier cost function shows the mean cost efficiency of 1.634 indicating that about 63% of the maize farms costs were wasted in relation to the farms adopting the best practices while producing the same level of maize output. The result obtained from the cost efficiency analysis indicates that very few farmers, i.e. 11%, are fairly efficient in producing at the given level of output using the cost minimizing input ratios. Likewise, about 45% of the variation in the total cost of maize production in the study area resulted from the differences in their cost efficiencies. The negative and significant estimated coefficients of schooling year and maize area in the inefficiency model implied that cost efficiency increased as these two parameters improved. The estimation of scale effects pointed out that the average maize farm operates at the stage I of the production surface which clearly indicates inefficiency in the allocation of resources and production. Therefore, efforts should be made to expand the present scope of production to actualize the potential inherent in it.

The major findings of the presented study have an important implication in enhancing efficiency among the maize farmers in the Chitwan district of Nepal. The significance of the schooling year of the household head implies that the provision of education facility as well as the inclusion of the younger generation which is more educated will significantly improve the cost efficiency of maize production. Moreover, agricultural productivity very much depends on the efficiency of the production process. Policies designed to educate people through proper agricultural extension services could have a great impact in increasing the level of efficiency to optimize the farm resources and hence to increase maize productivity in the study area. Thus, programs should be well fit to the uneducated farmers since the number of schooling years of the farmers in the study area is low. Furthermore, maize area as a variable implied that perceiving and responding efficiently to the need to change the economic condition require the allocative ability that is acquired by bringing more land area under maize cultivation to improve the economies of scale, from the present stage I to a more efficient stage II which will enable the maize farms to achieve the maximum possible output at the minimum cost of production. Therefore, it can be recommended that the government should direct its agricultural programs at including more educated people into maize farming and also to expand the maize growing area through the provision of adequate facilities.

REFERENCE

Aigner D.J, Lovell C.A.K., Schmidt P. (1977): Formulation and estimation of stochastic frontier production function models. Journal of Econometrics, *6*: 21–37.

Anonymous (2002): District profile of Chitwan. District Development Committee, Communication and Archive Center, pp. 6–41.

Battese G.E., Coellli T.J. (1995): A model for technical inefficiency effects in stochastic frontier production for panel data. Empirical Economics, *20*: 325–345.

Battese G.E., Corra G.S. (1977): Estimation of a production function model with application to the pictorial zone of Eastern Australia. Australian Journal of Agricultural Economics, *21*: 169–179.

CBS (2004): Statistical Pocket Book Nepal. Central Bureau of Statistics, Government of Nepal. National Planning Commission Secretariat, Thapathali, Kathmandu, Nepal.

Chambers R.G. (1988): Applied Production Analysis: A Dual Approach. Cambridge University Press, Cambridge, U.K.

Dhami N.B., Baniya B.K., Dahal K.N. (2004): Maize research highlights (2002 to 2004): Maize research activities at Khumaltar in 2003. In: Proceeding of the 24th National Summer Crops Research Workshop, Nepal Agricultural Research Council (NARC), Kathmandu, Nepal, pp. 124–130.

Gerpacio R.V. (2001): The maize economy of Asia: Impact of public and private sector maize breeding research in Asia (1966–1999). CIMMYT, Mexico, D.F.

Iraizoz B., Rapun M., Zabaleta I. (2003): Assessing the technical efficiency of horticultural production in Navarra, Spain. Journal of Agricultural System, *78*: 387–403.

Kaini B.R. (2004): Increasing crop production in Nepal. In: Proceeding of the 24th National Summer Crops Research Workshop. Nepal Agricultural Research Council (NARC), Kathmandu, Nepal, pp. 15–19.

Koirala K.B. (2004): Evaluation of exotic maize genotypes in the western hills of Nepal. In: Proceeding of the 24th National Summer Crops Research Workshop on Maize Research and Production in Nepal, June 28–30, Nepal Agricultural Research Institute, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal, pp. 114–120.

Kumbhakar S.C., Lovell C.A. (2000): Stochastic Frontier Analysis. Cambridge University Press, Cambridge.

Meeusen W., Broeck J.V.D. (1977): Efficiency estimation from Cobb-Douglas production functions with composed error. International Economics Review, *18* (2): 435–444.

MOAC (2005): Statistical information on Nepalese agriculture. Agri-business promotion and statistic division, Ministry of Agriculture and Co-operatives, Singha Darbar, Kathmandu, Nepal.

Ogundari K., Ojo S.O., Ajibefun I.A. (2006): Economics of scale and cost efficiency in small scale maize production. Empirical evidence from Nigeria. Journal of Social Sciences, *13* (2): 131–136.

Ojo S.O., Ajibefun I.A. (2000): Effects of training on labor productivity and efficiency in oil palm production in Ondo state, Nigeria. Journal of Sustainable Agriculture and Environment, *2*: 275–279.

Ojo S.O. (2003): Productivity and technical efficiency of poultry egg production in Nigeria. International Journal of Poultry Science, *2* (6): 459–464.

Pathik D.S. (2002): Maize research achievements and constraints. In: Rajbhandari N.P., Ransom J.K., Adhikari K., Palmer A.F.E. (eds.): Sustainable Maize Production Systems for Nepal. In: Proceeding of a Maize Symposium, December 3–5, 2001, Kathmandu, Nepal, NARC and CIMMYT, pp. 7–12.

Paudyal K.R., Ransom J.K. (2002): Policy intervention for improving technical efficiency of maize production in the hills of Nepal. In: Proceeding of the 8th Asian Regional Maize Workshop, Bangkok, Thailand, August 5–8, pp. 488–493.

Paudyal K.R., Ransom J.K., Rajbhandari N.P., Adhikari K., Gerpacio R.V., Pingali P. L. (2001): Maize in Nepal: Production systems, constraints and priorities for research. NARC and CIMMYT, pp. 1–48.

Paudyal K.R., Poudel S.K. (2001): Impact of public and private sector maize research in Nepal. In: Impact of Public and Private Sector Maize Breeding Research in Asia (1966–1999). CIMMYT, Mexico, D.F., pp. 66–80.

Reddy S.S., Ram P.R., Sastry T.V.N., Devi I.B (2004): Agricultural Economics. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.

Serchan D.P. (2004): Contributing to food security and improving the livelihood of the Nepalese people. In: Proceeding of the 24th National Summer crops Research Workshop on Maize Research and Production in Nepal, June 28–30, Nepal Agricultural Research Institute, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal, pp. 1–14.

Upadhyay S.R., Sharma D., Mahato R.K., Data V.K., Chaudhary D.K., Mishra K.K., Yadav R., Chaudhary T.N., Yadav G.P. (2004): Maize varietal improvement for Terai, inner Terai and foothill of Nepal. In: Proceeding of the 24th National Summer crops Research Workshop on Maize Research and Production in Nepal, June 28–30, Nepal Agricultural Research Institute, Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal, pp. 53–66.

Arrived on 1st July 2008

Contact address:

Pashupati Paudel, The United Graduate School of Agricultural Sciences, Ehime University, Tarumi 3-5-7, Matsuyama 790-8566, Ehime, Japan
e-mail: paudelp@agr.ehime-u.ac.jp