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TECHNICAL INEFFICIENCY OF OKRA (ABELMOSCHUS ESCULENTUS L. MOENCH) PRODUCTION AND ITS DETERMINANTS IN A STOCHASTIC FRONTIER FRAMEWORK: A CASE STUDY IN CENTRAL THAILAND

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ABSTRACT

This study uses a stochastic frontier framework to model an output and inputs in okra production, analyses farm-level technical inefficiency of okra production, and identifies the factors that influence such inefficiency in central Thailand. Primary data for this study was collected one crop season in 2017 from 260 okra households in five provinces, who contracted with the private companies to produce okra for export. Based on a Cobb-Douglas production function for single okra output and multiple inputs, the estimation was applied the Stochastic Production Frontier and the effects of exogenous factors on farm-level technical inefficiency were examined. The results revealed that the average technical inefficiency of okra production is 16% in the samples. Further, inefficiency is higher in the cropping system, okra and followed by okra before change to grow other cash crop, and irrigation system. Availability of the exporting company's support helps reduce such inefficiency as well. Moreover, the results reveal that years of schooling of okra growers, total of agricultural land area and availability of the okra exporting company have a positive impact on inefficiency score. While okra growers' sex, amount of family member for okra production, experience in okra production and distance to okra trading center have a negative impact on inefficiency score.

KEYWORDS*: Okra production, Positive List System, Stochastic Frontier Analysis, Tobit Regression.*

Introduction

Okra is one of the export vegetables cultivated in Thailand for decades. Its export quantity and value in 2016 were 2,649,408 Kilograms (Kg.) and 303,121,827 Baht (THB), increased by 34% and 34% from 2015, respectively (Thai Custom, 2017). Its plantation is mainly in the central Thailand and the major country import is Japan (nearly 98 percent of fresh pod). This cash crop takes only 90 days for one crop season from planting until harvesting, with daily two months for product collecting. Thailand used to

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face the export problem from the major import country when Japan suspended importing of whole okra following the promulgation of the Positive List System on May 29, 2006. Due to the chemical residues in okra higher than Japan's standard, Thailand's export of fresh okra to Japan in 2007 had decreased sharply from 2006. The okra growers then faced price instability and production cost rising including fluctuation in quantity and quality of okra affected by climate change. In order to solve the problem, the okra growers have become operating the farms under the contract with the export companies who provide inputs (especially seed) and supervision to limit the chemical use. Moreover, the companies purchase the fresh and graded produce from okra growers for exporting. This followed the advice of FAO Vegetable IPM (2004). For a decade of the implication, the situation of okra export to Japan has become gradually improve both quantity and value. However, okra growers are still facing higher risks to obtain higher incomes from the okra production due to climatic change. The other challenge is the efficiency of the inputs used and yield gained from the okra.

The purpose of this study is to measure one particular type of productive inefficiency, viz. technical efficiency, in okra production in the central Thailand and to identify the factors that influence such inefficiency in central Thailand. A farm is said to be technically inefficient if it produces output that is lower than the maximum possible level due to problems like managerial error, co-ordination failure, and wastage of resources. Further, farm level inefficiency is likely to be affected by exogenous factors, i.e., factors that are neither the inputs nor the outputs of the production process, but nonetheless affect the farm performance. In this study, the Stochastic Frontier Production Function method was used to measure technical inefficiency on the basis of original farm level survey data collected from okra farming households of varied agro-climatic zones, cropping system and irrigation system of Central Thailand. Demographic, weather related, and household level factors that affect such inefficiency in the production areas are investigated.

Theoretical Framework

Theory of Production and Productive Efficiency

A cross-sectional stochastic frontier model becomes increasingly popular because of its flexibility and ability to closely economic concepts with modeling reality. The modeling, estimation and application of stochastic frontier production function to economic analysis was assumed prominence in econometrics and applied economic analysis following Farrell's (1957), which technical efficiency (TE) is associated with the ability of a firm to produce on the isoquant frontier while allocative efficiency (AE) refers to the ability of a firm to produce at a given level of output using the cost minimizing input ratio.

Therefore, the technical efficiency (TE) is defined as the capacity of a firm to produce a predetermined quantity of output at a maximum output for a given level of technology (Bravo-Ureta et al., 1997) is the thing that should do. The stochastic frontier function is typically specified as:

$$Yi = f(Xij; ß) + vi - \mu i \quad (i = 1, 2, n) \qquad (1)$$

Where, Yi = output of the ith firm; Xij = vector of actual jth inputs used by the ith firm; $ß$ = vector of production coefficients to be estimated; vi = Random variability in the production that cannot be influenced by the firm and; μi = deviation from maximum potential output attributable to technical inefficiency.

The model is such that the possible production Yi, is bounded above by the stochastic quantity, $f(Xi; ß)\ exp(Vi)$ (that is when $\mu = 0$) hence, the term stochastic frontier. Given suitable distributional assumptions for the error terms, direct estimates of the parameters can be obtained by either the Maximum Likelihood Method (MLM) or the Corrected Ordinary Least Squares Method (COLS). However, the MLM estimator has been found to be asymptotically more efficient than the COLS (Coelli, 1995). Thus, the MLM has been preferred in empirical analysis.

In the context of the stochastic frontier production function, the technical efficiency of an individual firm is defined as the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by the firm. Thus, the technical efficiency of firm i is:

$$Tei = exp(-\mu i), \text{ that is} \qquad (2)$$

$$Tei = Yi/Yi^* = f(Xi; ß)\ exp(vi - \mu i) / f(Xi; ß)\ exp(vi)\ exp(-\mu i). \qquad (3)$$

Where, TEi = technical efficiency of farmer i; Yi = observed output and; Yi^* = frontier output. The technical efficiency of a firm ranges from 0 to 1. Maximum efficiency in production has a value of 1.0. Lower values represent less than maximum efficiency in production.

Tobit Model

The focus of this paper is not only to identify technical efficiency levels but also to analyze the micro-level determinants of technical inefficiency of okra farming households in central Thailand. The technical efficiency estimates obtained by the methods described above are regressed on some farm and household specific attributes using the Tobit model. This approach has been used widely in efficiency literature (Nyagaka et al., 2009; Obare et al., 2009). The choice of variables was intuitive although they have been found to have an effect on the level of efficiency among smallholder farmers. The structural equation of the Tobit model is therefore given as:

$$y^*i = Xi\beta + \varepsilon i \quad (4)$$

Where Y^* is a latent variable for the ith okra farmers that is observed for values greater than τ and censored for value less than or equal to τ. The Tobit model can be generalized to take account of censoring both from below and from above. X is a vector of independent variables postulated to influence efficiency. The β's are parameters associated with the independent variables to be estimated. The ε is the independently distributed error term assumed to be normally distributed with a mean of zero and a constant variance. The observed y is defined by the following generic measurement equation:

$$yi = y^* \text{ if } y^* > \tau$$
$$yi = \tau y \text{ if } y^* \geq \tau \quad (5)$$

Typically, the Tobit model assumes that τ = 0 which means the data is censored at zero. However, efficiency scores for the okra production range between 0-1. Thus, we substitute τ in equation 5 as follows:

$$yi = y^* \text{ if } 0 < y^* < 1$$
$$yi = 0 \text{ if } y^* \leq 0$$
$$yi = 1 \text{ if } y^* \geq 1 \quad (6)$$

It is important to mention that estimating the model using Ordinary Least Squares (OLS) would produce both inconsistent and biased estimates (Gujarati, 2004). This is because OLS underestimates the true effect of the parameters by reducing the slope (Goetz, 1995). Therefore, the maximum likelihood estimation is recommended for Tobit analysis.

Materials and Method

The Study Area

Five major areas in the central Thailand represented okra plantation were Suphan Buri, Ratchaburi, Nakhon Pathom, Kanchaburi and Ang Thong provinces. Total households who were cultivating okra for commercial purpose and registered with the Department of Agricultural Extension were 740 households (DoAE, 2016). These population of interest located diffusively in each province that has administrative district under the Thai Interior Department. The provincial administration divides into province, then district, sub-district or tambol, and finally village. Thus, the household units from the study areas were villagers in 5 provinces.

Data Collection Procedure

The population of interest constituted producers of okra in the central Thailand; the sampling unit was the okra household by using proportional stratified random sampling method to draw a sample household. From estimation 740 households who are okra producers in Suphan Buri, Ratchaburi, Nakhon Pathom, Ang Thong and Kanchaburi Province by referred the data from Dept. of Agricultural Extension (DoAE) in Bangkok, Thailand (DoAE 2016) for January-December, 2016; a sample of 260 households were selected randomly by referred a list of okra growers in the okra trading center of each province by using probability proportionality size following a simplified formula provided by Yamane (Yamane, 1967). Accordingly, the required sample size at 95% confidence level with degree of variability of 5% will be used to obtain a sample size required which represents a true population as follow:

$$n = \frac{N}{1 + N (e2)} \qquad (7)$$

In equation 1; *n* is Sample size, *N* is Population size and *e* is Allowable error (5%). Then, the sample size of each stratified sample was calculated from equation:

$$ni = \frac{nNi}{N} \qquad (8)$$

Where; *n* is Sample size, *N* is Population size, *ni* is Size of each stratified sample and *Ni* is Size of each stratified population.

Finally, an estimated of *Ni* and *ni* as follows for the five provinces, based on the intensity of okra production: Suphan Buri (163), Nakhon Pathom (58), Ratchaburi (16), Ang Thong (13) and Kanchaburi Province (10). Primary data was collected in May, 2017 using a semi-structured questionnaire adapted from a baseline survey Export Okra Production in Thailand conducted by the FAO Vegetable IPM.

The data included information on okra production such as: quantities of seeds, quantities of chemical fertilizer, quantities of herbicides, quantities of total agricultural land area and okra operating hour. The land area of okra production in rai (1,600 square meters) was used to standardize of the inputs in terms of the quantities per rai. Data was also collected on household socio-economic characteristics such as the okra growers' age, gender, years of schooling, experience in okra production, cropping system (grow only okra or not), household size, income and distance to okra trading center.

Method of Data Analysis

Three methods of were used to analyze the data collected. These were:

- Descriptive statistics consisting of simple percentages and proportions. These were used to examine the production data and socio-economic characteristics of the growers.
- The Stochastic Frontier Production Function: This was used to estimate the resource use efficiency in okra production. It is given by:

$$ln\ Yi = ln ßo + \sum ßj\ lnXij \qquad (9)$$

Where; *Yi* = Farm output in term of total quantities of okra product (in kg. per rai per crop) from farm i; *Xi* = Vector of farm inputs used. X1 = Amount of family member who support in okra production (in person per household per crop), X2 = Cropping system (in system per crop); X3 = Amount of seed (in seed per hole per rai per crop), X4 = Quantities of herbicide rate (in liter per rai per crop); X5 = Quantities of chemical fertilizer (in Kg. per rai per crop), X5 = Irrigation system (in system per crop), and X7 = Total of okra operating hour (in hour per rai per crop; *ßo* = intercept; *ßj* = vector of production function parameters to be estimated; *i* = 1, 2, 3, n farms; *j* = 1, 2, 3, m inputs.

The statistical significance shows the presence of a one-sided error component, in the model specified. This means that a traditional response function estimated by the ordinary least square cannot adequately represent the data, and the use of a stochastic frontier function estimated by the maximum likelihood estimation procedures is therefore appropriate. The parameters of the models were obtained by the maximum likelihood estimation method.

(iii) Tobit model, the model assumes that there is an underlying stochastic index equal to (Xiβ + εi) which is observed only when it is some number between 0 and 1; otherwise, Y* qualifies as an unobserved latent (hidden) variable. The dependent variable is not normally distributed since its values range between 0 and 1.

Empirical Results

Socio-Economic Characteristics of Okra Growers

Efforts were made to understand the socio-economic characteristics of okra growers in the study area. The characteristics considered were age, sex, years of schooling, experience in okra production, amount of family member for okra production, total agricultural land area, distance to okra trading center and total quantities of okra product.

The result is presented in Table 1. On age classification, 81.15% were found to be within the age bracket of 31 to 59 years. While 14.23% of the respondents is older than 60 years. Contrary to findings of past studies which reported the farming population to be ageing (Idowu, 1989), the present study shows a young farming population.

From gender perspective, the females were found to make up the bulk of okra growers in Central Thailand. About 54.20% of the sampled okra growers are women, which more women than men may be involved in okra production in order to supply the food needs from market purchases.

Years of schooling of okra growers is known to affect their production activities. From this study reveals that 48.10% of the respondents have 6-year schooling while about 35.80% are okra grower who have 12-year schooling. Thus, over than 60% of the respondents have had one form of formal education. Evidence indicates that the okra growers in Central Thailand is an educated one similarly with Gabriel et. al. (2006).

Cost and returns of okra production. As revealed in the Table 1, an average total cost of okra production is 6,934.62 THB. /Rai/Crop. While an average of total income of okra production is 64,263.92 THB. /Rai/Crop. It is clear that in Central Thailand, okra production is highly profitable to sustain an average growers' income.

Estimation of Parameter of the Production Factors

The parameters and related statistical test results obtained from the stochastic frontier production function analysis are presented in Table 2 by using Maximum Likelihood Estimate (MLE). Almost variables have positive effect on okra production which means these variables will increase the output of the enterprise, except amount of family members who support in okra production (X1), irrigation system (X6) and total okra operating hour (X7) has negative effect on okra production which mean these variables will decrease the output of the enterprise.

The estimated sigma square (δ2) is 0.5461 (t value 0.4533). The value of δ2 indicates the goodness of fit and correctness of the specified assumption of the composite error term distribution (Okoye et. al., 2007). The value of gamma (γ) is 0.9395 (t value 7.2294) shows that there is 90 percent variation in the production is due to differences in their efficiency, which is significant at the 5% level.

Amount of family members for okra production (β1). The coefficient of amount of family members for okra production had a negative sign. The production elasticity of output with respect to amount of family members for okra production is 0.0461. By increasing amount of family members for okra production per household per crop by 100%, output level will decrease by a margin of 4.6068%.

Cropping system (β2.) The coefficient of cropping system had a positive sign. The production elasticity of output with respect to cropping system is 0.0064. By increasing cropping system per crop by 100%, output level will increase by a margin of 0.6374%.

Amount of okra seed (β3). The coefficient of amount of okra seed had a positive sign. The production elasticity of output with respect to amount of okra seed is 0.1852. By increasing amount of okra seed per hole per rai per crop by 10%, output level will increase by a margin of 1.8524%.

Quantities of herbicide (β4). The coefficient of quantities of herbicide had a positive sign. The production elasticity of output with respect to quantities of herbicide is 0.0045. By increasing quantities of herbicide per rai per crop by 100%, output level will increase by a margin of 0.4474%.

Quantities of chemical fertilizer (β5). The coefficient of quantities of chemical fertilizer had a positive sign. The production elasticity of output with respect to quantities of chemical fertilizer is 0.4406, which is significant at the 5% level of probability. By increasing quantities of chemical fertilizer per rai per crop by 10%, output level will increase by a margin of 4.4062%.

Irrigation system (β6). The coefficient of irrigation system had a negative sign. The production elasticity of output with respect to irrigation system is 0.0307. By increasing irrigation system per crop by 100%, output level will decrease by a margin of 3.0697%

Total of okra operating hour (β7). The coefficient of total of okra operating hour had a negative sign. The production elasticity of output with respect to total of okra operating hour is 0.1849. By increasing total of okra operating hour per rai per crop by 10%, output level will decrease by a margin of 1.8495%.

Okra Grower-Specific Efficiency Scores

Predicted okra grower-specific efficiency scores in Central Thailand are summarized in Table 3. The scores were predicted after estimating the stochastic frontier production function. The finding showed that means economic efficiency score among all sampled growers was 83.45%. The maximum efficiency score was 94.71% while the minimum efficiency score was 44.25%. The finding also reveals that 55.77% of 260 okra growers have economic efficiency score above 80% means the average technical inefficiency of okra production is 16% in the samples.

Determinants of Inefficiency Model

The results in table 4 show estimates of the Tobit regression of selected socio-economic against okra growers-specific inefficiency scores. The results reveal that years of schooling of okra growers, total of agricultural land area and availability of the okra exporting company have a positive impact on inefficiency score. While okra growers' sex, amount of family member for okra production, experience in okra production and distance to okra trading center have a negative impact on inefficiency score. However, among the selected variables there's three variables were found to contribute significantly to inefficiency score namely: years of schooling, total of agricultural land area and distance to okra trading center.

Years of schooling of okra growers showed a positive effect on inefficiency score as was hypothesized. The coefficient was strongly significant at 1% level. The results indicate that an increase in the growers' education by a unit increased the output level by 7.45%. It indicated that growers with higher levels of education tend to be more efficient in production. Better performance by more educated growers may be attributed to the fact that education gives the growers the ability to perceive, interpret and respond to new information and improved technology such as chemical fertilizers, pesticides and planting materials much faster than their counterparts. However, Bravo-Ureta et al. (1997) in their study of peasant farmers in Dominican Republic found a negative relationship between education and economic efficiency.

Total of agricultural land area showed a positive influence on inefficiency score as hypothesized and it was significant at 5% level. The results indicate that an increase in the total of agricultural land area by a unit increased the output level by 2.73%.

Finally, ***distance to okra trading center*** showed a negative influence on inefficiency score as hypothesized and it was significant at 5% level. The results indicate that an increase in distance to okra trading center by a unit decreased the output level by 1.35%.

Conclusions & Policy Implications

The main objective of this study was to estimate the efficiency levels and assess the factors influencing technical inefficiency of okra production in Central Thailand. It was established that the mean efficiency among okra growers was 83.45%. Finally, the Tobit regression model estimation revealed that inefficiency score was positively influenced by the years of schooling of okra growers at 1% level and total of agricultural land area at 5% level. Whereas, distance to okra trading center was negatively influenced at 5% level, the positive impact of years of schooling on inefficiency score indicates that increase in human capital will enhance the okra growers' ability to receive and understand information relating to new agricultural technology. This finding supports argument by Abdulai et. al. (2001) that an increase in human capital will augment the productivity of growers since they will be better able to allocate family-supplied and purchased inputs, select the appropriate quantities of purchased inputs and choose among available techniques. There is therefore a need to promote formal education as a means of enhancing efficiency in production over the long-term period.

Based on the findings, there is the need for the government and NGOs concerned with Agriculture to organize seminars where okra growers would be trained to reduce over-dependence on okra production, especially the irrigation system and provide alternative employment to the young people in the area. So that smallholder can invest more in okra production to increase their economic efficiency.

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Appendix

Table 1: Socio-economic Characteristics of Okra Growers in Central Thailand

Characteristics	Frequencies	%	Mean	Minimum	Maximum
Age					
< 29	12.00	4.62	n.a.	n.a.	n.a.
30 - 39	60.00	23.08	n.a.	n.a.	n.a.
40 - 49	82.00	31.54	n.a.	n.a.	n.a.
50 - 59	69.00	26.54	n.a.	n.a.	n.a.
> 60	37.00	14.23	n.a.	n.a.	n.a.
	260.00	**100.00**	**0.00**	**0.00**	**0.00**
Sex (Dummy)					
1 = Male	119.00	45.80	n.a.	n.a.	n.a.
0 = Female	141.00	54.20	n.a.	n.a.	n.a.
	260.00	**100.00**	**n.a.**	**n.a.**	**n.a.**
Years of Schooling (Year)					
< 1	2.00	0.80	n.a.	n.a.	n.a.
1 - 6	125.00	48.10	n.a.	n.a.	n.a.
7 - 9	36.00	13.80	n.a.	n.a.	n.a.
10 - 12	93.00	35.80	n.a.	n.a.	n.a.
> 13	4.00	1.50	n.a.	n.a.	n.a.
	260.00	**100.00**	**n.a.**	**n.a.**	**n.a.**
Experience in Okra Production (Year)					
1 - 5	167.00	64.20	n.a.	n.a.	n.a.
6 - 10	45.00	17.30	n.a.	n.a.	n.a.
11 - 15	33.00	12.70	n.a.	n.a.	n.a.
> 15	15.00	5.80	n.a.	n.a.	n.a.
	260.00	**100.00**	**n.a.**	**n.a.**	**n.a.**

Irrigation system (Dummy)					
1 = Sprinkler or trickle	178.00	68.50	n.a.	n.a.	n.a.
0 = Other irrigation system	82.00	31.50	n.a.	n.a.	n.a.
	260.00	**100.00**	**n.a.**	**n.a.**	**n.a.**

Characteristics	Frequencies	%	Mean	Minimum	Maximum
Cropping System (Dummy)					
1 = Grow only okra	153.00	58.85	n.a.	n.a.	n.a.
0 = Grow another plant also	107.00	41.15	n.a.	n.a.	n.a.
	260.00	**100.00**	**n.a.**	**n.a.**	**n.a.**
Total of agricultural land area (Rai/Crop)	n.a.	n.a.	2.23	0.25	35.00
Distance to okra trading center (Km.)	n.a.	n.a.	3.81	0.00	10.00
Total quantities of okra product (Kg. /Rai/Crop)	n.a.	n.a.	2,908.73	1,300.00	4,500.00
Amount of family members for okra production (Person/Household)	n.a.	n.a.	2.01	1.00	4.00
Quantities of seed (Seed/Hole/Rai/Crop)	n.a.	n.a.	1.47	1.00	3.00
Quantities of herbicide (Liter/Rai/Crop)	n.a.	n.a.	285.00	0.00	300.00
Quantities of chemical fertilizer (Kg. /Rai/Crop)	n.a.	n.a.	80.27	30	110
Total of okra operating hour (Hour/Rai/Crop)	n.a.	n.a.	3.46	7.71	18.16
Total of okra cost (THB. /Rai/Crop)	n.a.	n.a.	6,934.62	3,500.00	20,000.00
Total of okra income (THB. /Rai/Crop)	n.a.	n.a.	64,263.92	21,900.00	103,500.00

Table 2: Estimates of Parameters of Stochastic Frontier Production Function Model

Production Factor	Parameter	Coefficients	Standard error	t-statistics
Constant term	$\beta 0$	6.6653**	0.5202	12.8140
Amount of family members who support in okra production (Person/household)	$\beta 1$	-0.0461	0.0489	-0.9420
Cropping system (1 = Grow only okra)	$\beta 2$	0.0064	0.0405	0.1572
Amount of okra seed (Seed/Hole/Rai/Crop)	$\beta 3$	0.1852	0.0637	2.9085
Quantities of herbicide (Liter/Rai/Crop)	$\beta 4$	0.0045	0.0112	0.3989
Quantities of chemical fertilizer (Kg. /Rai/Crop)	$\beta 5$	0.4406*	0.0847	5.2007
Irrigation system (1 = Sprinkler or Trickle)	$\beta 6$	-0.0307	0.0405	-0.7577
Total of okra operating hour (Hour/Rai/Crop)	$\beta 7$	-0.1849	0.1120	-1.6519
Diagnostic Statistics				
Total variance	$\delta 2$	0.5461	1.2046	0.4533
Variance ratio	γ	0.9395**	0.1300	7.2294
LR test	10.8290			

*****, ** is significant at 10 and 5% levels respectively.
Source: Computed from field survey data. 2017

Table 3. Efficiency Distribution of Okra Production in Central Thailand

Efficiency Level	Frequency	%
≤ 0.60	12.00	4.62
0.61 - 0.70	18.00	6.92
0.71 - 0.80	30.00	11.54
0.81 - 0.90	145.00	55.77
> 0.91	55.00	21.15
Total	**260.00**	**100.00**
Mean efficiency (%)	0.8345	
Minimum (%)	0.4425	
Maximum (%)	0.9471	

Source: Computed from field survey data. 2017

Table 4: Tobit Regression Estimates of Factors Influencing Inefficiency (Dependent Variable = Technical Inefficiency Score)

Economic Efficiency	Coefficient	t-value	P>|t|
Sex (1 = Male)	-0.0130	-1.0201	0.3077
ln (Years of schooling) (Years)	0.0745	6.8574	0.0000***
ln (Total of agricultural land area) (Rai)	0.0273	3.1644	0.0016**
ln (Amount of family member for okra production) (Person)	-0.0036	-0.1955	0.8450
ln (Experience in okra production) (Years)	-0.0085	-1.3031	0.1925
ln (Distance to okra trading center) (Km.)	-0.0135	-2.0124	0.0442**
Availability of the okra exporting company (1 = Taniyama Siam Co., Ltd.)	0.0328	1.6435	0.1003
Log likelihood	223.58		

, * is significant at 5% and 1% levels respectively

Source: Computed from field survey data. 2017

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