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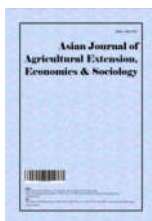
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Factors Affecting Profitability of Agribusiness Activities: A Case Study of Smallholder Pig Farming in Tharaka-Nithi County, Kenya

P. K. Micheni^{1*}, I. S. Nyariki¹ and G. K. Kosgei¹

¹*Department of Agricultural Economics, Agribusiness Management, Agricultural Education and Extension, Chuka University, P.O. Box 109-60400, Chuka, Kenya.*

Authors' contributions

This work was carried out in collaboration among all authors. Author PKM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ISN and GKK managed the analyses of the study and author PKM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: There have been concerted efforts to commercialize the pig sub-sector so as to make it more profitable to farmers, especially smallholder farmers. Despite the development, the profitability in the sector has not been consistent among the smallholder farmers. Smallholder farmers have been earning varying and dismal profits. The causes of the varying profits have not been empirically established with the influence of institutional arrangements from a transaction cost perspective and management factors contributing to this inconsistency not fully established. The study examined the influence of institutional arrangements and management factors on profit efficiency of smallholder pig farming in Tharaka-Nithi County, Kenya.

Research Methods: A two-stage sampling technique was employed in selection of 80 smallholder pig farmers. Semi-structured interview guides were administered and data was analyzed using descriptive statistics and stochastic frontier production function.

Findings: The study revealed that male (75%) respondents dominated were within the active age, had 6 years pig farming experience with basic education. The results of Stochastic frontier

*Corresponding author: E-mail: kananumicheni@gmail.com;

production revealed that feed costs ($p<0.01$) and breed type ($p<0.05$) negatively reduced profit efficiency of the respondents while herd size ($p<0.05$) and veterinary and drug costs ($p<0.01$) positively influenced profit efficiency. Inefficiency was increased by Gender ($p<0.1$) and Debt Asset Ratio ($p<0.01$) while information trust ($p<0.05$) and experience reduced.

Conclusion: The mean profit efficiency was 0.40 exhibiting low profit efficiency in the study area, efficiency level could be increased by 60% through better use of available resources, adoption of modern technology and transaction costs reduction. This would be acquired if good management practices and marketing channels are adopted. The gamma parameter (γ) was 0.63 meaning 63% net revenue variation is due to profit inefficiencies. The study contributes to Agribusiness field and would improve policies associated with agribusiness development in Kenya.

Keywords: *Smallholder farmers; institutional arrangements; management factors; stochastic frontier analysis; profit inefficiency.*

1. INTRODUCTION

The rising population and urbanization have pushed demand for animal protein to a new high. There is already a disparity between the rate of food production and demand in Kenya. This has led Kenya to import pork valued at USD 700,000 since the country produces an estimated 12,000 tons of pig meat worth KES 1.2 billion. In the last five years, the number of pigs slaughtered in Kenya has increased by about 8% from 360,000 to 388, 200 [1]. Inability to provide the required amount of animal protein in the diets of the populace is one of the major causes of food disparity [2].

In Kenya, the Livestock sector contributes to 50% of employment and 12% to Kenyas' Gross Domestic Product (GDP). This sector is comprised mostly of dairy, milk, meat, eggs, wool, hides and skins. The consumption of meat has been rapidly increasing over the last decade with an expectation of reaching 13.3 million tons by 2025 [3]. As most urban areas continue to grow, consumption of meat (beef, chicken, mutton, goat, pork and camel) is expected to keep on increasing from the current average of 19 kg per capita per year [4]. Pork could play an important role in effectively reducing the inadequacy of animal protein in the diets through pig farming. Unfortunately, in Kenya the smallholder farmers are not well organized and lack good agricultural practices leading to low yields, eventually very low returns. SHFs also lack business orientation, meaning they do not operate their farming enterprise as a business [5].

Over the years, the number of pigs being slaughtered in Kenya has been steadily rising. With a poverty level of 65% in Tharaka-Nithi County, Pig farming plays an important role in

risk diversification and livelihood security of smallholder and households as they present an important asset useful in generating income for purchase of farm inputs, school fees payment and covering emergency cash needs [6]. The small-scale pig farming enterprise has been found to be very profitable when better husbandry practices and management skills are applied [2]. Proper selection of the breeding stock as well as organized breeding programmes are needed to facilitate genetic improvement so as to improve pig productivity in Kenya [6,7].

However, smallholder pig farmers in Tharaka-Nithi County obtain varying and dismal profits from their enterprise due to a number of productivity and market related constraints ranging from diseases, poor nutrition and poorly organized markets. With good management skills and efficient institutional arrangements, pig production improves, increasing income and eventually increase profit levels of farmers. This can only be achieved if the pig sub-sector is carried as a business [8].

Development of the pig value chain is important as it has an effect on the farmers' profits as all the key chain actors offer support to each other to improve efficiency and competitiveness [9]. The sub sector in the county is largely informal with poorly organized markets, limited technology, information and services. Additionally, lack of feed quality control measures, disease risks that wipe out pig herds during outbreak periods lead to stunted growth which reduce market value. Exchange of good information in the produce market is also affected by lack of farmer organizations in the pig sector. This leads to high transactions costs due to low binding relationships between smallholder farmers and traders [10]. Therefore, to minimize these high transaction costs, smallholder farmers

need to establish efficient institutional arrangements.

A few studies have determined the influence of management factors and institutional arrangements on smallholder pig farmers profit efficiency. Most examined the effect of farm and farmer conditions, marketing, social, cultural, technological and institutional factors on profit efficiency at farm level [11,12,13,14,15,16,17,18]. However, it's not only the management factors and institutional arrangements that influence profit efficiency of smallholder pig farmers and extent of influence but also the identification of the critical factors that influence profit efficiency is an important priority for research.

Thus, there is a need for research to establish which management factors and institutional arrangements that needs to be targeted for smallholder pig farmers to be profit efficient. This study also attempted to fill this knowledge gap.

2. METHODOLOGY

2.1 Study Area, Sampling Procedure and Data Collection Instruments

The study was carried out in Tharaka-Nithi County, Kenya. Descriptive research design was used. A two-stage sampling technique was adopted for the selection of smallholder pig farmers in the study area. The first stage involved purposive selection of Maara constituency because of prominence of pig farmers in the area as well as good agro-ecological zone suitable for pig farming. The second stage involved stratification random sampling of 16 smallholder pig farmers from each of the five wards making a total of 80 by use of snowballing method to trace the farmers within the stratified areas.

Primary data were collected through semi-structured interview schedules by personal interview of the farmers and data obtained were analyzed using descriptive statistics and stochastic frontier production function.

2.2 Empirical Model Specification

Stochastic Frontier Production Function (SFPF) was applied in the analysis of data. To establish which factors led to profit inefficiency, Stochastic Frontier Approach was used. It accounts for the random error and the inefficiency component

[19]. Following [20], this study utilizes the [21] model by postulating a profit function, which is assumed to behave in a manner consistent with the stochastic frontier concept. The functional form of the stochastic profit frontier was determined by testing the sufficiency of the Cobb-Douglas which is highly restrictive by fitting it with the less restrictive translog, this is in line with the work of [22].

The stochastic profit model used is as shown in equation 3 which is basically input-output transformation and transaction costs model [23] which is the linearized Cobb-Douglas production function while equation 4 is the inefficiency model. The econometric model was typically defined to be:

$$Y_i = x_i\beta + e_i \quad \dots\dots\dots (1)$$

$$Y_i = \beta_0 + \sum_{i=1}^6 \beta_i X_i + V_i - U_i \text{ (Cobb-Douglas function)} \quad (2)$$

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i \text{ (Translog function)} \quad (3)$$

Where:

$\ln Y_1$ = Normalized profit (net revenue per kilogram of output sold); X_1 = Feed cost (kg); X_2 =Wage rate (include wage rate for both hired and family labor) (man-days); X_3 = Breed type; X_4 = Herd size; X_5 = Search costs and X_6 = Drug/Veterinary costs (Kshs); $B_0, \beta_1, \dots, \beta_5$ = Parameters to be estimated;

U_i = Degree of inefficiency which is half-normal distributed (iid $N|$) (0, σu^2). U_i is closely related to the profit inefficiency which may arise from management factors and institutional arrangements.

V_i = statistical disturbance term that is caused by factors outside the scope of the farmers which is assumed to be identically and normally distributed with a mean of zero (iid) and constant variance of $V \sim N(0, \sigma^2 v)$ and independent of U .

The coefficient of the variables x_1, x_2, x_3, x_4 , and x_5 are the estimates from profit function maximum likelihood and are interpreted as the elasticities of the variables. The coefficients are all correctly signed. Stochastic frontier model was used to determine the relationship between the pig Net Revenue and the inputs used by the selected smallholder pig farmers.

The objective of this study was analyzed using the inefficiency model where profit inefficiency (u)

was the dependent variable and the inefficiency factors were the independent variables.

The expression of inefficiency model is specified below:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} \dots \quad (4)$$

Where;

U_i – the inefficiency of the i^{th} farm; δ_0, δ_9 = Are parameters to be estimated; z_1 = Age; z_2 = Gender ; z_3 = Schooling years; z_4 = Group membership; z_5 = Management type; z_6 = Trust (price); z_7 = Trust (Information); z_8 = Debt Asset Ratio; z_9 = Experience; z_{10} = Record Keeping. A half normal distribution of the inefficiency variance was used in the estimation.

The variance of the random errors, σ_v^2 and that of the profit inefficiency effect σ_u^2 and the overall variance of the model σ^2 are related thus: $\sigma^2 = \sigma_v^2 + \sigma_u^2$, measure the total variation of profit from the frontier which can be attributed to profit inefficiency [24]. [21] provided log likelihood function after replacing σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and thus estimating gamma (γ) as: $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$. The parameter γ represents the share of inefficiency in the overall residual variance with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favor of OLS estimation [25,26]. Lambda (λ) that is (σ_u / σ_v) was also computed to assess the goodness of fit and correctness of the specified normal/ half-normal distribution assumption. It was also used to explain the disparities of pork output among smallholder pig farmers.

The study will use the average wage county wage rate as a proxy for the wages of the family workers. The average wage is the average wage of the hired workers in the pig farms in Tharaka-Nithi County. This is computed according to the rule that a worker would spend 2 hours in a day at the pig farm only.

3. RESULTS AND DISCUSSION

3.1 Pig Management Practices and Institutional Arrangements

The management practices and institutional arrangements of the sampled smallholder pig

farmers are presented in Table 1. The table shows the mean age to be 44 years which ranged from 24 to 76 years. This implies that most of the farmers were of middle age; therefore, they owned risk bearing abilities and innovativeness. At this age the farmers have great mental capacity to cope with daily challenges and demands of farming business. The average number of years spent in school was 10 years implying that the pig farmers were educated and had positive influence on adoption of improved technologies and exploitation of opportunities in pig production.

Majority (75%) of the farmers were males, while 25% were females indicating that men are more involved in production than females in the study area. In the African context males as the heads of households and owners of resources make major decision on production and who increases profit efficiency because they decide on procurement and use of production inputs. Females in this study area contributed to labour in light farm operations such as serving of feed, water and cleaning of the piggery.

Farmers had higher preference for large white (61%) to other breeds because of wide availability and high fecundity. Also, the mean herd size of 4 pigs implied that pig production was on small scale level, which might be due to economic condition of the farmer. The study revealed that majority of the pig farmers practiced penning (68%) which was a semi intensive management system, 32% practiced stall-feeding (intensive system) in which pigs were confined in clean pigsty and fed with balanced food. Smallholder pig farmers in the study area sold pigs to traders directly (60%) who offered exploitative prices compared to local consumers at 40% where high prices were offered with high search and contracting costs. The study showed that majority (59%) of smallholder pig farmers were not members of any farmer group, while 41% who were members of farmers group. Those in farmer groups benefited from trainings which made them to adopt new technologies and follow management practices recommended by extension workers and other trainers.

3.2 Profit Efficiency of Pig Producers in the Study Area

Maximum likelihood estimates (MLE) of the parameters in the stochastic frontier model are presented in Table 2.

The results of the production function showed that most of the inputs used were statistically significant at different levels except for labour costs and search costs. The coefficient of feed costs was rightly signed and statistically significant ($p < 0.01$) with coefficient of -0.255 meaning 1% increase in price of feeds would decrease net revenue level of the enterprise by 25% which was consonance with the findings of [18]. The breed type coefficient of pig was negative and statistically significant ($p < 0.05$) with coefficient of -0.100 indicated 1% increase on use of poor breeds would depress net revenue level of the enterprise by 10%. Herd size was positive and statistically significant at ($p < 0.005$) level with coefficient of 0.080 though inelastic indicating 1% increase in the number of pigs will increase net revenue by 8% and this was consistent with the study of [27]. Lastly, Veterinary and drugs costs was positive and statistically significant at ($p < 0.01$). The coefficient which was elastic in nature appeared to be a major determinant of profit level of pig enterprise in the study area. This however, implied that a 1% increase in price of veterinary and drugs would increase net revenue of the enterprise by 50% and this was in consonance with the findings of [28] who found that strengthened veterinary service system to quality animal health information and potential alternative interventions to antibiotic use including farm management improvement, vaccines and immunomodulators.

The coefficient for cost of labour was 0.444 and was not statistically significant thus appeared not to be a major determinant in profit efficiency of pig enterprise in the study area but had direct relationship. A unit increase in labour cost increased net revenue level by 0.444. This was in consonance with the findings of [29] where labour was not statistically significant but had an inverse relationship with mustard yield. The coefficient for search costs was -0.052 which was inelastic in nature and appeared not to be a major determinant of profit efficiency of pig enterprise in the study area. Therefore, a unit increase in search costs reduced net revenue level by 0.052.

3.3 Determinants of Profit Inefficiency in Pig Production

The result of the inefficiency model in Table 2 shows that gender was positive and significant at $p < 0.10$. This implies that profit inefficiency increases with gender suggesting that female

headed households are more profit efficient than the male headed households since they were more involved in farm operations concurring with the study of [6]. Trust in market information was negative and significant at $p < 0.05$, implying that profit inefficiency declined with lack of trust in market information. Transaction costs incurred from information asymmetry where farmers had to incur more costs to search for better customers and prices and these costs include; personal time, travel expenses, and communication costs. This was corroborated with the findings of [30] who found that information asymmetry lead to opportunism resulting to mistrust amongst the players in the milk value chain. The finding was also in consonance with the study of [9] who concluded that the higher the level of trust between business partners in the marketing channel, the better were the conditions of good business performance. [31] in their study that information sources were sure in inundated farming.

Debt Asset ratio was positive and statistically significant at $p < 0.01$. This implied that profit inefficiency increased with higher debt asset ratio. The higher the ratio indicated that farm business liabilities were more compared to assets and thus needed to be balanced. High ratio made farm business to be insolvent and hindered attracting more credit [32]. [33] opined in their own study that dairy farms with low debt asset ratio in UK were more efficient.

The results on pig rearing experience was found to be negative and significant at 5% in Table 2. This suggests that specialization was developed overtime leading to improved production methods and higher profit efficiency. This finding was in agreement with those of [34], that increased experience in agricultural production enhances critical evaluation of relevance of better production decisions including efficient utilization of productive resources.

Age variable had a positive sign with coefficient of 0.119 but was not statistically significant. These results were consistent with the findings of [18]. They revealed that older farmers are less willing to adopt new practices and modern inputs. Furthermore, young farmers were likely to have some formal education, and therefore might be more successful in gathering information and understanding new practices which, in turn will improve the profit efficiency through higher levels of technical and allocative efficiency. Formal education commonly measured in years of

schooling had no statistically significant relationship between the two variables. This is consistent with the study of [35] who concluded that farmers with some form of formal education did not exhibit higher levels of profit efficiency in the study area.

3.4 Distribution of Profit Efficiency

Table 3 presents the individual profit efficiencies of the sampled pig farmers using the estimated stochastic frontier model. The predicted profit efficiencies differed substantially among the farmers, ranging from 0.094 to 1. The estimates

are skewed to the left and the mean profit efficiency was estimated to be 0.40.

The study showed that pig farmers in the study area were producing at about 40 percent of the potential production level, indicating that the production level was about 60% below the frontier. According to a study by [32], this was an indication of product wastage due to inefficiency of resource used by the farmers. The result also suggested that profit efficiency in pig production in the study area could be increased by 60% through better use of available resources and use of more variable inputs to boost production.

Table 1. Percentage distribution of selected management and institutional arrangements factors of respondents (N=80)

Parameter	Frequency	Percentage	Mean	Std Dev.
Age (Years)			44	12
School Years			10	4
Experience			6	5
Gender				
Man	60	75		
Woman	20	25		
Total	80	100		
Type of Pig Breed				
Cross breeds	27	34		
Hampshire	3	4		
Landrace	1	1		
Large white	49	61		
Total	80	100		
Herd size			4	2.56
Trainings attended			2	0.690
Management type				
Penning	54	68		
Stall feeding	26	32		
Total	80	100		
Buyer type				
Local consumer	32	40		
Trader	48	60		
Total	80	100		
Trust (price, Inform)				
Yes	39	49		
No	41	51		
Total	80	100		
Group membership				
Yes	33	41		
No	47	59		
Total	80	100		

Source: Source field survey, 2019

Table 2. Maximum likelihood estimates for the parameters of the stochastic frontier production for pig production

Variables	Parameter	Coefficients	P> Z
Constant	β_0	-4.647	
Feed costs	B_1	-0.255	0.000***
Labour costs	B_2	0.444	0.256
Breed type	B_3	-0.100	0.004**
Herd size	B_4	0.080	0.001**
Search Costs	B_6	-0.052	0.254
Vet/ Drug Costs	B_7	0.505	0.000***
Inefficiency Model			
Constant	δ_0	-0.811	0.000***
Age	δ_1	0.119	0.458
Gender	δ_2	0.067	0.054*
Schooling years	δ_3	0.068	0.205
Group membership	δ_4	-0.291	0.477
Management type	δ_5	-0.003	0.993
Trust (Price)	δ_6	-0.059	0.909
Trust (information)	δ_7	-0.814	0.008**
Debt Asset Ratio	δ_8	5.007	0.000***
Pig rearing Experience	δ_9	-0.003	0.009**
Records	δ_{10}	0.237	0.685
Sigma-squared	δ^2	4.320	0.000***
Gamma	σ_u/σ_s	0.630	0.000***
Log-Likelihood function			-95.954
Wald chi2(8)		66.70	0.000***

Source Field Survey, 2019; ***Significant at 1%, **5%, *10%

Table 3. Deciles frequency of profit efficiencies of smallholder pig farmers

Efficiency level	frequency	Relative percentage
< 0.25	27	33.75
0.26-0.50	28	35
0.51-0.60	11	13.75
0.61-0.70	2	2.5
0.71-0.80	2	2.5
0.81-0.90	3	3.75
0.91-1.00	7	8.75
Total	80	100
Minimum		0.094
Maximum		1
Mean		0.402

Source: Field data Survey, 2019

4. CONCLUSION

The study was conducted to assess factors that affect profitability of smallholder pig farmers in Tharaka-Nithi County, Kenya. From the above study it may be concluded that the trusts on market information as well as experience of the household head were found to influence pig profit inefficiency negatively. Debt Asset Ratio also

influenced profit inefficiency positively on the farms in the study area. The study has indicated that pig farmers were not fully profit efficient, however, there is considerable potential for enhanced profitability

5. RECOMMENDATIONS

1. Pig producers should be organized into groups such as producer organizations or

cooperative societies which are avenues to achieving the necessary economies of scale and thus reduce information asymmetries and build up countervailing market power.

2. Based on the findings of the study, the following policy recommendations are made: Adequate training programme on pig production (to familiarize them with innovations) and basic finance management skills like the optimal level of debt-asset ratio and debt utilization.
3. Pig production is mostly male dominated in the study area. However, women empowerment programmes should be initiated through pig farming as they provide significant opportunities for financial access. Women also need to be encouraged to participate in pig production to increase their income and enhance their livelihoods.

The major key players in the sector should come up with a coherent and integrated response to address the core challenges faced by smallholder pig farmers. The government can work in partnership with other stakeholders to ensure coordination and cooperation across different national institutions and agencies, at central and local level, private sector organizations, producer organizations and development partners.

5.1 Suggestions for Further Research

The study focused on factors influencing profitability of smallholder pig farms, thus would recommend a further research on smart farming application in smallholder pig farming which could be used to support integrative management approach. In redesigning the study, capturing the effects related to smart solutions in smallholder pig farming could be considered.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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