

PROFITABILITY OF SMALLHOLDER PIG FARMING IN THARAKA-NITHI COUNTY, KENYA

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DECLARATION

I Micheni Pauline Kananu (A152/23009/2012) declare that this is my original work and has not been presented for the award of a degree in any other University or any other award.

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Date 24/11/2015

Supervisors' approval

We confirm that the work reported in this thesis was carried out by the candidate under our supervision and has been submitted with our approval as University supervisors.

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DEDICATION

This work is dedicated to my dad David, Mum Lucy and my siblings for their sincere love and commitment to my studies.

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TABLE OF CONTENTS

DECLARATION.....	ii
DEDICATION.....	iii
ACKNOWLEDGEMENT.....	iv
TABLE OF CONTENTS	v
LIST OF TABLES.....	viii
LIST OF FIGURES	ix
ABSTRACT	xi
CHAPTER ONE.....	1
INTRODUCTION	1
1.1 Background Information.....	1
1.2 Statement of the Problem	4
1.3 Objectives	5
1.3.1 General objective.....	5
1.3.2 Specific Objectives.....	5
1.4 Hypotheses.....	6
1.5 Research Questions.....	6
1.6 Justification of the Study	7
1.7 Scope of the study.....	8
1.8 Definition of Terms	8
CHAPTER TWO.....	10
LITERATURE REVIEW	10
2.0 Related studies	10
1.9 Theoretical and conceptual framework	13
1.9.1 Theoretical Framework.....	13
1.9.2 Empirical Framework.....	22

1.9.3 Conceptual Framework.....	29
CHAPTER THREE	33
METHODOLOGY	33
3.0 INTRODUCTION	33
3.1 Study Area	33
3.2 Research design	36
3.3 Target population.....	36
3.4 Sample size	36
3.5 Sampling Design.....	38
3.6 Data and Data Collection Instruments	38
3.7 Data analysis	40
3.8 Empirical model Specification	41
CHAPTER FOUR	52
4.0 RESULTS AND DISCUSSION.....	52
4.1 Descriptive Results	52
4.1.1 Production, management and institutional characteristics of smallholder pig farmers in Maara Constituency	52
4.2 Empirical results	60
4.3 Profit Efficiency of the pig Farmers	61
4.4 Factors influencing profit efficiency	65
5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	70
5.1 Summary	70
5.2 Conclusion	71
5.3 Recommendations	74
5.4 Suggestions for further research	75
APPENDICES	81
Annex1: QUESTIONNAIRE	81

ANNEX 2: RESULTS FROM DEAP VERSION 2.1	86
ANNEX 3: THARAKA-NITHI COUNTY MAP	87
ANNEX 4: PIG BREEDS	88
ANNEX 5: SUMMARY OF PROFIT EFFICIENCY LITERATURE	89
ANNEX 6: SECONDARY DATA SOURCES	92
ANNEX 7: VARIANCE INFLATION FACTORS (VIF)	93
ANNEX 8: STOCHASTIC FRONTIER PROFIT FUNCTION RESULTS....	94
ANNEX9: NORMALITY TEST.....	96

LIST OF TABLES

Table 1: Description of variables and expected signs	50
Table 2: Description of the inefficiency variables (Zs) and the expected signs.....	50
Table 3: Summary statistics of the descriptive variables (n=80).....	52
Table 4: Percentage frequency of gender	55
Table 5: Pig Breed details.....	55
Table 6: Percentage frequency of feeding system	56
Table 7: Market outlet percentage	57
Table 8: Frequency on information access	59
Table 9: Group membership details.....	60
Table 10: Smallholder pig farms profit efficiency levels (P.E).....	62
Table 11: Input slack results	64
Table 12: Individual profit efficiency of smallholder pig farmers in Tharaka-Nithi County.	86
Table 13: Summary of Profit Efficiency literature	89
Table 14: Secondary Data Sources	92
Table 15: Variance Inflation Factors	93
Table 16: Stochastic Frontier Profit Function Results.....	94

LIST OF FIGURES

Figure 1: Conceptual framework	32
Figure 2: Area of study map-Tharaka-Nithi County	35

LIST OF ABBREVIATIONS

A.I	Artificial Insemination
AFC	Agricultural Finance Corporation
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistics
GDP	Gross Domestic Product
GOK	Government of Kenya
KES	Kenya Shillings
KG	Kilogram
KNBS	Kenya National Bureau of Statistics
MLE	Maximum Likelihood Estimation
NGOs	Non-governmental Organizations
NR	Net Revenue
P.E	Profit Efficiency
SHFs	Smallholder Farmers
STATA	Statistical Analysis
USD	United States Dollar
VIF	Variance Inflation Factor

ABSTRACT

Pig sub-sector sustains livelihoods of many families in Kenya. Pig rearing has been one of well-established sub-sector in Kenya following growing and expansion of export markets, value addition and increasing awareness of food and nutrition security. Pig farming if efficiently managed has great potentials for increasing protein supply in Kenya. Pig farming in Tharaka-Nithi County is mainly done by smallholder farmers and this is due to small land size holding. 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 (farm and farmer characteristics) contributing to this inconsistency not fully established. The main objective of this study was to establish which institutional arrangements and management factors affect the profit efficiency of small-holder pig farmers in Tharaka-Nithi County. Data was collected from 80 smallholder pig farmers in Maara Constituency. The data was processed using STATA and DEA software. The work employed Data Envelopment Analysis to come up with profit efficiency rankings among the farmers and stochastic frontier profit function was used to analyze the factors that affect profit efficiency. DEA revealed average input slack value of 1208 which means farmers had a chance of reducing their input costs by this amount per year without compromising their output. This study further observed that education level, gender and level of trust negatively influenced profit inefficiency, while age, pig breed type, market outlet and debt asset ratio positively influenced profit inefficiency. The mean profit efficiency according to the DEA results was 0.40 implying that efficiency level could be increased by 60% through reducing the excess inputs used and better use of available resources. This would be acquired if good management practices and marketing channels are adopted. The gamma parameter (γ) was 0.63 which indicates that 63% of the total variation in net revenue level was due to profit inefficiencies. The findings could be useful to the stakeholders of the pig sub sector to formulate policies pertaining to pig enterprise inputs, marketing issues and financial products. Benchmarks can be established from the best practices farms which can be used as a package for enhancing and stabilizing profit efficiencies of smallholder pig farmers which in turn could help improve the Kenya economy. The study recommends for model pig centers in Tharaka-Nithi County as well as other counties showcasing best practice.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Agriculture contributes to 25% of the GDP in Kenya of which 70% is contributed by SHFs. Smallholder farming is the main source of livelihoods for more than 80% of the local communities (GOK, 2009). If well harnessed, it therefore has a potential to improve the Kenyan economy. This however, will depend to a large extent on the efficiency in agricultural production. The rising population and urbanization has 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 tones of pig meat worth KES 1.2 billion (FAO, 2012). Inability to provide the required amount of animal protein in the diets of the populace is one of the major causes of food disparity (FAO, 2012).

However, pig meat could play an important role in effectively reducing the inadequacy of animal protein in the diets through pig farming. This is because pig meat is a complete protein. Although, the pig industry in Kenya is relatively small (0.3 Million) compared to the other livestock, with Eastern region contributing about 13% (GOK, 2012). Population growth, urbanization and social views resulting from education will lead to increase in consumption of pig meat (Wabacha, 2004; FAO, 2012). The number of pigs slaughtered in Kenya has been steadily rising (FAOSTAT, 2009). Approximately 280,000

pigs were slaughtered in Kenya in 2009, compared to 163,908 in 2000 thus representing an annual growth rate of 8 % (FAOSTAT, 2009).

This industry is mainly dominated by smallholder farmers like other agricultural sub sectors (Mutua et al, 2010). Several factors such as suitable climate, less land required, quick returns on investments due to large litter size and faster maturity rate contribute to success of pig production by smallholders (Mutua et al, 2010). However, low productivity among SHFs remains a major obstacle to food security. Improved farming methods, quality inputs, reliable and efficient markets, credit access and favorable policies have been identified as crucial to improve productivity. Unfortunately, the SHFs are not well organized and therefore do not command a voice that can facilitate their access to appropriate services with a unified voice. In addition, due to poor husbandry practices, the farmers register low yields which generate very low returns. SHFs lack a business orientation, meaning they do not operate their farming enterprise as a business.

In Tharaka-Nithi County, pig farming is mostly practiced by SHFs. Pigs play an important role in risk diversification and livelihood security of smallholder and households as they are important assets useful in generating income for purchase of farm inputs, school fees payment and covering emergency cash needs (Mutua et al, 2010). With the poverty level of 65% in the county KNBS (2009) the populace needs to undertake farm enterprises which will offer quick returns on investments like pig farming. The small scale pig farming enterprise

has been found to be very profitable if good husbandry practices and management skills are applied (FAO, 2012). Improving the productivity of smallholder pigs, therefore, has a huge potential to meet these multi-functions of the pigs.

However, smallholder pig farmers in Tharaka-Nithi County obtain varying and dismal profits from their enterprise. Pig sub-sector has a seemingly greater potential if the enterprise is carried as a business. Good management skills and efficient institutional arrangements will increase pig production, increase income and eventually increase profit levels of farmers. Dismal profits can be attributed to a number of productivity and market related constraints ranging from diseases, poor nutrition and poorly organized markets due to personal negotiations and absence of contracts (Levy et al, 2014).

Development of the pig value chain is important as it has an effect on the farmers' profits. This is because all the actors in the chain will actively seek to support each other so that they can increase their efficiency and competitiveness (KIT et al, 2006). The sub sector in the county is largely informal with poorly organized markets, limited to 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 goods and information in the produce market is also affected by lack of farmer organizations in the pig sector. This

will lead to high transactions costs due to low binding relationships between smallholder farmers and traders (Key et al, 2000). Therefore to minimize these high transaction costs, smallholder farmers need to establish efficient institutional arrangements.

Varying and dismal profits of smallholder pig farmers are caused by therefore productivity and market related factors (Mutua et al, 2010; Kagira and Maingi, 2010). Research on whether management factors (farm and farmer characteristics) as well as institutional arrangements from transaction cost perspective influence varying and dismal profits has not been adequately researched. This study therefore will help in best practice benchmarking thus making it a profitable enterprise for smallholder farmers in Tharaka-Nithi County.

1.2 Statement of the Problem

Pigs are important assets for smallholder farmers in Tharaka-Nithi County, generating income for meeting planned and emergency household financial needs. Despite its importance, smallholder pig farmers are faced with a number of productivity and market related constraints ranging from low production to poorly organized markets. Strong growth opportunities to improve smallholder pig farming exist if the constraints are minimized thus making it a profitable enterprise. Poor feeding of pigs in terms of the quality and quantity of feeds, inbreeding and prevalence of diseases lead to low optimal weight of pigs as well as low selling prices thus low farm returns leading to low profits and this

has affected smallholder pig farmers livelihoods. Most past studies have largely focused on farmer beliefs, and perceptions especially on local pig farming practices and limited market participation due to lack of farmer organizations affecting profits in pig farming. However, issues of institutional arrangements from a transaction cost perspective and management factors (farm and farmer characteristics) that are presumed to influence profit efficiency have not been adequately researched. This research work therefore intends to fill this knowledge gap. Determining management factors and institutional arrangements affecting profit efficiency of smallholder pig farmers in Tharaka-Nithi County would be crucial in establishing benchmarks which can be used as a package for enhancing and stabilizing profit efficiencies.

1.3 Objectives

1.3.1 General objective

The overall objective of this work is to determine management factors and institutional arrangements that affect profit efficiency of smallholder pig farmers in Tharaka-Nithi County in order to establish benchmarks which can be used as a package for enhancing and stabilizing profit efficiencies of smallholder pig farms.

1.3.2 Specific Objectives

1. To identify the management and institutional arrangement attributes of smallholder pig farmers in Tharaka -Nithi County.

2. To determine the profit efficiency of the smallholder pig farmers in Tharaka-Nithi County.
3. To determine the influence of management factors and institutional arrangements on smallholder pig farms' profit efficiency in Tharaka-Nithi County.

1.4 Hypotheses

1. Smallholder pig farmers in Tharaka-Nithi County are not profit efficient.
2. The management factors and institutional arrangements attributes of smallholder pig farmers are not positively related to profit efficiency in Tharaka-Nithi County.

1.5 Research Questions

1. What are the management and institutional arrangement attributes of smallholder pig farmers in Tharaka-Nithi County?
2. What are the profit efficient levels of the smallholder pig farmers in Tharaka-Nithi County?
3. Which management factors and institutional arrangements are significant in the determination of smallholder pig farm profit efficiency and to what extent?

1.7 Scope of the study

The study was based on the farm level data on smallholder pig farmers who were in the newly formed Tharaka-Nithi County, Kenya. One year cross sectional data was used in this study. The target population was only confined to pig farmers who had less than 20 pigs thus it excluded large and medium scale pig farmers. The sampling units were households within the chosen constituency in Tharaka-Nithi County.

1.8 Definition of Terms

1. **Management factors**- these are practices that a farmer adopts to improve the welfare of his pigs in terms of output, nutrition and general well being for example breed selection and feeding systems.
2. **Institutional arrangements**-these are agreements governing the activities of people pursuing a certain objective for example ;a contract to simply exchange goods or farmers organizations, to enforce a contract entails expenditure of resources (Eaton et al, 2008). It include issues like transaction costs and how they affect exchange of goods, information on pork market, farmer groups and other organizations included in the market.
3. **Smallholder pig farmers**-these are farmers keeping less than 20 pigs.
4. **Transaction costs**- these are resources expended when enforcing an institutional arrangement and they include time, energy and money which are incurred during contacting, contracting and controlling (North, 1990; Williamson, 2002; Eaton et al, 2008).

5. **Profit efficiency**- the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm.
6. **Profit inefficiency**- the loss of profit for not operating on the profit efficiency frontier.
7. **Benchmarking**-Is the process of comparing one's farm business processes and performance metrics in relation to best practice farm's processes usually within a peer group defined for the purposes of comparison.

CHAPTER TWO

LITERATURE REVIEW

2.0 Related studies

Abdulai and Huffman (1998) examined the profit inefficiency of rice farmers in northern Ghana. The Empirical results show that farmers' human capital represented by education level contributes positively to production efficiency. Suggesting therefore, investment in farmers' education improves farm productivity hence increasing income and eventually profits.

Rahman (2003) estimated a stochastic profit function for Bangladesh rice farmers. There existed high level of inefficiency in rice farming based on the results since γ was close to one and the average profit efficiency scores were 60%. This implied that the farmers could improve their profit levels by 40%. Farmers also exhibited a lot of profit inefficiency. Farm-specific factors responsible were poor access to input markets, unfavourable tenancy arrangements and off farm employment.

Ogundari (2006) investigated factors that determine the profit efficiency among the small scale paddy rice farmers in Nigeria, using a stochastic Cobb-Douglas profit frontier model. The study revealed that there was presence of profit inefficiency among paddy rice farmers since the estimated gamma parameter (γ) of the model was 0.983 hence close to one. The average profit efficiency measure was 60%. Small scale paddy rice farmers were fairly efficient in their resources allocation.

Hyuha (2006) examined profit efficiency among rice producers in eastern and northern Uganda by using normalized translog functional form. The results showed that capital and area under rice influenced profit levels positively while the cost of family labor and other inputs had a negative effect. Based on the results, all farmers were not operating on the profit frontier and had scored a mean profit efficiency of 66%. About 70% of the farmers scored at least 61%. The efficiency levels at district levels were also analyzed and were as follows; Pallisa, Lira and Tororo with efficiency levels of 75, 70 and 65 percent respectively.

Costales (2006) examined factors influencing the level of farm –specific relative profit market in southern Luzon, Philippines using stochastic profit frontier regression. The empirical results showed that access to quality feeds, number of veterinary visits and efficient market outlet reduced profit inefficiency levels of small farms.

Ogunniyi (2011) examined the profit efficiency among maize producers in oyo state, Nigeria using stochastic frontier profit function. He applied a multi-stage random sampling technique to select maize producers. The results showed that maize farmers achieved on average 41% level of efficiency. This implied that on average, farmer in the study area could increase profit by 59% by improving their technical and allocative efficiency. Maize farmers exhibited a wide range of profit inefficiency ranging from 1% to 99% with a mean level of 41%.

Profit inefficiency among the farmers was due to low level of education, lack of extension services and poor technological practices.

Maganga et al (2012) explored on the determinants of profit inefficiency of Irish potato farms in the Dedza district of Malawi. Results revealed that there was a significant variation in profit efficiency ranging from 0.31 to 0.99 with a mean efficiency of 0.74, thus implying that profit inefficiency exists in Irish potato production in the study area. The study showed that there was substantial potential for enhancing profitability by reducing the costs by about 26% through improved efficiency. Education level, extension visits, farm experience, age and credit status influenced profit efficiency.

Kadurumba (2014) measured the economic efficiency of production for pig enterprise in Ebonyi State, Nigeria using stochastic profit function. Purposive sampling technique was adopted collected data from 60 pig farmers. The results revealed that age, level of education, farm size, extension contact and household size positively influenced Economic efficiency of the enterprise with mean efficiency being 75%. The study indicated that pig farmers were not fully economically efficient.

Of all these studies, none has focused on the application of DEA for the analysis of pig farm profit efficiency. Jacobs (2000) concluded that DEA being

a non-parametric (does not assume a functional form) and deterministic/ non-statistical method (does not assume statistical noise) can manage complex production environments with multiple inputs and outputs. Charnes et al (1994) concluded that DEA can be used in analyzing efficiency in production and profitability.

DEA is introduced through ratio form, that is, for each DMU a measure of the ratio of all outputs over all inputs is obtained (Hollingsworth and Parkin, 1998). DEA compares the levels of inputs and outputs for a given (farm) DMU against all other DMUs in the data set, to determine which DMU are producing at efficiency levels relative to the entire group.

This study was based on the work of Farrell (1957), whereby the performance of other DMUs was used to evaluate the behavior of each DMU relative to the outputs and the inputs used so as to obtain profit efficiency of each farm (objective).

1.9 Theoretical and conceptual framework

1.9.1 Theoretical Framework

Theorization of profitability in the context of small scale pig farming is guided by Utility and transaction cost theories which are oriented towards analyzing the factors that inform commercial performance.

The smallholder pig farmer is rational, in that he has to make a choice in selecting various factors of production as well as marketing his produce from

many alternatives. Smallholder pig farmers obtain several benefits from pig farming such as income generation for meeting planned and emergency household financial needs as well as source of food. Despite obtaining those benefits from pig keeping they are faced by a number of productivity and market related constraints ranging from diseases, poor nutrition and poorly organized markets. To obtain these benefits and make it a profitable enterprise then these constraints need to be minimized. Therefore he/she is the decision maker as a result of uncertainty with pig production and marketing which influences profit efficiency of a farm.

The utility function in this case is the profit efficiency score. The smallholder farmer is trying therefore to maximize utility by trying to attain the highest profit efficiency score (one) given certain constraints. To attain profit efficiency score of one, the farmer will try to achieve high profits. Profit is defined as the difference between revenues and costs and farms select activities so as to maximize this difference (Kreps, 1990). The pig farmers as part of the economic agents want to maximize net revenue with respect to levels of products and factors, Subject to constraints that are market determined fixed factors and technology. This can be expressed as:

$$NR=TR-TC \quad (1)$$

Therefore the smallholder farmer wants to be maximizing his/her NR which will be his/her π .

$$\text{Max } \pi = \text{TR} - \text{TC} (\text{TVC} + \text{TFC}) - \text{WL} \quad (\text{Kreps, 1990}) \quad (2)$$

Where;

TR = Total Revenue

TC = Total Cost

TVC = Total Variable Cost

TFC = Total Fixed Cost

WL = Labor Wage

$$\text{Max } \pi = p_q \cdot Q - p_x \cdot X - z^f - w_L, \quad \text{profit} \quad (3)$$

Where;

P_q = price of pork per Kg

Q = quantity of pork in Kgs

p_x = Price of variable factors

X = Quantity of variable factors: These factors may include feeds, drugs and veterinary expenses, contacting and contracting costs.

WL = labor wages

Z^f = Fixed factors and farm characteristics (fixed capital and farm size)

Revenue in this case is the income obtained from the sale of pork at the given market price. They need also to minimize the costs incurred in the production and sale of pork in order to remain with profit. X is a vector of a number of inputs like feeds, veterinary and drugs, contacting and contracting and labor wages. These inputs valued at their market prices are the costs incurred.

The farmer wants to obtain maximum output (pork) while using minimal inputs so as to obtain maximum profits. Supply functions and demand functions are derived from the profit optimization equation as follows:

$$q = F(X_s; Z^f) \quad (4)$$

Where;

q = Output (pork)

X_s = Represents variable inputs

Z^f = Represents fixed inputs

Therefore profit which is defined as current revenue less current total variable costs can be written as

$$P' = p F(X_s; Z^f) - \sum_{i=1}^m C'_i X_s \quad (5)$$

Where;

P' = profit

P = Unit price of output (pork)

C'_i = Unit price of the i^{th} variable input

The marginal productivity conditions for a profit maximizing farm are:

$$p \frac{dF(X_s; Z^f)}{dx_i} = c'_i \quad i=1, \dots, m \quad (6)$$

$C_i = C'_i / p$ (Normalized price of the i^{th} input

$$df/dx_i = c_i \quad i=1, \dots, m \quad (7)$$

Equation 5 can be written as equation 8, where p is defined as the unit-output-price profit as below:

$$P = p' / p = f(X_s; Z^f) - C'_i X_i \quad (8)$$

Equation 7 may be solved for the optimal quantities of variable inputs, denoted x_s^* as functions of the normalized prices of the variable inputs and of the quantities of the fixed inputs.

$$X_i^* = f_i(c, z) \quad (9)$$

Where:

C and z without subscripts denote vectors. By substituting equation 9 into 5 profit function is obtained.

$$\Pi^* = p(f(x_s; z^f) - \sum_{i=1}^m C_i' X_i) \quad (10)$$

The profit function gives the maximized value of the profit for each set of values $\{p, c, z\}$. Observe that the term within the large parentheses on the right-hand side of equation 10 is a function only of c (prices of output and input) and z .

Therefore profit function is given by:

$$\pi^* = \pi^*(p_q, p_x, z^f) \quad (11)$$

$$\text{S.t } g(q, x, l; z^f) = 0, \text{ production function}$$

$$\text{Supply function: } q = q(p_q, p_x, z^f) \quad (12)$$

$$\text{Factor demands: } x = x(p_q, p_x, z^f) \quad (13)$$

$$\text{Max. Profit: } \pi^* = \pi^*(p_q, p_x, z^f) \quad (14)$$

Sadoulet and de Janvry (1995)

Thus the farmers will be maximizing profits from sale of the pork subject to the constraints he/she is facing which may be management, financial and institutional arrangements.

This can be represented as;

$$\text{Max. Profit: } \pi^* = \pi^*(p_q; m, s, w) \quad (15)$$

Where;

P_q is the price of pork and its products

M represents management constraints which include age of the household head, gender, schooling years, herd size, type of breed kept and feeding system

s – Institutional arrangement constraints which include the market outlet used and lack of market and price information access and lack of group membership

w – Financial constraints which include debt asset ratio

A stochastic model is one of the econometric models that is used to show regression analysis of variables. Econometric model was adopted to show the regression analysis of smallholder pig farming. Constraints the smallholder farmer is facing explain/influence the level of profit the smallholder farmer is earning in addition to the other unexplained variables (error term) which are beyond his control.

Stochastic model (a model that includes random variables) for examining the linear relationship between dependent variable [profit (π)] and series of these

independent variables (x_{ii} , x_{ij} and x_{ik}) is shown below. Stochastic model is one of the econometric models that is used to show regression analysis of variables.

$$\pi = \beta_0 + \beta_i x_{ii} + \beta_j x_{ij} + \beta_k x_{ik} + \varepsilon \quad (\text{Gujarati, 1995}) \quad (16)$$

π - Profit

β_0 = is the intercept coefficient

β_i , β_j and β_k = are the slope coefficients of institutional arrangement constraints, management constraints and financial constraints.

X_{ii} - Institutional arrangement constraints for the i^{th} farmer

X_{ij} - Managerial constraints for the i^{th} farmer

X_{ik} -Financial constraints for the i^{th} farmer

ε -Error term

The value for β_i , β_j , and β_k show the amount by which profit changes due to a unit change in x_s .

The research work also was based on transaction cost theory which appreciates that exchanges in the market are not costless (Coese, 1960; Costales et al., 2006).

Institutional arrangements thus involve agreements to exchange goods or services. Resources used in the exchange relations such as time, energy and

costs are referred to as transaction costs (Costales et al., 2006; Eaton et al., 2008).

Transaction costs are put into three categories: Contacting costs, contracting costs and control costs (North, 1990; Furubotn and Richter, 1998). Contacting costs include; searching for customers and searching for information. This search can be conducted through visits to possible markets, communicating for instance through telephone calls and looking up prices. Looking up for prices is checking prices for the produce. Smallholder farmers have no advance knowledge of the prices they will receive and thus can depend on their agents e.g. extension officers or use the reported market prices. Contracting costs consists of opportunity costs of time for bargaining or negotiating to come to agreement. Control costs consist of opportunity costs of time put into supervision and costs to monitor implementation of contract. Switching costs is also added in case of premature termination of contract (Eaton et al., 2008).

The cost of information is the key to the costs of transacting, which consists of the costs of measuring the valuable attributes of what is being exchanged and the costs of measuring, protecting the rights and policing and enforcing agreements (North, 1990; Eaton et al., 2008).

According to North (1990), the resources of the economy consumed in transacting are of considerable magnitude and growing. North (1990) argued that the costs of production are the sum of transformation and transaction costs.

Lack of relevant information is one of the causes of market failure (North, 1990). Transaction costs arise from information asymmetry where farmers have to incur more costs to search for better customers and prices and these costs include; personal time, travel expenses, and communication costs. Information asymmetry may also lead to opportunism which consequently results to mistrust amongst the players in the value chain (Holloway et al., 2000). Low level of trust can lead to increased transaction costs to all the players in the industry. In case of farmer low level of trust on trader price, the farmer is likely to switch to another trader thus adding more costs (switching).

This implies that pig farmers incur costs in the process of marketing their pork. Therefore these costs, referred to as transaction costs, increase the price of pork or reduce their profit margins. To overcome some of the transaction costs, farmers resort to collective action, where they form marketing groups either formal or informal like farmer organizations or self help groups.

1.9.2 Empirical Framework

The work being a profit maximization study, can utilize one of the many profit maximization models for analysis. Measurement of efficiency helps in determining profitability of an enterprise and there is a link between profit and agricultural growth (Abdulai & Huffman, 1998).

Both parametric and non-parametric methods were considered to test efficiency. Parametric methods assume a particular functional form and they are also statistical in nature meaning they tend to make assumptions about the stochastic nature of data e.g. Cobb-Douglas and translog production functions. Non-parametric methods do not assume a particular functional form and are non-statistical in nature e.g. DEA Jacobs (2000).

In developing economies like Kenya, farm level data generally include measurement errors therefore use of parametric method to test farm efficiency is important. However, farmers face different factor endowments and prices therefore use of production function approach may not be appropriate. Application of stochastic profit function model can be used to measure farm specific profit efficiency directly, since it helps in overcoming the inaptness of production function approach. Stochastic frontier assumes a particular functional form as well as takes into account measurement errors (Nganga et al., 2010).

The concepts of technical and allocative efficiencies in the profit relationship are combined by the profit function approach and any errors in the production decision are assumed to be translated into lower profits or revenue for the

producer (Nganga et al., 2010). Nganga et al, (2010) defined profit efficiency as the ability of a farm to achieve highest possible profit given the prices and the levels of fixed factors of that farm.

Following kadurumba et al (2014) a stochastic profit function approach is deemed appropriate for this study. This study adopts the Battese and Coelli model of 1995 specified in equation 10. The stochastic profit function is defined as:

$$\Pi_j = f(P_{ij}, Z_{kj}) \cdot \exp(e_j) \quad (17)$$

Where;

Π_j is the normalized profit for the j^{th} farm defined as gross revenue less variable costs divided by farm specific output price, P_{ij} is a vector of price of the i^{th} variable inputs faced by j^{th} farm divided by price of output, Z_{kj} is the vector of k^{th} fixed factor of the j^{th} farm and

f is an appropriate function.

$$(e_j = v_j - u_j)$$

The error term e_j is assumed to behave in a manner consistent with the frontier concept.

V_j is a stochastic disturbance term representing the effect of random factors beyond the control of farmers such as weather, disease outbreaks, measurement

errors and omitted explained variables and it is independently and identically distributed as $N(0, \sigma^2 v)$.

U_j is an error term assumed to be non-negative truncation of the $N(0, \sigma^2 v)$ distribution (i.e. half normal distribution or exponential distribution)

$j=1, \dots, n$ is the number of farms in the sample.

If $U_i=0$, the farm lives on the profit frontier obtaining maximum profit given the prices it faces and levels of fixed factors. If $U_i>0$, the farm is efficient and loses profit because of inefficiency.

The Cobb-Douglas functional form is also an important tool in the analysis of efficiency. Its logarithmic transformation provides a model which is linear in the logs of the inputs and this makes it provide a simplified econometric tool for estimation. This model has a problem of restrictiveness most notably restriction of returns to scale to be equal across all farms in the sample. Returns to scale are concerned with how output varies with the use of inputs. Another restriction is elasticities of substitution equal to one in all the farms (Coelli, 1995)

$$y_i = f(x_i; \beta) + V_i - U_i \quad (18)$$

Where y_i is output of the i^{th} farm

x_i is a vector of inputs used by the i^{th} farm

β is a vector of parameters to be estimated

V_i - Statistical disturbance term

U_i is a non-negative variable representing inefficiency in production (Coelli, 1995).

Translog functional form is also popular in the estimation of profit efficiency. This model has the advantage of overcoming the restriction shortcomings of the Cobb-Douglas model. But this model also has the shortcoming of being exposed to high levels of multicollinearity and sometimes to low degrees of freedom problem due to the presence of interaction terms. The interaction terms of the translog lack economic meaning (Coelli, 1995).

Equation 10 is an example of the Translog model;

$$\ln y_i = \beta_0 + \sum \beta_{ij} \ln x_{ji} + \sum \beta_{jk} \ln x_{ki} + v_i - u_i \quad (19)$$

Where y_i and x_i are the outputs and inputs of the i^{th} farm respectively.

V_i = Symmetric error term assumed to be independently and identically distributed on two sides, it represents the random effects, measurement errors, omitted explanatory variables and statistical noise.

U_i = it's a non negative one sided error term, that represents the inefficiency of the farm. To obtain efficiency of the farm, normal distribution is truncated with mean of zero and constant variance.

U_i = Unknown parameters + Explanatory variables associated with inefficiency

The data envelopment analysis (DEA) is a non-parametric mathematical programming approach to frontier estimation (Coelli, 1995). According to Charnes et al (1994) it can be used in analyzing efficiency in production and profitability.

The DEA method simultaneously compares and ranks similar peer groups with respect to each DMUs relative efficiency (Cooper, Seiford and Tone, 2006). The idea is that by determining which DMUs are inefficient (with respect to other DMUs), it can also be determined how they may improve their efficiency i.e., what inputs and by how much each needs to be changed (reduced) to produce the required output to move up in the rank.

DMU refer to any entity that is to be evaluated in terms of its abilities to convert inputs into outputs. The efficiency of a decision-making unit (DMU) is measured relative to the efficiency of all the other DMUs subject to the restriction that all DMUs are on or below the frontier. Cooper, Seiford and Tone (2006) concludes that a farm can be rated as fully efficient (100%) on the basis of available evidence if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs.

This method of analysis has also its own shortcoming, it has been found out not to consider influence of errors in measurement and other noise in the data (Coelli, 1995). The implication of this shortcoming is that, it does not produce the usual diagnostic tools with which to judge the goodness-of-fit. But it has an advantage of removing the necessity of making arbitrary assumption regarding the functional form of the frontier and the normal distributional form of u_i (Charnes et al., 1994).

DEA is introduced through ratio form, that is, for each DMU a measure of the ratio of all outputs over all inputs is obtained. To select optimal weights we specify the mathematical programming problem below.

$$\text{Max}_{u,v} (u'y_i/v'x_i),$$

$$\text{S.t } u'y_j/v'x_j \leq 1, \quad j=1, 2, \dots, N,$$

$$u, v \geq 0 \quad (\text{Coelli, 1996}) \quad (20)$$

$u'y_i$ = Mx1 vector of output weights

$v'x_i$ = Kx1 vector of input weights

The aim of the farm (DMU) is to have values of u and v , which will maximize the efficiency of the DMU, subject to the constraint that all efficiency measures must be less than or equal to one. Since the problem with this particular ratio

formulation is that it has infinite number of solutions and to avoid this, a constraint is imposed $v'x_i = 1$, which provides:

$$\begin{aligned}
 & \text{Max}_{\mu, v} (\mu'y_i), \\
 & \text{St} \quad v'x_i = 1, \\
 & \quad v'y_j - v'x_j \leq 0, j = 1, 2, \dots, N, \\
 & \quad \mu, v \geq 0
 \end{aligned}
 \tag{Coelli, 1996} \tag{21}$$

Where u and v change to μ and v which reflects the transformation. This form is known as the multiplier form of linear programming problem. Therefore using duality in linear programming can derive an equivalent envelopment form of this problem (Coelli, 1996).

$$\begin{aligned}
 & \text{Min}_{\theta, \lambda} \theta, \\
 & \text{s.t} \quad -y_i = Y\lambda \geq 0, \\
 & \quad \theta x_i - X\lambda \geq 0, \\
 & \quad \lambda \geq 0,
 \end{aligned}$$

Where θ is a scalar and λ is a $N \times 1$ vector of constants. This envelopment form involves fewer constraints than the multiplier form ($K + M < N + 1$), and it's the preferred form to solve. The value of θ obtained will be the efficiency score of the i^{th} DMU. It will satisfy $\theta \leq 1$, with the value of one indicating a point on the frontier and hence a technically efficient DMU from the work of Farrell (1957) definition. Linear programming problem must be solved N times, once

for each DMU in the sample (Coelli, 1996). A value of θ is then obtained for each DMU.

Farrell (1957) concluded that measure of technical efficiency (θ) and any non-zero input or output slacks should be reported to provide an accurate indication of technical efficiency of a DMU in a DEA analysis. Coelli (1996) argued that for the i^{th} DMU the output slacks will be equal to zero only if $Y\lambda - y_i = 0$, while the input slacks will be equal to zero if $\theta x_i - X\lambda = 0$ (for the optimal values of θ and λ).

1.9.3 Conceptual Framework

The conceptual framework shows the interrelationship between management factors, institutional arrangements, financial factors and profit efficiency levels of the smallholder pig farmers. The conceptual framework was organized in terms of influence and feedback mechanisms of farm level profit efficiency. The framework focuses on input-output transformation and transaction costs (costs of production according to North (1990), policy recommendations and effects thereof.

Smallholder pig farmers have different management factors which include farm and farmer characteristics; farmers' education, training, age, and experience in the pig farming business, number of pigs and feeding systems.

Institutional arrangements in the marketing of pork are important in that they determine how players in the pork market interact, issues like trust and availability of information shapes the type of transaction to take place.

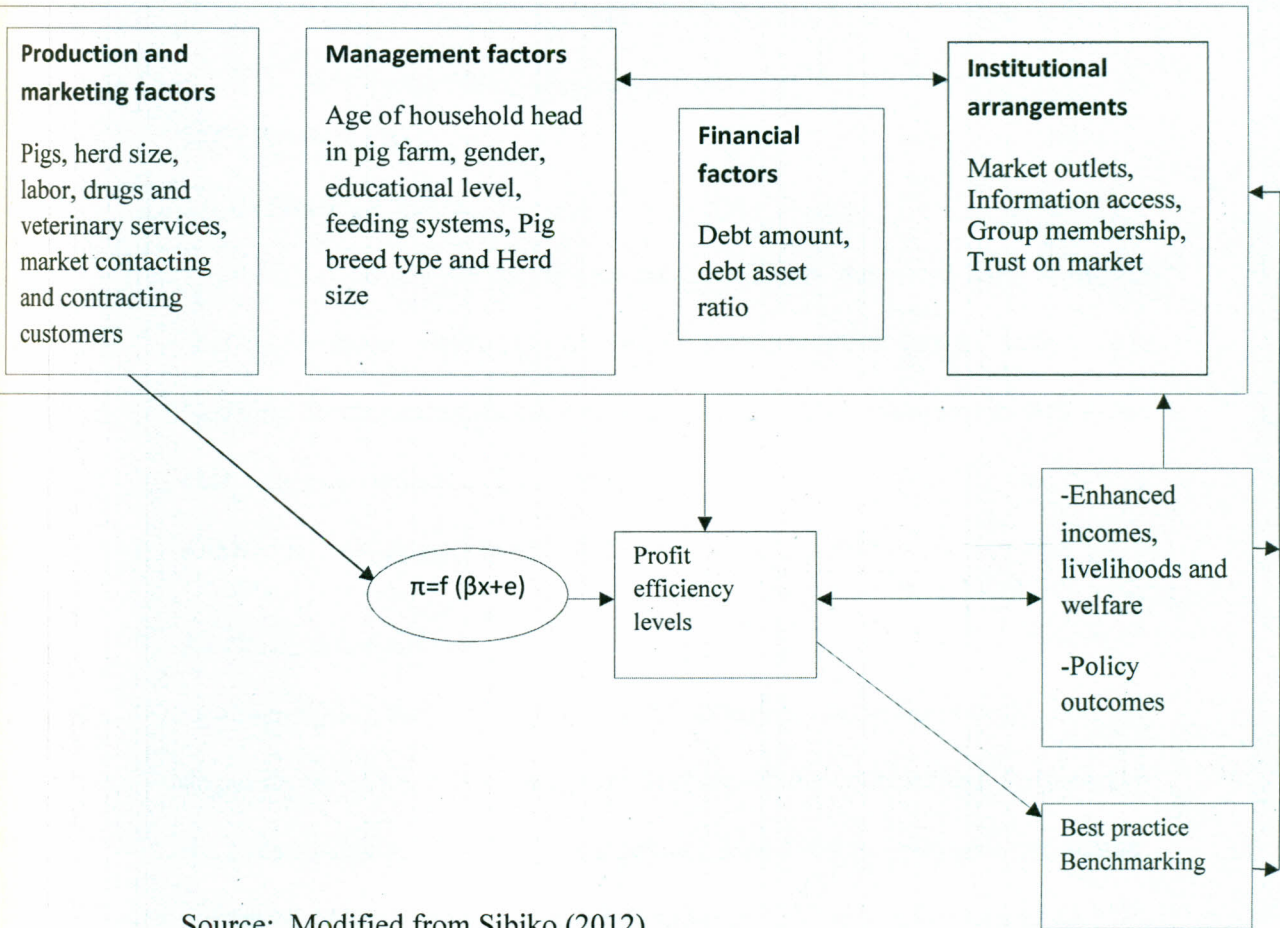
Financial factors like debt amount and debt asset ratio determine the level of profit efficiency. The institutional arrangements, financial factors and management factors interact with each other and together they influence the profit efficiency levels of the farmers. The management and financial factors will determine the level of output of the farmer and his cost of production. On the other hand, the institutional factors will influence the marketing of the pig and its products which will consequently have a cumulative effect on the farm's profit efficiency level.

No policy framework is in place for the pig sector in Kenya. Lack of policy guidance especially to smallholder pig farmers has resulted to detriment of local pig farm production thus low income and profit margins (FAO, 2012).

The profit efficiency and its influencing factors across the study areas are expected to influence policies on industry inputs, marketing issues and financial products. Once favourable policies are recommended the outcome is expected to have a feedback effect on improving profit efficiency and profitability.

Profit efficient levels of the farmers will be ranked and farms should adopt the best practice benchmarking process. This is where the best farms in their industry are identified where similar processes exist, and compares the results and processes of best farms to other farms. In this way, the pig farms learn how well the target farms perform and more importantly, the farm business processes that explain why these farms are successful. Smallholder pig farms which are profit inefficient therefore adopts practices in which the profit efficient farms are practicing, hence they will become profit efficient.

Eventually, enhanced incomes, livelihoods and welfare are anticipated. Improved profitability among the smallholder pig farmers are expected to have a feedback effect on management and institutional arrangements factors through informed and improved use of inputs, accessibility of efficient institutional arrangements and alteration of the current management aspects of the farmers.



Source: Modified from Sibiko (2012)

Figure 1: Conceptual framework

→ Direction of influence

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

This chapter covers the techniques and procedures that were used to collect data in the study. These include area of study, research design, sample size, sampling design, data collection procedures, research instruments as well as the data analysis methods. This chapter identifies and justifies the study area selected as well as tools used in the research and analysis.

3.1 Study Area

Tharaka-Nithi County is one of the 47 counties that were formed after the dispensation of the new constitution. It's one of the counties that form part of the Eastern region. The rainfall ranges between 1000 to 1400 mm per annum; with temperatures ranging from a minimum of 11°C to a maximum of 25.9° C. the rainfall pattern is bimodal: the long rains fall between March and June, while the short rains fall between October and December (Jaetzold and Schmidt, 1983). The county covers an area of 2638.8 km².

The agro-ecology of this area is influenced by high altitude of 1500m above sea level, thus part of the county is a highland and thus a conducive environment to rear pigs. Pigs especially large white are affected by heat stress therefore the researcher was motivated to select this area. The area is characterized by complex farming systems with annual and perennial crops, both for cash and food, as well as livestock. The major cash enterprises are tea

and dairy. Farmers rely mainly on rain-fed agriculture and the food crops they farm might be affected by uncertainty of weather conditions. Therefore, it's important if farmers engage in keeping livestock to act as insulators incase crops fail. The smallholder pig farmers in the selected County differ in terms of management factors and institutional arrangements which emanate from farm and farmer characteristics as well as the marketing channels adopted.

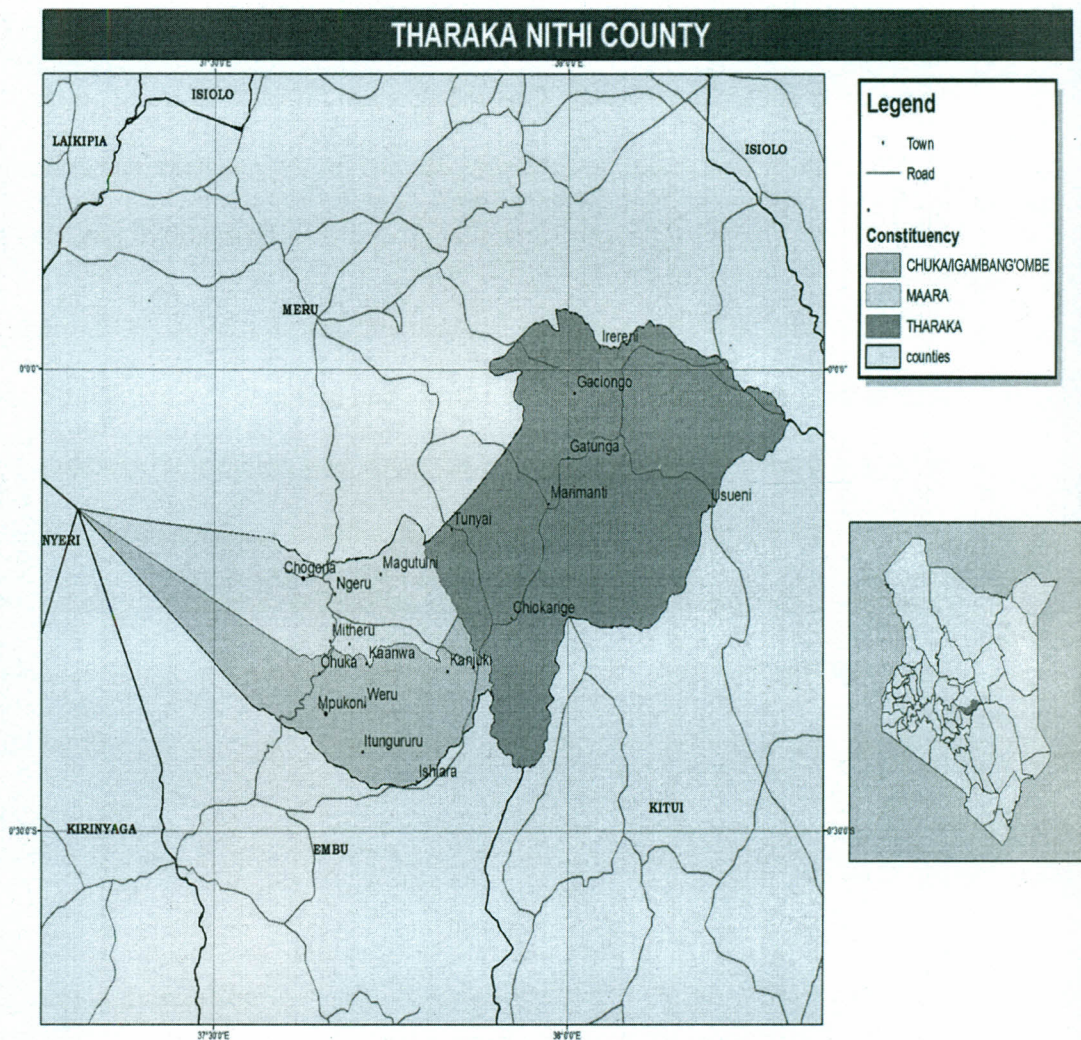


Figure 2: Area of study map-Tharaka-Nithi County

3.2 Research design

According to Orodho (2008) research design is the scheme, outline or plan that is used to generate answers to research problems. A descriptive research design will be used in this study.

Kothari (2005) defines descriptive research as all those studies concerned with specific predictions, narration and characteristics concerning individual groups or situations. Information was collected by administering structured interview schedules to a sample of smallholder pig farmers with the help of enumerators. Interviewing increases reliability of information collected by interview schedules since interviewers are able to get very sensitive and personal information from the respondents through interaction and genuine conversation.

3.3 Target population

Population can be defined as the entire group of individuals, events or objects having common observable characteristics (Mugenda and Mugenda, 2003). In this study the target population of smallholder pig farmers was considered.

3.4 Sample size

Literature has suggested that the sample size which can be taken depends on the type of the research to be undertaken and the study design. Gay in Mugenda

and Mugenda (2003) suggested that for descriptive study ten percentage of the population is enough for the population below 10,000. In this study, the following formula was used to calculate the sample size (Kothari, 2005).

$$n = \frac{Z^2 Pq}{e^2}$$

Where:

n= the desired sample size

q=1-p (1-0.05)

Z= the standard normal deviation at confidence level (95%) which is 1.96

e= Acceptable error (precision)

P= the proportion in the target population estimated to have characteristics being measured which will be 0.05 of the total population. Total population of Maara constituency is 107125, with approximately 5000 smallholder pig farmers. Therefore 0.05 of the population is 5000.

$$\text{Thus sample size} = \frac{(1.96)^2 (0.05) (0.95)}{0.05^2} \quad (22)$$

$$n=73$$

A sample size of 80 farmers was selected from the population of the Smallholder pig farmers in the county. This allowed the researcher to achieve the required sample size in the situation of non-response and spoilt questionnaires.

3.5 Sampling Design

Sampling design enables the researcher to collect data with minimal expenditure of effort, time and money (Orodho, 2008). A two-stage sampling procedure was utilized. This is a technique that requires two successive steps to obtain the required sample. The first stage involved Cluster sampling with Purposive selection of Maara constituency from the three constituencies in the county because of good agro-ecological zone suitable for pig farming. The second stage involved a simple random sampling of 80 smallholder pig farmers.

3.6 Data and Data Collection Instruments

This research used primary and secondary data. Primary data was collected by the use of a semi-structured interview schedule in the sampled farms.

A draft of semi-structured interview schedule was designed and pre-tested in May, 2014 on five households in Chuka division of Chuka-Igambang'ombe constituency. These households were not within the actual survey areas. The purpose of conducting the pre-test was to isolate issues pertaining to clarity, format, wording, sequencing and timing for subsequent revision of the questionnaire. The revisions particularly entailed addition of missing but necessary questions, removal of irrelevant questions and paraphrasing for clarifying the questions that appeared ambiguous to the respondents during the pre-test. After incorporating corrections, the final version of the Interview schedule was produced (Appendix 1).

A team of 4 enumerators who had earlier been trained on interview schedule administration and field survey techniques collected the data through face-to-face interviews between May and June 2014. Household heads, or in their absence, house members responsible for the farm management were interviewed. Data on important variables was collected especially those pertaining institutional arrangements in view of transaction costs, marketing outlet, information access and group membership.

Data related to yields (pork), a unit cost of labor per man day (the family labor expenditure per farm is the wage rate paid to hired labor), input prices such price per kg of commercial and non-commercial feeds, drugs and veterinary costs, searching and contracting costs. Data was also collected on the management factors, that is the farm and farmer characteristics such as age, gender, education level (years of schooling), herd size, breed type and feeding system. Data collected (quantity of pork and output price) were used to compute farm total revenue as $P \times Q$, where P is the price of the output and Q is the quantity produced while the farm level profit (Π) was computed as the difference between the total revenue and total variable cost expended on producing the pork i.e. [Net revenue in (Π) = $PQ - WX$].

Data on important variables was also collected especially those pertaining institutional arrangements in view of transaction costs, trust on market prices and information, marketing outlets, information access and group membership.

Lastly, data on debt obtained amount and asset value of each farm was collected.

Secondary data was obtained from publications and institution such as MoLD, mostly the information was used for literature review and boosting the study discussion.

3.7 Data analysis

Data was analyzed by the use of DEA and STATA version 10. Normality test was done to further check the reliability of the data since estimation of profit efficiency requires the inefficiency effects (u_i) to be stochastic and have a particular distributional specification. It's important to establish whether the inefficiency variable (u) was normal. Inefficiency effect was assumed to be non-negative truncations on $N(0, \sigma_u^2)$ with half normal distribution. A kernel density function was plotted in STATA to assess the correctness of the assumption. A normal curve was superimposed on the kernel density curve to test for normality. The explanatory variables were checked for multicollinearity and heteroscedasticity. Collinearity diagnostics in STATA involved the use of Variance Inflation Factor and tolerance level to check multicollinearity. As a rule of thumb, the variable is said to be highly collinear if the VIF of a variable exceeds 10. The values of the VIF included in the models were less than 10 and it was concluded that multicollinearity was not a serious problem. Presence of heteroscedasticity (non-constant error variance) makes the estimated coefficients to be inefficient and unreliable thus need to test and correct it.

Analysis of variance of the cross sectional data was done to test for heteroscedasticity, then it was subjected to Breusch-pagan/Cook-Weisberg test to establish its reliability. To correct the problem of heteroscedasticity, data was subjected to robust standard error.

3.8 Empirical model Specification

Objective 1 which was to characterize smallholder pig farmers was determined by use of descriptive statistics such as mean and frequencies.

To achieve objective 2 and 3 DEA and Stochastic Frontier Analysis methods were used respectively. Both DEA and Stochastic Frontier Analysis were used since each had its own weaknesses and strengths. There was a trade-off between these two methods of analysis. DEA has the disadvantage of assuming no statistical noise, but has the advantage of being non-parametric and thus requires no assumptions about the production frontier. SCF model on the other hand have the attraction of allowing for statistical noise, but has the disadvantage of being parametric and therefore requiring strong assumptions about the inefficiency term. In both methods however, some non-testable assumptions have to be made. In DEA one assumes no measurement error in output and in SCF one assumes a particular error distribution.

Profit efficiency of the smallholder pig farms in the constituency were established by use of the Data Envelopment Analysis (DEA) since it does not

assume a functional form. Data envelopment analysis compares the levels of outputs and inputs for a given decision making unit (DMU) against all other DMU in the data set to determine which DMU are producing at efficient levels relative to the entire group (Coelli, 1996).

The model included a number of inputs that were considered critical in pig production. The efficient scores provided benchmarks to be used for comparison in the industry. Farmers' net revenue was considered as the farm output while the production and marketing costs were considered as the critical inputs to determine profit efficiency of a farm. The output (net revenue) was got from the total revenue minus total cost. Total revenue was the price of pork multiplied by the quantity of pork while total costs were got from the input costs. The input costs included were feed costs, labor wages, veterinary and drug costs, contacting/search costs and contracting costs which were solved to come up with profit efficiency rankings that showed the best performing farmers.

$$NR = P_q(Q) - x(\text{Feed cost, veterinary and drugs expenses, labor wages, contacting and contracting costs}).$$

Where NR is the Net Revenue of the farmer

p_q is pork price and Q is the quantity of pork per kg

x is a vector of inputs.

This work utilized the constant return to scale (CRS) proposed by Charnes, Cooper and Rhodes (1978) which allows one to represent technology using a unit isoquant. When we have constant returns to scale also, the input and output oriented measures of technical efficiency will be equal. Input orientation refers to how to proportionally reduce the quantity of inputs without changing the output produced.

The quantity of input that is in excess and requires reduction and still obtains the same level of output as before is referred to as the input slack or input excess. The model is developed with the following assumptions; we have an enterprise with K inputs and M outputs and on each of the N farms. This is represented by x_i and y_i respectively. We therefore have a $K \times N$, input matrix, X, and the $M \times N$, output matrix, Y, represent the data of all N farms. DEA develops a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier.

In this case then DEA tries to find an optimal ratio of all the outputs over the inputs and thus the optimal combinations of inputs that will result to optimal profits were determined.

$$\pi^j(Pq, Xc) = \max(\sum_{n=1}^N P_q Q - \sum_{i=1}^N X_c) j=1, \dots, K \quad (23)$$

S.t

$$\sum_{k=1}^K Z^k Q_n^k \geq Q_n, n=1 \dots N \text{ (Outputs)} \quad (24)$$

$$\sum_{k=1}^K Z^k X_i^k \leq X_i \quad i=1, \dots, I \text{ (Variable costs)} \quad (25)$$

$$\sum_{k=1}^K Z^k x_{fi}^k \leq x_{fi}^k \quad f_i = 1, \dots, m \text{ (fixed inputs)} \quad (26)$$

$$\sum_{k=1}^K Z^k = 1 \quad (27)$$

(Whittaker et al, 1995; Jacobs, 2000)

Where;

π^j is total profit of the j^{th} farmer

P_q is the output price

Q is the output quantity

X_{ci} is the i^{th} variable input expenditure

X_{fi} is the i^{th} fixed input expenditure

Vector z = measures input use intensity and serves to form a frontier by connecting linearly "best-practice" farms.

The objective function (23) expresses the optimal return to inputs.

The first set of constraints (24) show the maximum possible output of the farmers.

The second set of constraints (25) expresses the minimum possible variable inputs that can be used. The third set constraint (26) shows the level of fixed inputs that a farmer who is a best performer should not exceed.

The last constraint (i.e., summing Z to one) allows the technology to have increasing, constant, and decreasing returns to scale (Whittaker et al, 1995). Farms will be efficient if Z equals one. In other words a composite unit cannot be constructed which outperforms it. If Z is smaller than one, farm will be inefficient. Hollingsworth and Parkin (1998) concluded that a composite unit provides targets for the inefficient unit and Z represents the maximum inputs a farm should be using to attain at least its current output. This model gave the profitability coefficient rankings for each farm as compared to the 'peers'.

Stochastic Frontier approach was used to establish factors which led to profit inefficiency. Accuracy of data gathered from smallholder pig farmers is sometimes inaccurate since they don't keep up to date records thus accuracy depends on farmers' capability to recall. Also pig production which is attributed to climatic conditions and diseases may lead to inaccurate records. Stochastic frontier method accounts for the random error and the inefficiency component (Jacobs, 2000). 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 Nganga et al (2010).

The factors determining inefficiency were determined by the use of the maximum likelihood Estimation method (MLE) in STATA 10 using the frontier model which is the second stage approach. The maximum likelihood procedure estimated all the parameters and was preferred because its estimates are more consistent as compared to the ordinary least squares estimates (Aigner *et al.*, 1977; Greene, 2008).

Stochastic profit frontier is a statistical technique that generates a stochastic error term and an inefficiency term by using the residuals from an estimated profit frontier. Using STATA, the stochastic profit model used is as shown in equation 22 which is basically input-output transformation and transaction costs model (North, 1990) while equation 20 was the inefficiency model.

The econometric model is typically defined to be:

$$Y_i = x_i\beta + e_i$$

$$Y_i = \beta_0 + \sum_{i=1} \beta_i X_i + V_i - U_i \quad (\text{Cobb-Douglas function}) \quad (28)$$

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i$$

(Translog function) (29)

Y_1 = Normalized profit (net revenue); this is the dependent variable and it is defined as the net revenue per kilogram of output sold.

X_1 = Wage rate (include wage rate for both hired and family labor); 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.

X_2 = Feed cost;

X_3 = Drug/Veterinary costs;

X_4 = Search costs

X_5 = Contracting costs;

X_6 = Herd size

; $B_0, \beta_1, \dots, \beta_6$ = Parameters to be estimated;

U_i = Farmer specific characteristics related to production efficiency/ one sided inefficiency component, which are often assumed to be iid $N| (0, \sigma_u^2) |$ (in other words half-normal distribution). U_i is the degree of inefficiency or the distance from the profit function frontier. Therefore U_i is closely related to the profit inefficiency which may arise from managerial and institutional arrangements slacks.

V_i = statistical disturbance term/ it is caused by stochastic noise. It is normally distributed

The coefficient of the variables x_1, x_2, x_3, x_4, x_5 , and x_6 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 third objective was analyzed using the inefficiency model where profit inefficiency (u) was the dependent variable and the inefficiency factors were the independent variable

The expression of inefficiency is represented below

$$U_i = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 + \delta_6 z_6 + \delta_7 z_7 + \delta_8 z_8 + \delta_9 z_9 + \delta_{10} z_{10} + \delta_{11} z_{11} \quad (29)$$

Where; U_i – the inefficiency of the i th farm; $\delta_0, \dots, \delta_{11}$ = Are parameters to be estimated; z_1 = Group membership; z_2 = Gender of the household head ; z_3 = Breed type of pig; z_4 = market outlet; z_5 = Debt asset ratio; z_6 = Feeding system; z_7 = Level of trust; z_8 = Access to information; z_9 = Debt amount; z_{10} = Age of the farmer and z_{11} = Schooling years of the farmer. 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 (Battese and Corra, 1977). Battese and Coelli (1995) 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 (Kumbhakar and Lovell, 2000; Greene 2008). 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.

The hypothesized relationships for the production, marketing and inefficiency functions were shown in table 1 and 2 below.

Table 1: Description of variables and expected signs

Variables (Xs)	Units of measure	Expected sign
Output (Y)	Kilograms(kg)	
Herd size	Number/kg	+
Pork weight	Kilogram(kg)	+
Feed cost	Feed cost/kg	-
Pork price	Kshs/kg	+/-
Searching cost	Search cost/kg	-
Contracting cost	Contract cost/kg	+
Hired/Family Labor	Person-days per year/kg	+/-
Veterinary and drugs	Kshs per year/kg	+/-

Table 2: Description of the inefficiency variables (Zs) and the expected signs

Variable (Zs)	Units of measure	Expected sign to PE
Profit inefficiency (u)	0 – 1	
Gender	1=Male 0=Otherwise	+/-
Age	Years	+/-
Education level	Years	+/-
Feeding system	1=Penning 2=Stall feeding	+/-

Breed type	1=Cross breed 2=Large white 3=Hampshire 4=Landrace	+/-
Group membership	1=Yes 0=Otherwise	+/-
Level of trust	1=Yes 0=Otherwise	+/-
Access to information	1=Access 0=Otherwise	+/-
Market outlet	1=Consumer 2=Trader	+/-
Debt amount	Kshs/Year	-
Debt asset ratio	Ratio	+

Source: Survey data, 2014

The resulting coefficients will have either positive or negative signs which indicate the effect of the variable on efficiency. A positive sign indicates that the presence of the variable has an increasing effect on inefficiency while a negative sign indicates a reducing effect on inefficiency. All the hypothesized variables were run in the model

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter discusses the empirical findings of this work. The chapter starts with unveiling the characteristics of the pig farmers in Maara Constituency which is followed by DEA profit efficiency rankings calculations which gives the efficiency level of the farms. Then the frontier model is used to determine the factors that influence inefficiency; where the second part of maximum likelihood estimation for factors affecting inefficiency is done.

4.1 Descriptive Results

4.1.1 Production, management and institutional characteristics of smallholder pig farmers in Maara Constituency

The average pig weight was 100kg while the standard deviation 13. The output had large standard deviation which showed that the production was variable and not evenly distributed. This variation in production in the farms may be attributed to the difference in breeds, feeding system and the herd size. An average of Kshs 304 per kg of pork was recorded and the mean net revenue was found to be 24215 and a standard deviation of Kshs. 41594.

Table 3: Summary statistics of the descriptive variables (n=80).

Variable	Minimum	Maximum	Mean	Std. Deviation.
Net revenue	200	300000	24215	41594
pork price(Kshs/kg)	250	360	304	51
Pig weight(kg)	80	150	100	13

Herd size (number)	2	16	4	2
Feed costs(kshs)	5400	264000	44859	43674
Labour wages(person-days/yr)	14400	14400	14400	0
Search costs(kshs)	300	4600	1534	585
Contract costs (kshs)	350	5000	1503	514
Drug/Veterinary costs(kshs)	700	6000	1684	791
Age of the household head(yrs)	24	76	44	12
Education level (sch yrs)	2	17	10	4
Debt amount	5000	510000	118855	127616
Farm Assets	351500	10100000	1627123	1542138

Source: Survey data, 2014

The farmer characteristics that are hypothesized influence management practices include; age, education level, experience, gender and types of breed selected. The mean age of pig farmers was 44 years which indicate that many of the farmers were fairly aged. This is the average approximate age in years of the respondents at the time of questionnaire administration.

The mean education level was found to be 10 years of schooling, thus considered as farmers having basic education therefore they are literate. The lowest education level was found to be 2 years of schooling.

The average herd size is 4 pigs with 2 and 16 being minimum and maximum respectively; meaning pig enterprise in Maara Constituency was done mainly by small holder farmers. Smallholder pig farmers claimed that feeds were expensive therefore they were not willing to expand their herd size. This is consistent with the findings of Deka et al (2007) where he found out that farmers complained of feed constraints as the main reason for households not increasing their herd size due to lack financial assistance from the government or NGOs to procure the feeds or household to produce additional feeds for the pigs.

The average asset base of smallholder pig farmer was Kshs 1,627,123. Assets included structure and buildings, farm implements used in pork production, land, herd size and chuff cutters. Farmers had an average mean debt amount of Kshs 118,855.

4.1.2 Gender

Many studies have showed that many of the people who control resources in the household are male, thus they are the ones who are involved in farm

business decision making. The women however are involved in pig management by feeding; this is consistent with the findings of Mutua et al (2010). It follows that the bulk of the labor of taking care of the small livestock falls on the shoulder of women who culturally are expected to take care of the homestead.

Table 4: Percentage frequency of gender

Gender	Frequency	Percentage
Man	60	75%
Woman	20	25%
Total	80	100

Source: Survey data, 2014

The results show that 75% of the sampled farmers were men while 25% were women, therefore level of women participation can be seen to be low.

4.1.3 Herd details

Farmers have higher preference for large white to other breeds which is at 61%. Crossbreeds accounted for 34%, Hampshire at 4% while landrace was 1%.

Table 5: Pig Breed details

Type of pig breed	Frequency	Percentage
Cross breeds	27	33.75

Hampshire	3	3.75
Landrace	1	1.25
Large white	49	61.25
Total	80	100

Source: Survey data, 2014

Farmers have higher preference for large white to other breeds which is at 61%. Crossbreeds accounted for 34%, Hampshire at 4% while landrace was 1%.

4.1.3 Feeding system

Smallholder pig farmers mostly practice two types of feeding system in Maara constituency: penning and stall-feeding as shown by table 6.

Table 6: Percentage frequency of feeding system

Feeding system	Frequency	Percentage
Penning	54	68
Stall feeding	26	32
Total	80	100

Source: Survey data, 2014

The results indicate that penning dominate pig production with 68% while stall-feeding (in which pigs are kept in a mostly permanent structure and feeding includes some purchased concentrates) was 32%.

4.1.4 Marketing

The results from table 7 below indicate that 60% of the farmers sold their pork to traders while 40% sold to local consumers (neighbors).

Table 7: Market outlet percentage

Market Outlet	Frequency	Percentage	Pig price (mean)
Local consumer	32	40	353
Trader	48	60	271
Total	80	100	

Source: Survey data, 2014

The main reason smallholder farmers kept pig was to meet emergency costs therefore they desperately searched for traders to buy their pigs however, traders offered them exploitative prices. Smallholder farmers therefore made very dismal profits.

Farmers who sold their pork directly to local consumers couldn't sell all pork at once although price was higher. They incurred a lot of search and contracting costs leading to low profits. Smallholder farmers neither sold their pork through processors nor cooperatives. The results in table 7 show that the best average price of pork per kg is offered by the local consumer which is at Kshs 353 while the traders offered an average price of kshs 271 per kg.

4.1.5 Farmers trust on market

The results on table 7 indicate that smallholder farmers received better prices when they sold their pork directly to local consumers as compared to when they sold to traders. Smallholder pig farmers therefore had low level of trust on trader's price compared to the price they received from local consumers. Lack of trust can lead to increase of transaction costs due to switch costs. More also, traders estimate the weight of a pig, thus making farmers to mistrust them due to poor standards of measurement. Level of trust is key in making institutional arrangements and it's related to the duration of relationships and the degree of openness with which the partners exchange information. High level of trust between businesses partners in the marketing channel, the better are the conditions of good business performance ((KIT, Faida MaLi and IIRR, 2006).

4.1.6 Information access

Poor access to appropriate and timely market information is one of the constraints which pork markets face. The lack of market information especially by the smallholder farmers represents a significant impediment to market access. Results on table 10 reveal that lack of access to information will lead to high transaction costs and reduce net revenue eventually lowering profit efficiency. This is consistence with the findings of Mwale (1998) where he concluded that smallholder farmers obtain low income due to high transaction costs which result from information asymmetry.

Table 8: Frequency on information access

Access Information	Frequency	Percentage	Net Revenue (Mean)
Yes	25	31	112,128
No	55	68	30,536

Source: Survey data, 2014

The results from the table indicate that 55% of the smallholder farmers had no access to information concerning pig prices and markets while 25% had access. Smallholder pig farmers who had access to information obtained high mean net revenue of Kshs 112,128 compared to those who had no access to information.

4.1.7 Group Membership

Farmers in groups benefited from those groups by getting trainings, access to credit and market information. Therefore, they can function as important catalysts for innovation adoption and upgrading of production systems through promoting efficient information flows.

Farmer organizations and similar form of collective action are avenues to achieving the necessary economies of scale and thus reduce information asymmetries and build up countervailing market power and this is consistent with work of Mark elova et al (2009).

Table 9: Group membership details

Group Membership	Frequency	Percentage
No	47	59
Yes	33	41
Total	80	100

Source: Survey data, 2014

Farmers who are members of group are associated with higher adoption rates of technology and they follow management practices as recommended by extension workers and or other trainers. The results reveal that 59% of the smallholder pig farmers had not joined group, with 41% only in groups.

4.2 Empirical results

4.2.1 Validation tests

4.2.1.1 Multicollinearity test

Explanatory variables were checked for multicollinearity using a technique of Variance Inflation Factor (VIF) and tolerance level (Gujarati, 1995). Each explanatory variable was regressed on all other explanatory variables. The larger the value of VIF, the more collinear is the variable. If the VIF of a variable exceeds 10 and R^2 0.90 the variable is said to be highly collinear. The results (annex 7) showed that the VIF values for the explanatory variables included in the model were less than 10 and tolerance level ($1/VIF$) was more

than 0.1 and therefore it was concluded that there was no serious problem of multicollinearity.

4.2.1.2 Heteroscedasticity test

Heteroscedasticity was tested using the Breusch-pagan/Cook-Weisberg test and low levels were found since the overall chi-square value was 31.55 and significant at 10% significance level and different from zero (0.0171). The established presence of heteroscedasticity in the cross-sectional data required correction through use of robust standard error..

4.2.1.3 Normality test

A kernel density function plotted in STATA assessed the correctness of the normality assumption as shown in Annex 9. A normal curve was superimposed on the kernel density curve to test for normality. The normality test figure in annex 9 confirms that u had a fairly normal distribution. Therefore, profit efficiency estimation in the study was made possible.

4.3 Profit Efficiency of the pig Farmers

DEA model was used to calculate profit efficiency levels of smallholder pig farms that is efficiency rankings of the farms to achieve the second objective. DEA model was run with factors of production and marketing costs as inputs and the farm profits as the output to give us the profit efficiency rankings of the farms.

Table 10: Smallholder pig farms profit efficiency levels (P.E)

Farm	P.E	23	0.529	46	0.253	69	0.380
1	0.597	24	0.278	47	0.545	70	0.377
2	0.593	25	0.186	48	1.000	71	0.549
3	0.121	26	0.247	49	0.372	72	0.692
4	0.440	27	0.840	50	0.431	73	0.290
5	0.413	28	0.253	51	0.207	74	0.499
6	0.601	29	0.398	52	1.000	75	0.111
7	0.538	30	0.789	53	0.115	76	1.000
8	0.028	31	0.130	54	0.133	77	0.397
9	0.792	32	0.552	55	0.141	78	0.596
10	0.899	33	0.096	56	0.300	79	0.949
11	0.524	34	0.392	57	0.279	80	0.521
12	0.344	35	0.205	58	0.420		
13	0.193	36	0.100	59	0.187	Mean	0.402
14	0.323	37	0.101	60	1.000		
15	0.382	38	0.876	61	0.500		
16	1.000	39	0.151	62	0.387		
17	0.395	40	0.232	63	0.189		
18	0.094	41	0.127	64	0.373		
19	0.301	42	0.399	65	0.302		
20	0.167	43	0.138	66	0.541		
21	0.385	44	0.108	67	0.117		
22	0.307	45	0.172	68	0.267		

The results of DEA software revealed that the average efficiency to be 40%.

Showing that, most farmers had low ranking when compared to each other.

Relative efficiency ranges between zero and one ($0 \leq \theta \leq 1$). Optimal efficient is

one, while their input and output slacks equals zero (Cooper, Seiford and Tone, 2006).

Three farms had profit efficiency score of 1 thus they were efficient while the rest were inefficient. The most inefficient farm had inefficiency level of 0.005, thus had to reduce input costs by 99.5% in order to acquire its target value. Target value refers to the value that is generated as target which would take the farm to the efficient level. Therefore farmers had a chance of increasing profitability by 60% through reducing input excesses so as to reduce their costs. Farmers therefore need to reduce the amount of inputs quantities used while maintaining their output (Coelli, 1996). This shows that pig farmers still haven't reached optimal level of profitability.

The DEA method of analyzing this data was input orientated. The results showed how the farms would proportionally reduce the quantity of inputs used without changing the output produced to ensure the farms become profit efficient. Input slacks/ excess after analysis showed the amount of input quantity that can be reduced and still obtain the same level of output as before as the farm efficiency level moves up the rank.

The results of input slacks are presented in table 11. The average input slack value was found to be Kshs 1208 for each farm. The results reveal that each

smallholder pig farmer had a chance of reducing input costs by this amount per year without compromising their profit levels. This would make them to move up the profit efficiency ranks.

Table 11: Input slack results

Input slacks	Average slacks per farm
Feed costs	461
Searching costs	355
Contracting costs	323
Labour costs	4824
Veterinary and drugs costs	79
Average input slacks	1208

Feed costs was found to be the highest cost a farmer incurred but with a slack value of 461. Labor slack value was the highest amounting to 4824. It means that the farmers have a chance of reducing costs of this amount per year on labor wages and still produce the same quantity of output. Search and contracting costs had slack values of 355 and 323 respectively. Lastly, drugs and veterinary costs had a slack value of 79.

4.4 Factors influencing profit efficiency

To achieve the third objective of finding out the factors influencing profit efficiency the second stage of the stochastic frontier model was run. The frontier model was found significant in explaining the inefficiency factors. This was because the wald chi was found to be significant at 99% confidence level. This shows that the parameters of interest are not equal to zero [$\chi^2(13) = 66.70$], thus based on p-value ($\text{prob} > \chi^2 = 0.0000$), we are able to reject the null hypothesis. Therefore including these variables created a statistically significant improvement in the fit of the model.

Gamma estimate was 0.63 which is significant. This implies that 63% of the difference between the observed and maximum production frontier output were due to differences in farmer's level of profit inefficiency and not related to random variability. It means inefficiency effects dominate the random noise in explaining profit per unit of output across farms. Therefore these variations in farms' profits were caused by management and institutional arrangements factors of the farmer.

4.4.1 Profit inefficiency

The resulting coefficients had either positive or negative signs which indicated the effect of the variable on inefficiency. A positive sign indicates that the presence of the variable has an increasing effect on inefficiency while a negative sign indicates a reducing effect on inefficiency. All the hypothesized variables were included in the model.

Table 12: Stochastic profit frontier results

Inefficiency Model	Parameter	Est. Coefficient	P-value
Gender	δ_1	-4.130	0.075*
Education level	δ_2	-1.060	0.007**
Age	δ_3	3.550	0.000***
Feeding system	δ_4	-5.950	0.393
Pig breed type	δ_5	4.310	0.000***
Group Membership	δ_6	-2.910	0.419
Market Outlet	δ_7	2.780	0.000***
Level of trust (price)	δ_8	-6.030	0.000***
Information access	δ_9	-4.370	0.527
Debt asset ratio	δ_{10}	4.860	0.000***
Diagnostic Statistics			
Sigma2	δ_2	4.320***	
Sigma S	$\sigma_u + \sigma_v$	2.840	
Sigma-v	δ_v	1.040	
Sigma-u	δ_u	1.800*	

Lambda= λ	σ_u/σ_v	1.730***	
Gamma = γ	σ_u/σ_s	0.630***	

Source: Computed from MLE result/Survey data, 2014.

*Significant at 10% S.L, **significant at 5% S.L, ***significant at 1% S.L

Wald $\chi^2(10) = 66.70$

Prob> $\chi^2 = 0.0000$

Log

likelihood = 1144

Sigma-u=0: LR output is $\text{Chibar2}(01) = 1.92$ P value is Prob>= $\text{chibar2} = 0.083$

Formal education which was measured in years of schooling had a negative coefficient of -1.06, thus reduced profit inefficiency meaning it increased profit efficiency of the farms. This is consistent with the findings of Kadurumba et al., (2014) who found a statistically significant correlation between level of education and economic efficiency. The results indicate that the farmers with some form of formal education exhibit higher levels of profit efficiency in the study area.

A positive and statistically significant relationship was found between age of the farmer and profit inefficiency. Indicating that old tend to exhibit higher levels of profit inefficiency which is completely different from what is expected and this is consistent with the findings of Nganga et al., (2010).

Gender was found to affect profitability. It was influencing profit inefficiency negatively thus increasing profit efficiency. A large number of farms were

managed by men but in the real sense women did all the tasks. Men were the decision makers of farm activities; women were involved in day to day activities of the farm like feeding the animals. They are also not included in making important farm decision that influence profits like breed selection and acquisition of credit. This concurs with Mutua et al., (2010) where she found that women were not allowed to make decisions concerning pig management. Empowering women to make decisions would increase pig farms profit efficiencies more.

The negative and significant coefficient of the level of trust variable indicates that the higher the level of trust for the farmer reduces profit inefficiency. A positive and statistically significant relationship was found between pig farm debt asset ratio and profit inefficiency. This indicates that debt asset ratio tend to exhibit higher levels of profit inefficiency. This finding is consistent with findings of Hadley et al (2002). The higher the ratio the higher the liabilities of the farm compared to its assets. There is need for farms to have a good balance between assets and liabilities. Farms with high debt ratio are said to be highly leveraged, that is could be in danger if creditors start to demand repayment of debt. The results show that a 1% increase in debt asset ratio profit efficiency reduces by 4.86%.

The Market outlet had a positive coefficient which was statistically significant at 99% confidence level. The type of channel a farmer adopted to sell his pork was dependent on the accessibility of information on prices and market as well as on the level trust of this information.

It can be seen from the results that a positive and statistically coefficient of breed type indicates a reduced profit efficiency of the farms. 61% of farms reared large white because of its wide availability while 33% had crossbreeds. Farmers who reared large white pigs increased profit inefficiency by 4.31% as compared to those who kept crossbreeds. Many farmers keep large white since it was found to have desirable growth potential and high fecundity.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The aim of this study was to evaluate the factors influencing profit efficiency of smallholder pig farmers in Tharaka-Nithi County. The specific objectives of the study were to identify the management and institutional arrangement attributes of the smallholder pig farmer in Tharaka-Nithi County and then rank farmers based on their profit efficiencies and finally determine the factors that affect profit efficiency of small holder pig farming and their extent. Descriptive statistics was used to identify the management and institutional arrangement attributes of smallholder pig farmers in the County. DEA model gave profit efficiency levels of the farms and input slacks were given for each farm. Second stage of the stochastic profit frontier was used to determine the factors that affect profit efficiency and their extent.

The results showed that male farmers dominated pig farming in this area; the average education of the farmers was high school level. Most of the farmers kept large white with each farm having an average of 4 pigs. Despite Stall feeding being practiced; Penning was the most common. In marketing the most common market outlet was through a trader and most farmers never accessed information.

Age, debt asset ratio, pig breed type and market outlet were found to influence profit inefficiency positively. This means these factors increase profit inefficiency of the farmers. On the other hand level of trust for the farmer, access to information, gender, feeding system, group membership and schooling years influenced profit inefficiency negatively. This means that these factors have the effect of reducing profit inefficiency of the farms.

5.2 Conclusion

This study aimed at determining how profit efficiency of the Smallholder pig farmers is influenced by herd management and institutional arrangement attributes both at the farm and market level. The DEA results determined efficient and inefficient pig farms with respect to five variable costs (Feed, labor, search, contract and drugs/veterinary). This technique helped to determine which farms had the best practices and also provided helpful insights for farm management. This concurs with the findings of Hiedari et al., (2011) where the DEA helped them to segregate efficient from inefficient farmers.

The DEA results showed that farms' efficiency level averaged 40% indicating that the farms can potentially increase their profits by 60%, by reallocating inputs. This means that the total input cost could be reduced by 60% without reducing the income from its present level (Hiedari et al, 2011). This is consistent with the findings of Kadurumba et al, (2014) who concluded that the

prices of pig farming inputs and marketing costs can have a major influence in pig farming profitability. According to Hiedari et al (2011) an efficiency score of a farmer less than one indicates that he is using more input than required and therefore it will be helpful to avert wastage of input without reducing the output level.

Stochastic frontier analysis revealed a number of factors that influence profit efficiency. The type of breeds which farmers kept was found to be an important factor influencing pig farming profit efficiency. In Maara constituency, it was found out that majority of the farmers kept large white (61%) and other breeds were not very popular. Only 1% of the farmers kept landrace and this is because of its high fat content. Though Hampshire breed provide leanest meat with fast growth rate it was kept by 4% of the farmers and this was because it was not easily available as well A.I services.

The type of market outlet a farmer preferred was found to be important in influencing pig farming profitability. The scenario on Maara constituency revealed that majority of the farmers sold their pigs to local traders (60%) who exploited them. Farmers who sold their pork to local consumers (40%) obtained higher prices but they incurred more transaction costs and also faced market uncertainty thus reducing the profit levels of the farm.

The gender of the pig farm decision maker also had an influence on profit efficiency. From the area of study most farmers were men (75%). Women farmers were found to be good pig managers (Mutua et al, 2010). Women Farmers made pig farms to reduce profit inefficiency, thus it's important to allow women to make decisions in pig enterprise.

Marketing of pig is important in determining profitability of the pig business. The study has showed that trust within pig value chain is crucial in influencing profitability. Pig value chain is dominated by informal marketing channels. Pig marketing channel in the study area was found to be simple, but there were a number of constraints to efficient functioning of the market arising from lack of market and price information. These constraints increased transaction costs. The trusts on price and market information as well as access in market information were found to influence farmer's profitability. Therefore they can help improve farmers' confidence on where they market their pigs.

The debt asset ratio was also an important factor which should be considered by farmers. The higher the ratio indicates the farm business uses more borrowed funds to finance it business compared to owns equity thus insolvency might occur. Higher debt asset ratio might also hinder the farm from obtaining more credit.

5.3 Recommendations

The pig farming business profitability has been found to be influenced by farm characteristics and marketing arrangements. To start with, Ministry of Livestock Development and NGOs should come up with plans and strategies which will help improve productivity through benchmarking. The best practice of best-performers (efficient farms) should be adopted by poor-performers (inefficient farms) in-order to enhance their performance. The study has shown that the breed of the pig influenced profit level of the farm. Farmers should be advised by the experts to keep breeds that balance cost of production and yield especially cross breeds. Thus farmers should be provided with several pig breeds which will encourage cross breeding and also adoption of artificial insemination services. Availability of more pig breeds and encouraging of cross breeding is necessary in encouraging pig farm productivity and hence more returns.

Based on the findings of this study, an effort to emphasize primary schooling will have a positive impact on the PE in smallholder pig farming. The farmers should be trained on basic finance management skills like the optimal level of debt-asset ratio and debt utilization. This should involve advice on the level of debt that is healthy to their businesses.

The study has shown that most pig farms were headed by men and thus more efficient than female-headed households. From the results, 25% of pig farms were headed by women. Despite this substantial role, women have less access to land than men. Rural women also have less access to credit than men, which limits their ability to purchase better breeds, quality feeds and other inputs to adopt new farming techniques. Most of the studies showed that women took lead in farm management (handled almost 80 percent of the work) since men were rarely at home, but were rarely involved in decision making processes.

5.4 Suggestions for further research

There are a number of directions in which this study can be extended. This study only focused on the profit efficiency of smallholder pig farmers. An extension could be used to analyze large scale pig farms. In redesigning the above possible studies, capturing the effects of farm extension services and records keeping could be considered.

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APPENDICES

Annex1: QUESTIONNAIRE

Identification

- i. Ward ----- Village -----

- ii. Name of Enumerator -----Farmer's Name -----

- iii. Date -----Starting time ----- Ending time -----

1. Pig Production for the last one year

Breed type	Management system	Number of pigs sold	Market outlet	Weight of pig at disposal (kg)	Price per unit measured (kshs)	Amount received (kshs)
Large white						
Landrace						
Cross breeds						
Hampshire						

Management system: 1. Stall feeding 2. Penning/Tethering

Market outlet: 1. Trader 2. Local consumer

2. Pig Details for the last one year

Breed type	Number of pigs at the beginning of one year	Number of pigs purchased within one year	Number of pigs dead within one year	Number of pigs sold within one year	Number of pigs at the end of one year
Large white					
Landrace					
Crossbreeds					
Hampshire					

3. Animal breeding

i. Has any inbreeding occurred in your pig enterprise? 1. Yes 2. No

If yes does it affect the live weight of pigs at the age of six months?

.....

4. Institutional arrangements

Type of institutional arrangement	Tick	Costs involved	Unit costs	Total costs
Spot market				
contract				
Farmer organization				

Costs: 1. Customer search 2.Bargaining /Negotiation 3. Others (specify)

5. Market Information for the last one year

A. Do you have access to market and price information?

1. Yes 2. No

B. If yes, fill the table below.

Type of Information	Source	Cost Involved (type)	Amount
Price			
Quality			
Market availability			

Source: 1.Neighbours/ Farmers/ Traders 2. Newspaper/Mobile phone3. Government4.None5.Other (Specify-----)

Cost of information: 1. Calling costs 2. buying information, 3. Subscription 4. Opportunity cost of time

6. Buyers

Buyer	Unit of measurement	No. of Units	Price per unit	Trust (information)	Trust (price)	Time spent to reach buyer	Opportunity cost of time spent	Cost involved in sale
Local consumer								
Trader								

Level of trust: 1. highly trusted 2. Trusted 3. Mistrusted

7. Do you take your pig(s) to slaughter house? 1. Yes 2. No

If yes, what is the distance to the slaughter house in Kms -----?

What is the total slaughter costs incurred? -----

If No, is your pig purchased at farm level? 1. Yes 2. No

If No, how much cost due you incurs to transport pig to the market? -----

8. Groups

i. Do you have membership in any group? 1. Yes 2. No

If yes fill the below table

Type of Group	Tick
Pig Group	
Self help Group	
Cooperative	
None	

ii. What are the benefits derived from the group? Tick

1. Pig marketing

1 Input procurement

2 Market information

3 Security for Credit

- 4 Training
- 5 Veterinary Services
7. Others (Specify)

9. Farm Expenditure in pig enterprise

Cost item		Units per month	Cost per unit	Total cost (in case it is not possible to break-down the costs)
Forages and root tubers				
Commercial Feed	1. Commercial concentrate feed			
	2. Mineral Supplement			
	3. others			
Hired Labour				
Family Labour				
Veterinary services				
Water				
AI Services				
Transportation of feeds cost				
Deworming				

10. Assets

Type of asset	No of units	Unit price	Total
Land			
Pigs			
Vehicles			
Structure and building			
Wheelbarrow			
Pangas and Jembes			
Chuff cutter			

11. Credit

- i. Do you use credit in your farm? _____ (1=yes, 0=No)
If yes answer the questions below.
- ii. Last year (2013) how much credit did u have? _____
- iii. Have you finished paying? _____ (yes, no)

12. Background information

- i. Who is the head of household _____ sex (man/ woman)

Age _____

- ii. Number of Schooling years _____
- iii. For how many years have you been doing pig farming ____

-The end-

ANNEX 2: RESULTS FROM DEAP VERSION 2.1

Instruction file = pigmaara-ins. txt : Data file = pigmaara-dta.txt

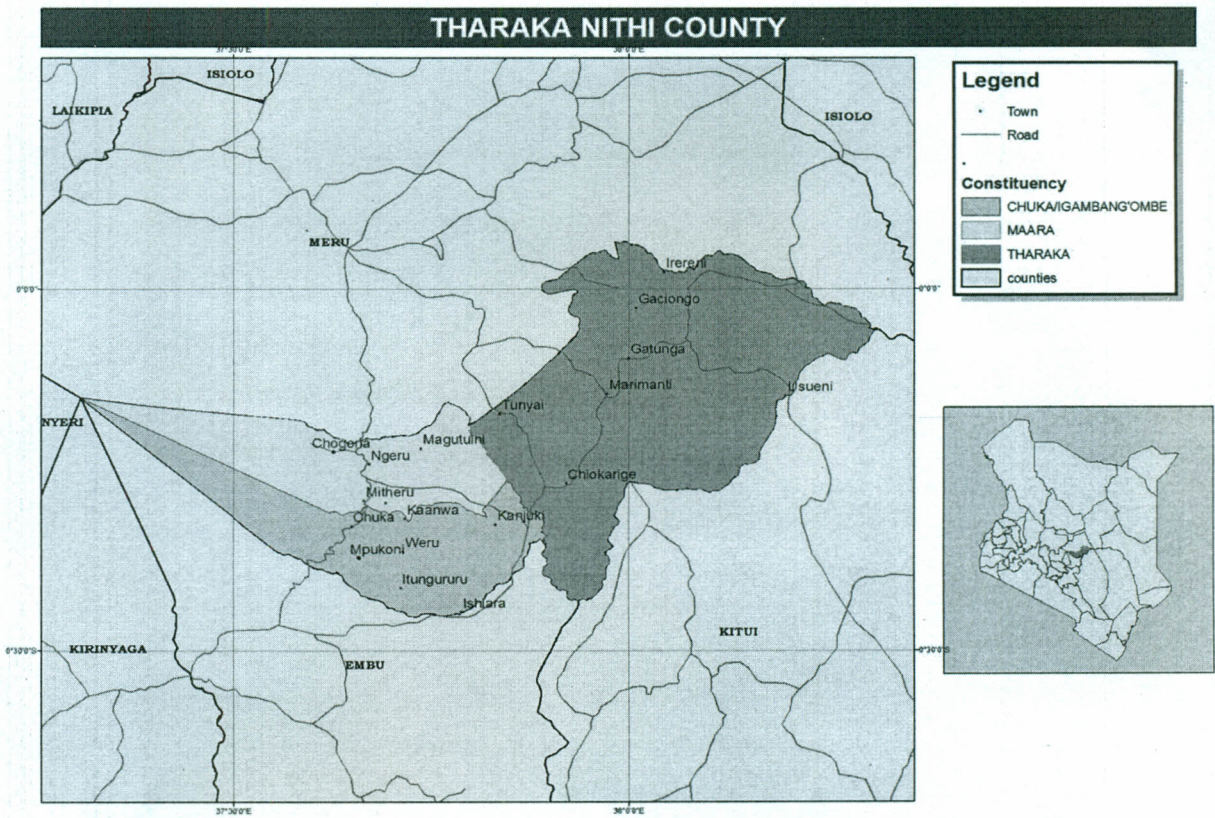
Input orientated DEA, Scale assumption: CRS;

Table12: Individual profit efficiency of smallholder pig farmers in Tharaka-Nithi County.

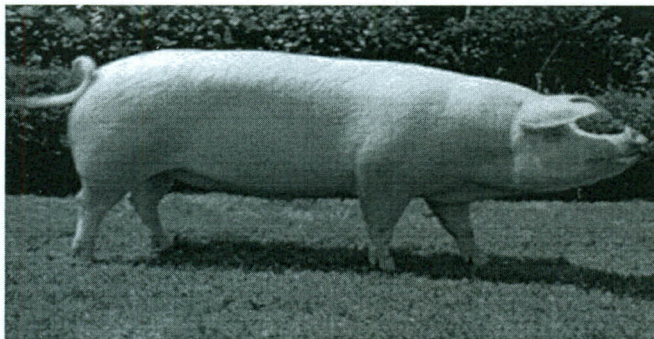
Farm	P.E	23 0.529	46 0.253	69 0.380
1	0.597	24 0.278	47 0.545	70 0.377
2	0.593	25 0.186	48 1.000	71 0.549
3	0.121	26 0.247	49 0.372	72 0.692
4	0.440	27 0.840	50 0.431	73 0.290
5	0.413	28 0.253	51 0.207	74 0.499
6	0.601	29 0.398	52 1.000	75 0.111
7	0.538	30 0.789	53 0.115	76 1.000
8	0.028	31 0.130	54 0.133	77 0.397
9	0.792	32 0.552	55 0.141	78 0.596
10	0.899	33 0.096	56 0.300	79 0.949
11	0.524	34 0.392	57 0.279	80 0.521
12	0.344	35 0.205	58 0.420	
13	0.193	36 0.100	59 0.187	Mean 0.402
14	0.323	37 0.101	60 1.000	
15	0.382	38 0.876	61 0.500	
16	1.000	39 0.151	62 0.387	
17	0.395	40 0.232	63 0.189	
18	0.094	41 0.127	64 0.373	
19	0.301	42 0.399	65 0.302	
20	0.167	43 0.138	66 0.541	
21	0.385	44 0.108	67 0.117	
22	0.307	45 0.172	68 0.267	

ANNEX 3: THARAKA-NITHI COUNTY MAP

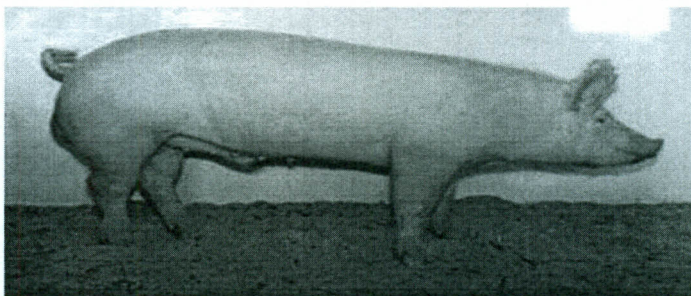
Figure 2: Tharaka-Nithi County Map



ANNEX 4: PIG BREEDS



Large white



Landrace



Hampshire

ANNEX 5: SUMMARY OF PROFIT EFFICIENCY LITERATURE

Table 13: Summary of Profit Efficiency literature

Authors and year	Study title	Objectives	Analytical method	Main findings Mean PE (%)	Variables influencing PE
Abdulai & Huffman, 1998	Profit inefficiency among farmers in Northern Ghana	To estimate profit inefficiency of rice farmers	Stochastic profit function	Not calculated	Level of education(+)
Rahman, 2003	Profit efficiency for Bangladesh rice farmers	To examine the profit efficiency of rice farmers To determine the profit efficiency of rice farmers	Stochastic profit frontier	60%	Access to input(+), unfavorable tenancy arrangement(-)
Ogundari, 2006	Determinants of profit efficiency among small scale rice farmers in Nigeria	To derive a statistical measure of profit efficiency of small scale up-land rice.	Stochastic profit function	60%	Age(+), Education level(+), Farm experience(+) and household size(+)
Hyuha, 2006	Profit efficiency among rice producers in Eastern and Northern Uganda	To examine the profit efficiency of rice producers To identify the factors influencing profit efficiency in rice production	Normalized stochastic translog function	66%	Family labor cost(-), area under rice(+) and capital(+)

Costales, 2006	Scale and access Issues Affecting smallholder hog producers in an expanding peri-urban market, Southern Luzon, Philippines	To identify factors influencing the level of farm-specific relative profit inefficiency	Stochastic profit frontier regression	Small farms- 68% Large farms- 64%	Access to quality food(-), Number of veterinary visits(-), Market outlet(-)
Nganga, 2010	Profit efficiency among Kenyan smallholder s milk producers in Meru-South District	To estimate the economic efficiency of smallholder milk producers in Kenya To analyze the profit efficiency among sampled farmers. To identify farm specific characteriti cs that explain variation in profit efficiency	Stochastic profit frontier and inefficienc y model	60%	Education level(+), experience(+), Si ze of the farm (+) and age(-)
Ogunniyi, 2011	Profit efficiency among maize producers in Oyo state, Nigeria.	Measure profit efficiency among maize producers in Oyo state, Nigeria. To	Stochastic translog profit functional form	41.4%	Education (-), extension contact (-), experience(-) and non-farm employment(+)

Maganga, 2012	Unexploited profit among smallholder farmers in Central Malawi	determine factors that explain profit inefficiency To measure the profit efficiency of sample Irish potato farms Explore determinants of profit inefficiency in Dedza district of Malawi	Stochastic profit translog frontier analysis.	74%	Age(+), non-farm employment(-), education(-), extension visits(-), credit status(-), farm experience(-), degree of specialization(-) and frequency of weeding(-)
Kadurumba, 2014	Measure economic efficiency of production for pig enterprise in Ebonyi state, Nigeria	To estimate the economic efficiency level. Identify factors determining efficiency levels in pig production.	Stochastic profit function	75%	Age(+), level of education(+), farm size(+), extension contact(+) and household size(+).

ANNEX 6: SECONDARY DATA SOURCES

Table 14: Secondary Data Sources

Data	Source
Ministry of Livestock Validated report 2011	MoLD
County Statistics	Kenya Open Data
Journal publication	Online
National pig Development strategy 2012	
Pig sector review in Kenya(FAO) 2012	

ANNEX 7: VARIANCE INFLATION FACTORS (VIF)

Table 15: Variance Inflation Factors

Variable	Factor Collinearity Statistics	
	Tolerance (1/VIF)	VIF
Labor wage/kg	0.114	8.72
Vet/drugs costs/kg	0.169	5.90
Search costs/kg	0.255	3.91
Feed costs/kg	0.352	2.84
Herd size	0.355	2.81
Age of household head	0.672	1.49
Schooling years	0.852	1.17
Feeding system	0.359	2.78
Gender	0.427	2.34
Breed type of the pigs	0.452	2.21
Level of trust	0.252	3.96
Type of Market outlet used	0.583	1.71
Group membership in associations	0.900	1.11
Debt asset ratio	0.802	1.25
Mean VIF		3.01

ANNEX 8: STOCHASTIC FRONTIER PROFIT FUNCTION RESULTS.

Table 16: Stochastic Frontier Profit Function Results

Variable (ln)	Estimated Coefficient	P-Value
Feed costs/kg	-0.884	0.000***
search costs/kg	-0.063	0.613
Contracting costs/kg	0.130	0.308
Labor wages/kg	-0.376	0.112
Veterinary and drugs costs/kg	0.078	0.770
Herd size	0.121	0.434
Constant	10.302	0.025*
Inefficiency Model		
Gender	-4.130	0.075*
Education level	-1.060	0.007**
Age	3.550	0.000***
Feeding system	-5.950	0.393
Pig breed type	4.310	0.000
Group Membership	-2.910	0.419
Market Outlet	2.780	0.000***
Level of trust	-6.030	0.000***
Information access	-4.370	0.527
Debt asset ratio	4.860	0.000***
Constant	0.000	0.000***
Diagnostic Statistics		
Sigma2 (δ^2)	4.320	
Sigma S ($\sigma^2u + \sigma^2v$)	2.840	

Sigma-v (δv)	1.040
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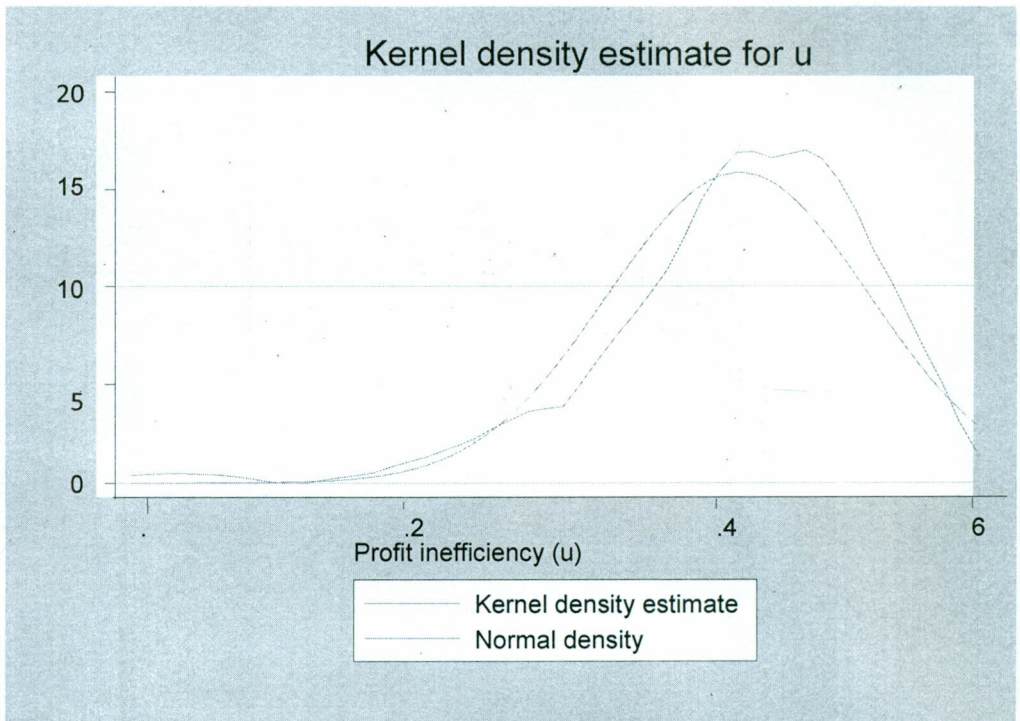
Sigma-u(δu)	1.800
-----------------------	-------

Lambda= $\lambda = (\sigma^2 u / \sigma^2 v)$	1.730
---	-------

Gamma = $\gamma = (\sigma u / \sigma s)$	0.630
--	-------

ANNEX 9: NORMALITY TEST

Normality test



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