

**GENDER ANALYSIS OF GROSS MARGIN AND TECHNICAL EFFICIENCY IN IRISH
POTATO VALUE CHAIN: CASE STUDY OF KINANGOP SUB COUNTY,
NYANDARUA COUNTY**

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DECLARATION

This research paper is my original work and has never been presented for a degree award in any other University or institution of higher learning.

Signature..... Date.....

This paper has been submitted for examination with my approval as a University Supervisor.

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DEDICATION

I dedicate this work to my loving daughter Elsie Jepkemoi for her love and understanding especially for the period I was away for my studies.

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Table of Contents

DECLARATION	II
DEDICATION	III
ACKNOWLEDGEMENT	IV
LIST OF ACRONYMS/ABBREVIATIONS.....	VII
LIST OF TABLES.....	VIII
LIST OF FIGURES.....	IX
ABSTRACT	X
CHAPTER ONE: INTRODUCTION.....	1
1.1 Background.....	1
1.2 Statement Problem.....	3
1.3 Objectives of Study.....	4
1.4 Research Questions	5
1.5 Significance of the Study.....	5
1.6 Operational Definition of Terms	6
CHAPTER TWO: LITERATURE REVIEW.....	7
2.0 Introduction	7
2.1 Theoretical Literature.....	7
2.1.1 Gross Margin Analysis	7
2.1.2 Risk Averse Peasant Theory	7
2.1.3 Stochastic Production Frontier Model	8
2.2 Empirical Literature	10
2.2.1 Studies on Value Chain and Gross Margin	10
2.2.2 Studies on Technical Efficiency	10
2.3 Overview of the Literature and Research Gaps	12
2.4 Conceptual Framework	13
CHAPTER 3: METHODOLOGY	14
3.0 Introduction	14
3.1 Theoretical Framework	14
3.1.1 Gross Margin Analysis	14
3.1.1 Stochastic Production Frontier Model.....	14
3.2 Empirical Framework.....	16
3.2.1 Gross Margin Analysis	16
3.2.1 Technical Efficiency.....	17
3.3 Study Area	21
3.4 Sample Size	21

3.5 Sampling Procedure	22
3.6 Methods of Data Collection	22
3.7 Data Preparation and Analysis	23
CHAPTER FOUR: RESULTS AND DISCUSSION	24
4.0 Introduction	24
4.1 Socioeconomic Characteristics	24
4.1.1 Comparison of socioeconomic characteristics of Producers	24
4.2.2 Socioeconomic characteristics of traders	25
4.2.3 Socioeconomic characteristics of Processors	25
4.3 Gender disaggregation of actors producing and marketing Irish potatoes in Kinangop.....	25
4.3.1 Producers	26
4.3.2 Middlemen (Brokers).....	27
4.3.3 Traders.....	27
4.3.4 Processors	27
4.4 Marketing and price determination.....	28
4.4.1 Marketing channels	28
4.4.2 Price determination	28
4.5 Gross Margin Analysis.....	29
4.5.1 Gross margin analysis for farmers	29
4.5.2 Gross margin analysis for traders	30
4.5.3 Gross margins analysis for processors	31
4.5.4 Comparison of gross margins across actors in the Irish potato production and marketing	32
4.6 Constraints at production and marketing.....	33
4.7 Technical Efficiency	33
4.7.1 Reliability of the model.....	33
4.7.2 Stochastic frontier estimation	34
4.7.3 Distribution of technical efficiency levels.....	35
4.7.4 Determinants of technical inefficiency	36
CHAPTER 5: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS	40
5.0 Introduction	40
5.1 Summary of findings	40
5.2 Conclusion.....	41
5.3 Recommendations	42
5.4 Suggestions for further research	43
REFERENCES	45
APPENDICES.....	49

LIST OF ACRONYMS/ABBREVIATIONS

APVC	Agricultural Productivity Value Chain
BDT	Bangladesh Currency
CIDP	County Integrated Development Plan
CIP	International Potato Strategy
DEA	Data Envelopment Analysis
EGIA	Evaluating the Impacts of Gender Integration in Agriculture
FAO	Food and Agricultural Organization
GM	Gross Margin
IFPRI	International Food Policy Research Institute
Kg	Kilograms
Km	Kilometers
Ksh	Kenya shillings
LR	Likelihood Ratio test
MLE	Maximum Likelihood Estimation
OLS	Ordinary Least Squares
SPFM	Stochastic Production Frontier Model
TE	Technical Efficiency

LIST OF TABLES

- Table 3.1: Variables in the stochastic production frontier model
- Table 3.2: Variables in the inefficiency model
- Table 4.1: Comparison of male and female socioeconomic characteristics
- Table 4.2: Comparison of costs incurred by men and women in potato production
- Table 4.4.3: Comparison of gross margins for male and female farmers
- Table 4.4: Comparison for Retailers and Wholesalers
- Table 4.5: Comparison for male and female traders
- Table 4.6: Comparison of gross margins for Irish potato actors in Kinangop
- Table 4.7: MLE for the stochastic frontier model
- Table 4.8: Distribution of farmers as per technical efficiency levels
- Table 4.9: Estimates of technical inefficiency and socioeconomic characteristics

LIST OF FIGURES

Figure 1: Conceptual framework on how variables influence gross margins and technical efficiency

Figure 4: Marketing channels of Irish potatoes in Kinangop sub County

ABSTRACT

Irish Potato (*Solanum tuberosum L.*) is a very important food crop grown in Kenya mostly by small farm holders. Kenya has made concerted effort to improve agricultural productivity and to lower gender gaps in agriculture. In improving production however, men and women have been considered average farmers yet gender differences in regard to opportunities and constraints abound. This study analyzed gender differences in gross margins and technical efficiency in Irish potato value chain in Kinangop sub County. Data from a gender disaggregated sample of 288 farmers, 99 traders and 39 processors drawn from the production and marketing levels of potato value chains was collected using questionnaires. Data was then analyzed using gross margin and stochastic production frontier analysis. Findings reveal that women in agriculture were more marginalized than men. At the production level, they had lower gross margins of Ksh 5907 compared to men who had Ksh 9240. At the marketing levels, women are mainly small scale retailers whereas men are mainly wholesalers. In comparing gross margins across actors, farmers had the lowest gross margins of Ksh 7585 and processors realized the highest gross margins of Ksh 63513 on average. In terms of technical efficiency, female farmers are less technical efficient at 0.49 compared to their male counterparts who were 0.54 technical efficient. Stakeholders and policy makers should not only strive to focus on promoting efficiency and productivity but also focus on policies that strengthen market access especially at farmer level. Women should be highly integrated into agricultural programs through trainings and capacity building to help them enhance their efficiency, productivity and access to market for produce and hence improved earnings.

CHAPTER ONE: INTRODUCTION

1.1 Background

Irish Potato (*Solanum tuberosum L.*) is second important food crop after maize and is mainly grown by small scale farmers in Kenya, (Kaguongo, 2014). It has short maturity period with high yields and it is not highly affected by changes in climate. Irish Potato is mainly grown in high altitude areas of 1500m above sea level where maize production is low (Muthoni and Nyamongo, 2008). FAO (2008), notes that in the high altitude areas such as Nyandarua, Nakuru, Bomet, Meru, Embu, Kirinyaga, Molo among other highland areas, farmers do three complete planting seasons each lasting 3-4 months unlike maize which completes only one planting season in a year; one planting season lasting for more than ten months.

In Kenya, about 500,000 smallholder farmers cultivate and yield about one million tons of Irish potato making Kenya be ranked the fifth producer of Irish potato in sub-Saharan Africa, (FAO, 2008). The Kenyan government and other stakeholders have recognized the role of Irish potatoes in enhancing the livelihoods of smallholder farmers since it is a source of food, employment and income.

Irish Potato becomes the main source of food during times of hunger in most rural homes in Kenya, (Muthoni & Nyamongo, 2008). As compared to cereals which are grown both for domestic consumption and international trade, potatoes are mainly grown for local use therefore, they are a very important food in developing countries (Taiy *et al*, 2016). Potato production has gained great importance as a result of increased processing industry and increased demand for fresh and processed potato products in the rapidly expanding urban areas in the country (CIP, 2011). Irish potato is an important crop in Nyandarua County as most households in the County depend on it to sustain their livelihoods. The County contributes up to 33% of ware Irish potato produced in Kenya with a net worth of up to 7 Billion Ksh. The Irish Potato Value chain supports 131,697 farm families in the County (Nyandarua County Potato Strategy, 2017-2021).

Value chain provides information on a service or product from production level to disposal after use (Kaplinski and Morris, 2003). Value chain gives a range of activities on a product from its design to the level of final consumption. (Humphrey and Schmitz, 2001). Through value chain analysis, producers can be linked to markets since it helps in identifying opportunities and

constraints that affecting productivity. Irish potato value chain therefore helps to identify avenues for promoting productivity and marketing of potatoes among smallholder farmers. (Taiy *et al* 2016). Economic policy tools can be developed and implemented by obtaining information from analyzed value chains which give more details on value added, nature of markets and distribution of incomes. (Hoeffler, 2006). Negative sentiments around production and marketing of produce can be demystified by jointly analyzing a value chain (Hoeffler 2006).

Several studies have analyzed potato value chain in Kenya and beyond and most of the findings reveal that the chain is characterized by high level of mistrust, poor market integration, low production levels that is unable to meet the marketed surplus and limited investment on breeding programs for better seed quality, low levels of infrastructural development and commercialization activities geared at strengthening the value chain (FAO, 2010). Taiy *et al*, (2016), notes that some of the factors affecting Irish potato enterprise include weather changes, price fluctuations losses after harvest due to lack of on-farm ware potato storage among many producers in the country.

Kenya's population is ever expanding and the demand for food crops is ever increasing and therefore, there is need for continued rise in agricultural productivity and improvement in efficiency in food crops production. Productivity in Irish potato production can be improved by increasing productivity and producing potatoes of high value. Recognizing that some constraints related to production are gender-specific is very crucial in improving potato productivity because men and women experience different opportunities and constraints on various aspects and at various levels (Adewuyi and Adebayo, 2014).

Small scale farmers can be affected by gender issues which can also hinder them from adopting technologies that are promoted by various projects. (Kanesathan, 2012). Gender influence in agriculture can be analyzed using domains such as assets and resource ownership, intra-household decision making, access to information and participation and income use along a given value chain. (Kanesathan, 2012). Incorporation of gender into agricultural decisions is therefore very critical in boosting household food security and income.

In Kenya however, little research has been done to assess the impacts of incorporating gender on agricultural activities among households and communities. A research project that is evaluating the impact of incorporating gender transformative approaches in agriculture (EGIA) aims to

improve food security, gender equality and nutrition outcomes in Kinangop Sub-County, Nyandarua County. The desired outcome of the project is to develop evidence on effectiveness of gender transformative approaches and provide a solid grounding for scale-up and use by policy makers and stakeholders in Kenya and beyond.

Ascertaining the differentials by male and female farmers on key issues around food production such as technical efficiency in production, gender roles, gross margins differentials, opportunities and constraints is an important way of recognizing the gender issues in agriculture. This is because women's effort on production is very enormous and their opportunities are limited compared to that of men. Some of the constraints that women suffer include working for long than men in many instances, their opinions are ignored even when they are pertinent to household welfare improvement, receive less income, have limited rights to own property and are subjects of threats and violence (IFPRI, 2014). This study seeks to undertake an analysis of gender differential performance in terms of gross margins and technical efficiency on Irish Potato value chain among smallholder farmers in Kinangop sub-County, Nyandarua County where the EGIA project is based. The study can be used in identifying areas of possible intervention aimed at improving productivity and foster market access thus boost their incomes and enhance their household livelihoods.

1.2 Statement Problem

In Kenya, the potential benefits from Irish Potato production have not been exploited fully due to seasonality in production, poor marketing system and post-harvest losses (Taiy *et al.*, 2016). The lack of up-to-date market information limits potato producers comprising mainly of women such as those of Kinangop Sub-County from negotiating for better prices with buyers. Such gender inequality issues in agricultural production have largely been addressed through development projects, however, these projects have put little consideration into gender issues and norms that strengthen access to productive resources, enhance decision making at household, improve efficiency and boost profitability among women farmers (Croppenstedt *et al.*, 2013).

Gender sensitive agricultural strategies contribute significantly to increased productivity and incomes especially among women. In designing agricultural research therefore, there is need to integrate gendered analysis approaches such as gross margin and technical efficiency analyses so as to best design and conduct agricultural research. Application of gender specific approaches of

analysis is very critical in highlighting differences among men and women hence crucial guiding on how to design approaches that meet the needs of men and women. In Kenya however, the use of these gender specific approaches is very limited.

There exists some studies that have been disaggregated in terms of gender to evaluate how men technically efficient as compared to women such as one by Nwaru and Nduku (2012) carried on sweet potatoes in Imo State, Nigeria. Few studies disaggregated in terms of gender that assess differences in profitability also exist such as that by Adewuyi *et al.* (2014), that sought to understand the if there exists any significant differences in the levels of profit realized by men and women engaged in rice production in Adamawa State, Nigeria. In Kenya however, such studies are scarce and this shows the little recognition of gender issues in agriculture. Many studies in the country have been done to assess an average farmer and thus there is little if any application of gender-specific models to conduct research. This therefore highlights the little recognition of the role that gender-balanced agricultural interventions plays in enhancing realization of sound agricultural policies and ensuring that Kenya is a food secure country.

In an effort to fill this gap, this study carried out a gender analysis of gross margin and technical efficiency on Irish Potato value chain in Kinangop Sub-County, Nyandarua County with keen interest on identifying areas of possible intervention that can be used to enhance productivity and access to reliable markets by women in order to boost their incomes and enhance their household livelihoods.

1.3 Objectives of Study

Broad objective

To assess if there exists any significant differences in technical efficiency levels and gross margins among men and women acting on Irish potato value chain in Kinangop Sub-County, Nyandarua County.

Specific objectives

- i. To identify and gender disaggregate different actors at production and marketing levels of Irish Potato value chain in the study area.

- ii. To estimate gendered gross margin differences of actors producing and marketing Irish potatoes.
- iii. To investigate any significant differences in technical efficiency levels between men and women engaged in production of Irish potatoes.

1.4 Research Questions

- i. How are the actors at the production and marketing levels of Irish potato value chain in Kinangop disaggregated in terms of gender?
- ii. Is there any significant difference in the levels of gross margins of actors producing and marketing Irish potatoes in Kinangop?
- iii. Is there any significant difference in the level of technical efficiency of male and female Irish potato farmers in the study area?

1.5 Significance of the Study

Information on the gender differences in technical efficiency and gross margin in agricultural production emanating from this study is very important in designing sound gender specific agricultural policies aimed at promoting productivity, ensuring that households particularly for small holder farmers are food secure and can realize increased income levels

Policy makers and development partners can use the findings from this study to know where to target in designing policies and projects geared towards ensuring equal access to productive resources in production and hence promoting efficiency and gender equality in agriculture. The findings can help to bring out the different roles of men and women in agricultural product value chain and this is important in the formulation of appropriate policies geared towards women empowerment in the study area and can be replicated across the agricultural sector in the country and beyond.

The research findings from this study is part of bigger findings from the project that is evaluating the Impacts of Gender Transformative Approaches in Agriculture, Food Security and Nutrition Outcomes in Kinangop Sub-County, Nyandarua County. The project outcome is to promote women productivity in agriculture by enhancing access to productive resources and thus add unto bridging knowledge gaps in gender and agriculture.

Many efforts have been put towards addressing gender differences in agriculture with an aim of promoting a greater economic efficiency which gives women the tools to be more productive and reliable in the society (IFPRI, 2014). In Kenya however, agricultural studies that are disaggregated in terms of gender are scarce depicting a limited recognition of this aspect in improving agricultural production in the country. This study is an attempt to address this gap through collection and analysis of gender-disaggregated data in potato production and marketing in Kinangop Sub-County.

1.6 Operational Definition of Terms

Gender: This refers to the different social and cultural responsibilities assigned to men and women and how that affects them and their overall household wellbeing.

Gross Margin: it is the difference between total revenue and total variable costs associated with Irish potato farming and marketing enterprise.

Irish Potatoes: A low cost edible white potato group tubers grown mainly in the highlands with moderately cool climatic condition.

Technical efficiency: Refers to how an Irish potato producer can utilize a given set of inputs to produce highest possible yield of output.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter presents both the theoretical and empirical literature reviewed regarding gross margin and technical efficiency analysis. It also presents the research gaps identified from the literature reviewed and the conceptual framework.

2.1 Theoretical Literature

2.1.1 Gross Margin Analysis

The variance of total revenue and total variable costs associated with an enterprise is the gross margin. In computing gross margin, the overhead or fixed costs are not considered because they will always be incurred regardless of the level of enterprise involved, (Beatrice Daniel 2015). Fixed costs are peculiar to subsistence farming, (Adewuyi *et al.* 2014). The gross margin of different enterprises should therefore not be compared if they have varying fixed costs, (Beatrice Daniel, 2015).

Gross margin gives a good indication of the financial health of an enterprise and shows management efficiency of the enterprise, (Hammod, 2001). Gross margin therefore provides a satisfactory mechanism of measuring resource efficiency along any given value chain.

2.1.2 Risk Averse Peasant Theory

This theory defines peasants as households who own a piece of land utilize mainly household labor to produce from their farms with the objective of ensuring household survival by avoiding risk. This theory states that farmers may not be efficient in maximizing profit but their action and decisions portray that they are economically rational. In allocating their household resources, they first ensure that they are safe in regard to household food security. The theory also adds that resource allocation is done such that expected utility in a household is maximized over long period of (Wiesmann, 1998).

Poor small scale farmers are necessarily risk averse and attempt to increase family security rather than maximize profit, (Mandela, 2005). Farmers prefer to engage in peasant farming to ensure production of household food requirements other than getting involved in high risk profit making ventures (Bedri, 1992). Farmers produce with very high levels of uncertainty because of factors such as market fluctuations, natural calamities among other factors. This uncertainty makes

farmers to be risk averse in their production decisions, a scenario which affects diffusion of technological innovations in agriculture.

2.1.3 Stochastic Production Frontier Model

Technological relationships in input and output quantities have long been estimated by econometricians until after Farrell (1957) pioneered works that put more considerations on estimating the production frontier functions (Gatemberezi, 2011). This was done in an effort to draw theory and empirical work more close (Aigner *et al.*, 1977).

The production of highest possible output levels resulting from some set of inputs is measured by technical efficiency (Farrell 1957). The deviation from a farm's maximum possible level of output is explained by to technical inefficiency. The aspect of technical inefficiency within farms became a subject of interest and as a result, many studies measuring inefficiencies in all fields have been done.

Farrell's measure of technical inefficiency was conditional on the level of inputs involved in production. This method of estimation of technical inefficiency has been widely applied but has undergone several improvements. In 1968, Aigner, and Chu, modified how Farrell measured technical inefficiency to incorporate technical inefficiency due to farm specific factors and formulated deterministic frontier model. This deterministic form of the model was a Cobb-Douglas form and was estimated using linear or quadratic software design algorithms, (Battese, 1992).

The deterministic model was later in 1977 modified by Aigner, Lovell, and Schmidt and Meeusen, and van Den Broeck to capture random factors and modelled the stochastic production frontier model (SPFM) also denoted as the general stochastic production frontier. The SPFM estimates the relationship between levels of inputs and outputs using two errors. This function of SPFM was estimated by Maximum Likelihood estimation (MLE) procedure which was a correction the Ordinary Least Squares (OLS) that was a two-step procedure. In this two-step procedure the function was first estimated to identify factors affecting technical inefficiency after which the farm specific characteristics are regressed on the technical inefficiency.

Technical inefficiency existence makes levels of production for a given level of inputs less for farms involved in production and this is the assumption that most frontier functions of productions

adhere to (Battese and Tessema, 1992). The SPFM estimation thus acknowledges that for any given level of inputs, actual production is lower than the highest possible attainable level of production. In the efficiency analysis, it was suggested that it is important to establish factors causing inefficiency (Kumbhakar *et al.* 1991). It is important to determine the factors causing inefficiency and estimate the extent to which they contribute to lowering the level of maximum possible level of output. (Baten *et al.*, 2006). Frontier estimation has been widely accepted in agricultural economics and industrial settings because it is consistent, easy to estimate and it is flexible (Battese and Coelli, 1992; Baten et al, 2006 and Coelli and Battese, 1996).

In agricultural studies, there are common errors that can only be measured using the stochastic production frontier model (Coelli *et al.*, 1996), and thus this is an advantage of SPFM over Data Envelopment Analysis (DEA). The DEA recommends that expanding output or reduce input, this should be done in fixed proportions; and this in itself is a limitation (Mukami, 2018).

The model that was applied to this study is the model suggested by Battese, and Coelli (1995) in which model specification was estimated in one step to find out the model parameters for both functions of production and technical inefficiency. This model has been applied widely in estimating technical inefficiency of an average farmer among smallholder farmers in many agricultural studies. This study aims to estimate gender specific stochastic production frontier models of both men and women engaged in Irish potato farming in Kinagop Sub-County in order to establish if there exists any variation in levels of technical efficiencies between male and female farmers. This aimed to bring out the productivity performance differences across gender and identify specific avenues for enhancing food productivity and improve food security in the study site, the country and beyond.

2.2 Empirical Literature

2.2.1 Studies on Value Chain and Gross Margin

Agricultural product value chain (APVC) analysis have been done in an effort to promote productivity and marketing of agricultural products. This is because jointly analyzing APVC reveals constraints that affect actors along the chain which helps stakeholders to formulate recommendations and policies for combating them and ensure that a particular product is improved. Gross margin analysis helps to quantify resource use efficiency along a given product chain and this method of analysis has been used in most studies to show the variations in gross margins among actors in the chain.

In Mauche Ward in Njoro majority of the farmers earned Kshs. 50,000 to 70,000 per year from potatoes grown on between 0.1 and 1 acre of their land (Taiy *et al.*, 2016). Irish potato value chain in Tanzania there were variations in gross margins with the highest gross margin of Tshs. 2939 per Kg obtained by local processors while the traders were receiving the average gross margin of Tshs. 421 per Kg and farmers were getting an average margin of Tshs. 36.5 per Kg, which was the lowest gross margin compared to the other actors in the chain (Beatrice Daniel, 2015).

In the production of rice in Adamawa State Nigeria, male farmers obtained higher profits than female counterparts (Adewuyi and Adebayo 2014). It was important to ascertain differences in profits both by male and female farmers so as to recognize the importance of gender issues in production of food crops (Adewuyi *et al.*, 2014). Sweet potato value chain in two districts in Bangladesh comprised of input sellers, farmers, local traders, retailers and consumers where a farmer gets a profit of approximately Bangladesh currency (BDT) 30,000 per acre of land while traders gets BDT 3 gross margin by selling 1 Kg of sweet potato (Sorwar *et al.*, 2015).

2.2.2 Studies on Technical Efficiency

Studies analyzing technical efficiency (TE) levels among small scale farmers have mainly used the SPFM in their analyses and most of them revealed varied levels of technical efficiencies among farmers in Kenya and across the world. Technical efficiency levels are also influenced by various factors most of which are associated with household characteristics. Technical efficiency among snow peas small scale farmers in Nyandarua County was between 30-90% with a mean of 70% (Mukami, 2018). In Kisii County, smallholder farmers have a technical efficiency level of 36.8%

with factors affecting TE being the quantity of planting fertilizer used, certified seeds and fragmentation index (Kiprop *et al.*, 2015).

Technical efficiency level in resource use among farmers in Nyandarua North District was recorded at 67% with significant determinants such education, access to extension, access to credit and group membership (Nyagaka *et al.*, 2010). Technical efficiency levels among farmers engaged in maize production in Kenya ranged between 8% and 98% with technical efficiency mean being 49%. Technical efficiency in maize production is significantly influenced by education level, age, gender, use of farm machinery and off-farm income (Kibaara, 2005).

In the production of rain-fed Irish potato by farmers in Plateau state Nigeria there is a wide variation in technical efficiency between the most and least efficient farmer i.e. 2.37% and 95.6% respectively and a mean of 74%; determinants included education, farming experience, potato variety and off-farm income (Jwanya *et al.*, 2014). In Imo State, Nigeria female farmers had a higher technical efficiency at 92% than that of male at 85% with main factors of TE being experience level of a farmer and credit access (Nwaru and Nduku 2012).

Irish Potato production in Dedza District, Central Malawi recorded technical efficiency level at 83% and some of the determinants of technical efficiency levels included off-farm income, education, experience, specialization level, weeding, age and household size (Maganga 2012). Seed potato farmers of Badakshan Province of Afghanistan reported a technical efficiency level of 24%; an indication of high inefficiency levels at a 76% (Srinivas *et al.*, 2012). In Nyabihu District, Rwanda smallholder Irish potato production was reported to have a technical efficiency mean of 60.5% with its determinants including area under potato, seed, and family labor, fertilizers, gender, marital status, extension services, education, access to credit and farm size (Gatemberezi 2011).

2.3 Overview of the Literature and Research Gaps

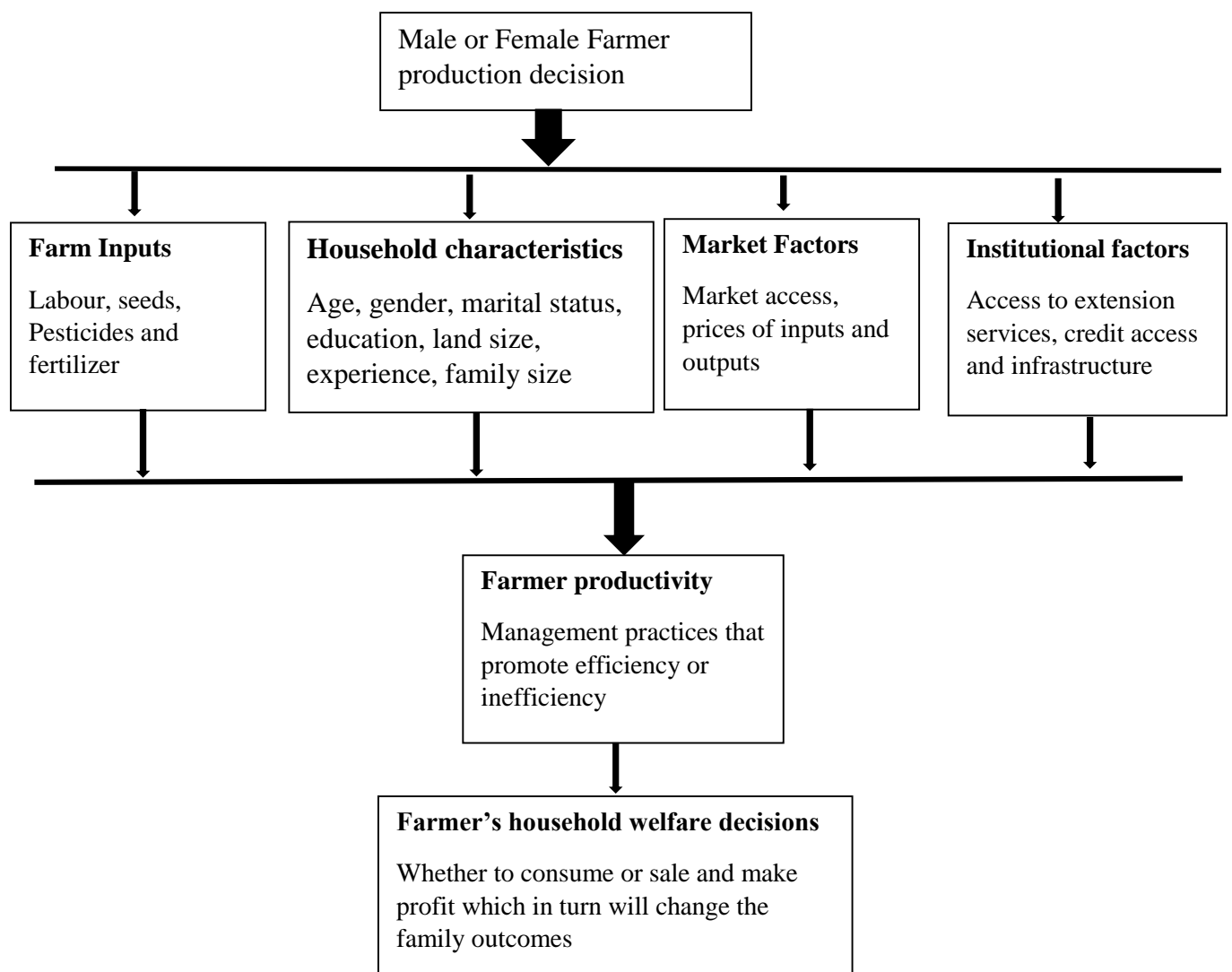
Gender influences agricultural productivity among smallholder farmers through domains such as resource ownership, information access, intra-household decision making and income use. Gender issues in agriculture are being inadequately reflected in agricultural research thereby affecting agricultural policies and programs. Studies done to assess productivity performance in agriculture such as efficiency and gross margin have been based on analysis from farmers where both male and female farmers have been assumed to have equal access to land and other productive resources. This analysis is at best able to identify average productivity performance for an average farmer but not specific on the performance differences between gender.

This study used gender-specific models gross margin analysis and stochastic production frontier to find out gross margin and technical efficiency levels of male and female potato producers and actors in the Irish potato marketing. These models are mainly employed in the analysis of an average farmer as shown in the literature. The outcome of this study adds into the existing literature in the context of Kenya by introducing gender-specific modes of analysis to bring out an understanding of performance differences across gender in agricultural production.

2.4 Conceptual Framework

Farm inputs, socioeconomic characteristics, institutional and market factors affect farmer's management and productivity processes once a farmer has made a decision to produce a particular crop. Proper management practices at farm level will imply technical efficiency which translates to enhanced household welfare and income. This relationship is presented in figure 1 below.

Figure 1: Conceptual framework on how variables influence gross margin and technical efficiency of a farmer



Source: Author, 2019

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter presents the theoretical and empirical framework, the study area sample size, sampling procedure and the methods of data collection and analysis.

3.1 Theoretical Framework

3.1.1 Gross Margin Analysis

The variation between total revenue and total variable costs defines the gross margin associated with an enterprise. In gross margin analysis, fixed costs are not considered because they will be incurred regardless of any enterprise undertaken.

The Gross margin is obtained using the following equation:

$$GM = \sum PQ - \sum VCX \text{ ----- (ix)}$$

Where GM is Gross Margin, P the price of output, Q is output, VC is variable input cost and X is input used in production. $\sum PQ$ is the sum of total revenue and $\sum VCX$ is the sum of variable cost of production. Gross margin can be expressed as a ratio or a percentage to give the Gross Margin Ratio/Percentage (GMR) which is helpful in comparing margins of different enterprises at different levels of the value chain. The GMR formula is given as:

$$GMR = \frac{\sum PQ - \sum VCX}{\sum PQ} \times 100\% \text{ ----- (ii)}$$

Rarely do farmers do enterprise analysis and planning before setting up the enterprise and thus therefore do farming as a tradition yet they could be making losses. For a farmer to do farming, it is important for them to know how it performs and thus gross margin analysis is critical in evaluating the viability of the farm enterprise for any farmer.

3.1.1 Stochastic Production Frontier Model

In analyzing production processes, functions have been estimated over time based on the implicit assumption that all farms are producing in a technical efficient manner and the average farm defines the frontier. The deviations from the frontier are therefore associated with unmeasurable

factors. The need to estimate these unmeasurable factors led to the formulation of the frontier models of production which accommodate the measurement errors. The estimation procedures are stochastic in nature and the therefore, term stochastic production frontier models (SPFM).

SPFM has been widely in the estimation of technical efficiency in many fields. The model is as shown;

$$Y_i = f(X_i, \beta) \exp(V_i - U_i) \text{----- (ii)}$$

Where Y_i , $f(X_i, \beta)$ and U_i are as stated in the deterministic model and V_i is an arbitrary error related to random factors and has a zero mean. V_i are factors outside the farmer control while U_i are factors that a farmer has control over them.

Most empirical studies on stochastic production frontier models assume that the V_i , $i=1, 2, \dots, N$ have an independent and identical distribution as $N(0, \sigma_v^2)$ chance variables and do not depend on U_i s which are assumed to be zero or positive truncations and half-normal distributions, $N(0, \sigma^2)$ (Aigner *et al.*, (1977) and Meeusen *et al.* (1977)).

Technical efficiency level of a given farm (TE_i) is determined as a ratio of actual output and frontier output that results from given level of inputs used in the farm, (Aigner *et al.*, 1977). The observed output and potential output is defined by Y_i and Y_i^* respectively as shown in the (iii) and (iv) below.

$$Y_i = f(X_i, \beta) \exp(V_i - U_i) \text{----- (iii)}$$

$$Y_i^* = f(x_i, \beta) \exp(V_i) \text{----- (iv)}$$

Technical inefficiency equation therefore defined as;

$$TE_i = \frac{Y_i}{Y_i^*} \text{----- (v)}$$

$$TE_i = \frac{f(X_i, \beta) \exp(V_i - U_i)}{f(X_i, \beta) \exp(V_i)} \text{----- (vi)}$$

$$TE_i = \exp(-U_i) \text{----- (vii)}$$

Where Y_i , $f(X_i, \beta)$, V_i and U_i are as defined in (i) above and Y_i^* is the highest possible output. $TE_i = \exp(-U_i)$ in equation (vii) therefore measures technical inefficiency and is constrained between zero and one. The technical inefficiency effects U_i in equation (vii) is a linear function constituting the socioeconomic factors, (Coelli *et al*, 1995). U_i is therefore modelled as;

$$U_i = \alpha Z_i \text{----- (viii)}$$

Where α is the unknown parameters that were found after estimation and Z_i is the individual farmer’s socioeconomic characteristics.

Estimation of the SPFM varied over time from its formulation period such that the model can either be estimated by two-step procedure or by single estimation procedure. The estimation procedure by Battese *et al.*, (1995) was a single step process done by maximum likelihood estimation This study adopted this estimation procedure by Battese, *et al.*, (1995) to estimate the SPFM functions in equation (ii) and (vii) simultaneously where two estimations were done, one for male and the other one for female.

3.2 Empirical Framework

3.2.1 Gross Margin Analysis

The study identified actors along the Irish potato value chain that operate at the production and marketing levels of the value chain. Alongside identification, the study mapped the dominance of different gender along the chain. Once actors have been identified and data disaggregated into male and female, gross margin differences were computed for all actors identified on the chain.

The gross margin was computed by computing the differences between revenue and variable costs involved in production and trading of Irish potato in Kinangop Sub County. Variable costs varied from one actor to another for example, variable costs for a farmer may include; cost of seed used, costs of hiring machinery, labour costs, cost of fertilizer and transportation cost for both inputs and yields. Costs of a trader may include transport cost, costs in buying potato yields, storage costs and other marketing costs. The gross margin was computed using the mathematical formula;

$$GM = \sum PQ - \sum VCX$$

Where PQ is the revenue and VCX is the variable cost of production for the identified actors along the chain. The gross margin ratio equation will be given as:

$$GMR = \frac{\sum PQ - \sum VCX}{\sum PQ} \times 100\% \text{ ----- (xi)}$$

This gross margin differences was compared both for men and women actors along the value chain where gender comparisons were made at the same level of the value chain.

3.2.1 Technical Efficiency

Differences in technical efficiency of male and female farmers who produce Irish potatoes were established by estimating a Cobb-Douglas functional form of SPM. The choice of this model is form is made basing on the fact that agricultural production varies due to factors such as plant pathology, insects and climatic hazards (Gathemberezi, (2011) and Mukami 2018). Two models; one for male and the other for female farmers were estimated simultaneously by maximum likelihood estimation method as this takes into account the unplanned errors and inefficiency of the farmer. The simultaneous estimation procedure does not also violate the assumption on how the error terms are distributed. The model was estimated by a linear Cobb-Douglas production function and the functional form of the model that was estimated is presented as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i \text{ -----(x)}$$

Where; ln is natural logarithm, Y_i is the potato yield of a farmer in Kgs, X₁ is the total farm size under potato production, X₂ is the amount of seed used in planting in Kg, X₃ is both hired labour and family labour used in production per acre, X₄ is the fertilizer used in Kgs, X₅ is pesticides used in production of Y_i, V_i is random factors that are outside the control of a farmer and U_i is the farmer specific characteristics which influence technical efficiency and $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and β_6 are parameters to be estimated.

The stochastic Cobb-Douglas production frontier model that was estimated for this study is specified as;

$$\ln Y_i = \beta_0 + \beta_1 \ln LSUP + \beta_2 \ln Seed + \beta_3 \ln HRDL + \beta_4 \ln FAML + \beta_5 \ln FERT + \beta_6 \ln PEST + V_i - U_i \dots$$

- (xi)

The variables for the stochastic production model was defined and measured as shown in table 3.1 below;

Table 3.1. Variables in the Stochastic Production Frontier Model

Variable	Description	Measurement	Code	Expected sign
Potato output	Potato yield from in Kgs for a farmer	Kgs	Y	Dependent Variable
Land size under potato production	Total farm size under potato production in the season considered for study	Acres	LSUP	+
Seed	Quantity of potato seed used during the season	Kgs	Seed	+
Hired labour	Total hired labour used to produce Y	Man working days	HRDL	+
Family labour	Total family labour used to produce Y	Man working days	FAML	
Fertilizer used	Quantity of fertilizer used by farmer	Kgs	FERT	+
Pesticides	Pesticides used in crop management	Kgs	PEST	+

Technical inefficiency model for this paper is defined as;

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \alpha_8 Z_8 + \alpha_9 Z_9 + e_i \dots$$

-- (xii)

Where U_i is the technical inefficiency, Z_1 is the farmer's age, Z_2 number of children, Z_3 is the farmer level of education, Z_4 is the farmer's experience in potato production, Z_5 is size of farm that a farmers has in acres, Z_6 is the marital status of the farmer Z_7 is the credit accessibility by a farmer, Z_8 is the farmer's extension services access and Z_9 is the availability of market to sale

produce while $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7$ & α_8 are parameters to be predicted. The variables Z1 to Z9 was estimated to show the level of their influence on technical efficiency.

The inefficiency model that was estimated for this study is specified as follows;

$$U_i = \alpha_0 + \alpha_1 \text{Age} + \alpha_2 \text{No.Child} + \alpha_3 \text{Edu} + \alpha_4 \text{Exper} + \alpha_5 \text{Landsz} + \alpha_6 \text{Marit} + \alpha_7 \text{Credit} + \alpha_8 \text{Exte} + \alpha_9 \text{Markrt} + e_i$$

----- (xiii).

The variables for the inefficiency model was defined and measured as shown in table 3.2 below;

Table 3.2. Variables in the Inefficiency Model

Variable	Description	Measurement	Code	Expected sign
Technical efficiency	Inefficiency effects	Numbers ($0 \leq U_i \leq 1$)	U _i	Dependent variable
Age	Age of the farmer	Years	Age	+/-
No. of children	Number of household members	Numbers	Famsz	+
Education level	Farmer level of education	Years of schooling	Edu	+
Farmer Experience	Experience of a farmer in potato production	Years of farming	Exper	+
Farm size	Total farm size of farmer in acres	Acres	Landsz	+
Marital status	Whether a farmer is married or not	Dummy, 1 if married, 0 otherwise	Marit	+/-
Credit access	Whether farmer received credit to undertake potato production activity during the season	Dummy, 1 if accessed credit, 0 otherwise	Credit	+
Extension service access	Whether farmer extension services while undertaking potato production activity during the season	Dummy, 1 if accessed extension services, 0 otherwise	Exte	+
Market access	Whether farmer knows where to sell potato yield	Dummy, 1 if knows where to sell, 0 otherwise	Mrkt	+

The two equations (xi) and (xiii) were estimated concurrently in single-step procedure to obtain maximum likelihood approximations. The single-step procedure is powerful in that it ensures that the errors in technical inefficiency are independently and equally distributed, (Battese *et al.*, 1995). The stochastic frontier model was estimated twice, one for male and one for female using maximum likelihood in STATA.

3.3 Study Area

The study was done in Nyandarua County whose headquarters is Ol'kalou. The County has an altitude of upto 3500M and experiences moderate to low temperatures. County experiences two rainy seasons; long rains lasting between months of March and May of up to 1600mm and short rains between September and December of up to 700mm. The county has 25 county wards and 5 Sub Counties which include; Kinangop, Kipipiriri, O'Kalou, Ol'jororok and Ndaragwa, (Nyandarua CIDP, 2013-2017).

Kinagop Sub County is the largest among the five Sub Counties and covers an area of 822KM² with 6 divisions, 16 locations and 8 wards. It has a total population of 233,100 comprising of 114,265 male and 118,835 female found in up to 45,141 households spread all over the Sub-County (Nyandarua CIDP, 2013-2017). The Sub-County has 8 wards namely; Murungaru, North Kinangop, Gathara, Njabini, Nyakio, Magumu, Engineer and Githabai. The sub-County's headquarter is at Engineer town. The study was be conducted in Gathara, Githabai, Njabini, Nyakio, Engineer and Magumu; these are the wards where the EGIA project is based.

The sub-County is largely agricultural and has the main economic activity comprising of dairy and crop farming. Crops mainly include Irish potato, garden peas, cabbage, carrots and kales, with Irish potato being the main crop that is grown by the smallholder farmers and thus the highest income earner among households (Nyandarua CIDP, 2013-2017). The Irish potato produce is mainly sold in Kenya's capital, Nairobi.

3.4 Sample Size

Target population of study were Irish potato value chain actors producing and marketing potatoes in Kinangop Sub County. The target sample size n was computed using a simplified formula proposed by Yamane, (1967) and Israel (1992). This formula assumes 95% confidence level and p of 0.5 and thus the sample size n is given by;

$$n = \frac{N}{1 + N(e)^2}$$

Where: n = sample size, N = population size and e =precision rate. This study aimed to add unto the outcome of a bigger project that is Evaluating the Impact of Gender Integration into Agriculture (EGIA) in Kinangop Sub-County. The Sub County comprises of 45141 households (Nyadarua

CIDP2, 2018-2022). From this 45141 households, the study drew male and female individuals that were be used for this study. Therefore, these households were the population size that were used to draw individuals that were considered for study. The study allowed a margin of error of 5% to compute the sample size as;

$$n = \frac{45141}{1 + 45141(0.05)^2}$$

$$n = 396$$

3.5 Sampling Procedure

The study targeted actors producing and marketing Irish potatoes. Farmers sampled were analyzed for technical efficiency and profitability differentials of male and female farmers. The study also extended to examine differences in profitability of other actors at the marketing level mainly wholesalers, retailers and processors. Data collected was gender disintegrated for producer and traders on the Irish potato value chain.

The study purposively selected the six wards of Gathara, Njabini, Githabai, Magumu, Nyakio and Engineer from Kinangop sub-County. This selection was guided by the fact that the study adds onto the outcome of a bigger EGIA project that is working with farmer groups in the Sub County.

Stratified sampling was applied to select Irish potato producers from non-potato producers. 145 male farmers and 143 female farmers were purposively selected and interviewed for study. Snowball method was also used to obtain information from the actors marketing and processing Irish potato. Snowball method is a technique where a person conducting research identifies and gets in touch with a person or group relevant for the study and then asks them to guide him/her to the next person for the study (Bryman, 2008). This method is used when the population for the study are unknown, (Beatrice Daniel, 2015). Wholesalers, retailers and processors were asked to identify their colleagues who were then selected for the study. A total of 39 wholesalers, 60 retailers and 39 processors were identified and selected from the various markets found in the wards.

3.6 Methods of Data Collection

Primary data was obtained using structured questionnaires that were designed for this study. The questionnaires were administered through one on one interviews by enumerators were trained to

administer the exercise. The questionnaires were pre-tested and changes needed to improve the questionnaire were incorporated after which the data was collected. The questionnaires were designed for farmers, wholesalers, retailers and processors.

3.7 Data Preparation and Analysis

Data that was collected was cleaned up then coded and entered into computer software in readiness for analysis. The data was analyzed by use descriptive statistics, gross margin analysis and stochastic production frontier analysis using STATA

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the analysis and the discussion of results with a descriptive analysis of actors in the Irish potato value chain comprising of producers, middlemen, traders and processors. Included in the chapter is also the marketing and price determination, gendered gross margin analysis of key actors and the technical efficiency analysis of male and female producers.

4.1 Socioeconomic Characteristics

4.1.1 Comparison of socioeconomic characteristics of Producers

The findings show that male and female respondents had a mean age of 47 and 42 years respectively, implying that farmers within the energetic age bracket are active in Irish potato production. Most respondents (87% male and 76% female) were married; with an average number of four children per individual. The reasonably small number of children could suggest that most married men are monogamous. The study showed that men have an average of 15 years farming experience with women having 14 years experience. Increased farmer experience in production is associated with efficient utilization of productive resources.

Education is an important component in ensuring that sustainable growth and development in agriculture is achieved. Education level indicates a farmer's ability to adopt technologies being promoted in agriculture and influence decisions around production and marketing. The study revealed that at least 56% of female respondents have attained primary education while 52% of male farmers had attained primary education and below with 34% and 39% having attained secondary education respectively.

The main form of land ownership is inheritance with over 60% of both male and female farmers having acquired land through inheritance. The average farm size for men is four acres and that of women is two acres with farm size under potato being 1.1 acres and 0.70 acres for men and women respectively. Over 90% of both farmer groups use farmer based seed and over 90% of both men and women producers use DAP fertilizer with men applying an average 127Kgs per acre of land under potato production and women apply 100Kgs per acre. The type of pesticides used by both male and female producers varied from one individual to the other only 6% of women and 10% of men not applying pesticides on their farms. Men farmers produce an average of 3260Kgs of Irish

potatoes while women produce an average 2650Kgs of Irish potatoes per acre. The findings discussed in this section are shown in table 4.1 below.

Table 4.1: Comparison of male and female socioeconomic characteristics

Variable	Categories	Men	Women
		Means	
Age		47 years	42 years
No. of children		4	4
Farm size		4 acres	2 acres
Experience		15 years	14 years
Land under Potatoes		1.1 acres	.70 acres
Quantity of fertilizer used (Kgs)		127 Kgs	100 Kgs
Quantity of Potatoes produced		3260 Kgs	2650 Kgs

Source: Author, 2019

4.2.2 Socioeconomic characteristics of traders

The findings show that the average age for traders is 41 years. 60% of the traders are female while 39% are male. This study agrees with the findings by Beatrice Daniel (2015) who found out that over 55% of female dominated in undertaking small scale businesses in Njombe in Tanzania. Majority of the respondents are married with responses at 77%, single at 17%, widowed at 5% and divorced at 1%. 59% of the responses have attained primary education and below, 39% having attained secondary education and 2% have attained tertiary education with none having gone to the university. Average number of children per respondent is 3.

4.2.3 Socioeconomic characteristics of Processors

The findings show that the average age for processors is 35 years 50% of the processors being female while 50% are male. Majority of the respondents are married with responses at 63%, single at 37%, 11% of the respondents have attained primary education and below, 50% having attained secondary education and 34% have attained tertiary education with 5% having gone to the university.

4.3 Gender disaggregation of actors producing and marketing Irish potatoes in Kinangop

The Irish potato value chain in Kinangop sub-County is made of actors such as producers, transporters, middlemen, traders and local processors. This implies that there is a high level of

interactions among actors in the study area. The activities undertaken at the production and marketing nodes of the value chain include production, sorting, packaging, transporting, retailing, processing and consuming. The different actors identified in Irish potato value chain in Kinangop include input suppliers, producers who are mainly farmers, middlemen made of village brokers, traders who constitute both wholesalers and retailers, processors who comprise local hotels and one food processing unit and consumers who are mostly individuals in the study area. Each of the key actors is discussed in the sub-sections below.

4.3.1 Producers

Producers comprised of men and women who are smallholder farmers in Kinangop. These smallholder farmers own an average of 4 acres among men and 2 acres among women with an average land under potato production of 1.1acres and 0.7acres respectively. The form of land ownership owned by these individual farmers is mainly through inheritance with men at 64% and women at 70% and only 8% and 6% of men and women renting land respectively. The average production is 3260Kgs for male farmers and 2650Kgs/acre for female farmers.

In production, highest costs is mainly accounted by the costs of land preparation, planting and weeding and the costs of fertilizer with each constituting 42% and 23% among male farmers and 43% and 24% among female farmers as shown in table 4.2 below.

Table 4.2: Comparison of costs incurred by men and women in potato production

Variable	Men		Women	
	Means (Ksh)	Proportion of total costs (%)	Means (Ksh)	Proportion of total costs (%)
Cost of fertilizer	6151.897	23	4635.524	24
Cost of manure	2758.138	10	1784.266	9
Cost of pesticides	1383.345	5	1067.063	6
Cost of transport	374.2069	1	276.8531	1
Cost of land preparation, planting and weeding	11438.97	42	8297.902	43
Harvesting costs	4862.621	19	3218.881	17
Total cost of production	27106.62	100	19224.9	100

Source: Author, 2019

4.3.2 Middlemen (Brokers)

These are mainly middlemen who link farmers to urban traders. From the responses obtained from both the male and female farmers, 99% of these middlemen are men. They do not buy potatoes directly from farmers but only lead urban traders to where they can obtain the potatoes from the farmers. These middlemen earn through a predetermined rate where their task is to dictate for lower buying price from farmers and the urban traders will pay them the excess of what they were willing to buy the potatoes at farmer level. Most farmers sold their Irish potato produce through these middlemen. The value addition done mostly by the village traders is sorting and packaging the potatoes. Some of them also transport the potatoes.

4.3.3 Traders

These comprise of both retailers and wholesalers. The findings show that 19% of the traders are wholesalers and 81% are retailers, 39% of these being male while 61% being female. From the male respondents, 40% are wholesalers and 60% are retailers while 95% of the female respondents are retailers and only 5% are wholesalers.

Traders in Kinangop transport Irish potatoes from rural farms to trading centers found in the various wards of the sub-County such as Kwa Haraka, Njambini, Engineer, Kinamba, Githioro, Ng'othi, Magumu and Soko Mjinga. The main form of retailing is where retailers buy produce from farmers and sell to roadside buyers mainly in form of 20Kg tins. The wholesalers who were mainly found at Soko Mjinga market which is located along the Nakuru-Nairobi highway buy Irish potato produce from farmers in large quantities and sell mainly to urban traders. The price of produce varied from one trading center to another but prices were higher in Magumu and Soko Mjinga markets due to their proximity to the Nairobi town.

The value addition done at trader's level include storage where 82% of traders stored their produce, transportation which was done mainly by motorbike especially retailers at 76% and repackaging where traders buy produce from farmers in larger gunny bags such as 130Kgs and 20kg tins and repackage them in small gunny bags of 50 or 90Kgs and 15Kg tins respectively and sell them at a higher prices to maximize on profits.

4.3.4 Processors

In Kinangop sub-County, processors were mainly hoteliers who peeled and fried potatoes or cooked them with 50% of these hotels being owned by men and 50% are owned by women. These

hotels were distributed across the trading centers with majority of them being found in Engineer trading center. There was only one food processing unit who peeled and chopped Irish potatoes in large quantities and transported them for supplies in major chips making hotels in Nairobi. The most common potato product in the study area is Chips. The value addition at processors level include storing, peeling and frying at the hoteliers' level while at the food processing unit include weighing, storing, washing, peeling, packaging and distribution. The processors temporarily preserved the peeled potatoes in cold water.

4.4 Marketing and price determination

4.4.1 Marketing channels

The marketing of Irish Potato in Kinangop is characterized by small scale traders operating individually with marketing actors mainly comprising of producers, village traders, retailers and wholesalers, processors and consumers. The channels involved in the distribution of Irish potato produce and products are as shown below with the main marketing channel in the study area being channel number 5.

1. Producer → Consumer
2. Producer → Trader → Consumer
3. Producer → Processor → Consumer
4. Producer → Trader → Processor → Consumer
5. Producer → Middlemen → Trader → Processor → Consumer

Figure 4.1: Marketing channels of Irish Potato in Kinangop

4.4.2 Price determination

Price determination is a very important marketing element in any marketing system. In Kinangop sub-County, price determination varied across actors. The study found that at the producer level, 93% of farmers mentioned that prices are determined by the middlemen and they are forced to comply with the proposed prices because they have limited bargaining power and poor access to markets and market information.

Prices at the traders level are determined by the sellers and in many instances, prices within a given market are uniform such that buyers have less bargaining power and limited options in regard to prices. At the processors level, the price for potato produce is determined by both the potato seller and the buyer made a decision on the price. On the price of the potato product, the processor solely

determines the price per portions of product. The findings on price determination are in agreement with the findings by Beatrice Daniel (2015) on price determination of Irish potatoes in Njombe and Wangígómbe districts in Tanzania.

4.5 Gross Margin Analysis

4.5.1 Gross margin analysis for farmers

The findings as presented in table 4.3 below shows that women receive lower gross margins of Ksh 20,676 than men who receive Ksh 32,341 within a given planting season. This earnings translate to Ksh 5,907 and Ksh 9240 for women and men respectively within a month and Ksh 11 and 10 per kg of potatoes sold; which is equal to 15.4% and 14.8% GMR or value of sales on average. GMR is generally the percentage of each shilling revenue that is retained as gross profit in a given enterprise. The low GM ratios for both men and women farmers imply that volume of sales are low. The low gross margins realized can be attributed mainly to low prices received by farmers. These findings are line with the findings by Adewuyi and Adebayo (2014) who found out that the gross margin realized by male farmers is higher than that of female farmers involved in rice production in Adamawa state in Nigeria. The positive values realized in potato production implies that potato farming is a viable enterprise and therefore there is need to curb on the challenges that lower the gross margins.

Table 4.3: Comparison of gross margins for male and female farmers

Variable	Men		Women	
	Means (Ksh)	Proportion of total costs (%)	Means (Ksh)	Proportion of total costs (%)
Cost of fertilizer	6151.897	23	4635.524	24
Cost of manure	2758.138	10	1784.266	9
Cost of pesticides	1383.345	5	1067.063	6
Cost of transport	374.2069	1	276.8531	1
Cost of land preparation, planting and weeding	11438.97	42	8297.902	43
Harvesting costs	4862.621	19	3218.881	17
Total Variable Cost	27106.62	100	19224.9	100
Quantity sold (Kgs)	3385.586		1855.175	
Total revenue	59447.93		39900.35	
Gross Margin per season	32341.31		20675.86	
Gross Margin per month	9240.40		5907.40	
Gross Margin per Kg	10		11	
Gross margin ratio	15.4%		14.8%	

Source: Author, 2019

4.5.2 Gross margin analysis for traders

The gross margin was analyzed for retailers and wholesalers and also a comparison is made for male and female traders. The findings showed that retailers earn a lower profit of Ksh 10407 in a month which translates to Ksh 13 per Kg which equals to 31% value of sales on average. Wholesalers earn a profit of Ksh 245,258 in a month which translates to Ksh 15 per Kg which is equal to 28% of the value of sales on average as shown in table 4.4 below. Male traders earn an average of Ksh 120,354, which translates to Ksh 15 per Kg and equals to 26% value of sales in a month whereas female traders earn an average of Ksh 18246 which translates Ks 12 per Kg and equals to 35% value of sales on average within a month as shown in table 4.5 below. Majority of the male traders (40%) are wholesalers compared to female traders who only constitute 5% of wholesalers among female traders. This therefore implies that women constitute a majority of the small scale Irish potato traders whereas men constitute large scale traders in this study area.

Table 4.4: Comparison for Retailers and Wholesalers

Variable	Retailers	Wholesaler
Total cost of purchasing potatoes	20914.37	568025
Cost of transport	844.5402	42833.33
Storage cost	328.7356	0
Security costs	154.9425	3237.5
Loading, offloading and gunny bags	11.49425	11950
County government costs	218.7126	2704.167
Total Variable Costs	22469.34	601850
Quantity sold last one month (Kgs)	780	16240
Total income	33163.51	874008.3
Gross Margin in the last one month	10406.8	245258.3
Gross Margin per Kg	13	15
Gross margin ratio	31%	28.%

Source: Author, 2019

Table 4.5: Comparison for male and female traders

Variable	Men	Women
Total cost of purchasing potatoes	305015	32095.57
Cost of transport	24393.75	1260.759
Storage cost	455	246.8354
Security costs	1912.5	178.2278
Loading, offloading and gunny bags	6750	118.9873
County government costs	1532	263.7722
Total Variable Costs	323918.3	34160.35
Quantity sold last one month (Kgs)	7998	1520
Total income	461662.5	52406.01
Gross Margin in the last one month	120354.3	18245.66
Gross Margin per Kg	15	12
Gross margin ratio	26%	35%

Source: Author, 2019

4.5.3 Gross margins analysis for processors

Processors earn the highest gross margins compared to all actors in the value chain with an average gross margin of Ksh 63513 per month which translates to Ksh 48 per Kg and a gross margin ratio of about 55% of the value of sales in a month. This high gross margin realized can be attributed to

low operation costs such as use of simple processing tools and low labour costs. They also located in urban centers where demand is available and can dictate the prices of their product and hence can sell at high prices.

4.5.4 Comparison of gross margins across actors in the Irish potato production and marketing

The findings show that farmers earn the lowest gross margin of Ksh 7585 in a month which translates to Ksh 10 per Kg of potatoes sold and equals 15% GRM or value of sales on average. The low profits realized by farmers is due to the low prices of produce that they receive from the middlemen and are also highly affected by weather changes and price fluctuation. Traders receive an average gross margin of Ks 38874 which translates to Ksh 14 per Kg and 29% of the value of sales in a month on average. The gross margin is higher compared to that of farmers because of the fact that they dictate the selling price of their produce and can even negotiate for high prices. Processors on the other end realize a gross margin of Ksh 63513 which translate to Ksh 48 per Kg of potato produce sold and equals to 55% of the value of sales in a month on average. The GRM imply that processors retain highest percentage of each shilling revenue realized from sale of potatoes while farmers retain the lowest as shown in table 4.6 below. The high gross margins realized by processors can be attributed the value addition that processors add unto the potato produce which enables them to sell the product in small portions at higher prices. Most processing units are also located in trading centers and thus there is readily available of market to sell the product. The findings for this study are in line with the findings by Beatrice Daniel (2015) who found out that farmers realize the lowest profit followed by traders and then processors in potato production and marketing in Tanzania.

Table 4.6: Comparison of gross margins for Irish potato actors in Kinangop

Variable	Farmers	Traders	Processors
Total costs	23193.13	96210.44	50736.05
Total quantity sold/processed	2625.694	2776.64	1330.5264
Price per kg (Ksh/Kg)	19	48	86
Total Income	49742.01	135084.1	114248.9
Gross Margin in the last one month	7585.14	38873.66	63512.89
Gross Margin per Kg	10	14	48
Gross margin ratio (%)	15%	29%	55%

Source: Author, 2019

4.6 Constraints at production and marketing

Different actors face different challenges at different levels of Irish potato value chain. The main challenges experienced by farmers in order of severity include lack of market, weather changes, pests and diseases and poor seed quality. Traders were mainly affected by lack of market, price fluctuation and weather changes. Processors on the other hand experienced challenges that included lack of market, price fluctuation of potato produce and poor quality of potatoes.

4.7 Technical Efficiency

4.7.1 Reliability of the model

4.7.1.1 Multicollinearity

This is a state where there is significant relationships among independent variables. This kind of relationship renders statistical inference unreliable and therefore it is important to assess the existence of multicollinearity. A number of literature on stochastic frontier analysis consider multicollinearity problem to be less important and has less effect on the model estimates (Castagno and Gallon, 2017). Some literature argue that, when the estimation targets to find out the technical inefficiency, multicollinearity is not a serious problem and therefore the interpretation of the estimates is secondary (Puig & Junoy, 2001). However, according to Kennedy (2001) and Gatemberezi (2011), a coefficient whose value is 0.8 or more implies a higher correlation in the referred independent values. Based on this criterion, the correlation coefficients of the model indicate that there is no multicollinearity as shown in appendix 4.

4.7.1.2 Heteroscedasticity

This refers to where variance of error terms varies across observations. It is ubiquitous that heteroscedasticity is a major issue when using cross-sectional data, making it difficult to make a consistent inference from regression results. Due to the existence of composite error terms in the stochastic frontier model, the standard tests for heteroscedasticity are not consistent for stochastic frontier models (Guermat and Hadri, 1999). The two proposed a test where the model is estimated with the variance σ_u and σ_v are treated as a constant and then the same model also estimated where each of the variance or both depend on the explanatory variables. The models estimated are then compared by likelihood ratio (LR) test. Following this criteria, the LR test for all models tested were not significantly different both for male and female farmers suggesting the absence of heteroscedasticity as shown in appendix 5.

4.7.2 Stochastic frontier estimation

Results for variable parameters in the production frontier are also presented in table 4.7 below.

An estimated Gama (γ) of 0.80 for male farmers and 0.98 for female farmers implies that 80% and 98% of the variation in output from the frontier is due to technical inefficiency for male and female farmers respectively. This implies that a lot of the variance in the error is due to technical inefficiency error (u) and not the random error (v) and therefore technical ineffectiveness has significant effect in explaining the output level among farmers in the sample. The likelihood ratio (LR) test is 22.25 and 58.33 for male and female farmers respectively and both are greater than 5.4 at one restriction and one percent level of significance and hence much of the variation emanates from the technical inefficiency effects. The total variance is statistically significant ($P = 0.0000$) both for male and female implying goodness of fit and correctness in the specification of the distribution of the assumptions of the composite error terms.

The variables land under potato production had positive significant ($p = 0.000$) effect on output both for men and women engaged in production. Seed used and fertilizer used were positive and significant at 5% and 10% respectively for male farmers whereas the two variables are both positive and significant ($p = 0.000$) for female farmers. 99% of the farmers reported to be using both hired and family labour and this variable reported to have positive and significant effects at 5% for female farmers and positive but insignificant for male farmers. The variable for pesticide use was positive for male farmers and negative for female farmers but insignificant for both farmer groups.

Table 4.7: MLE for the stochastic frontier model

Variable	Parameter	Male	Female
Constant	β_0	7.85603*** (0.14956)	1.2749 (0.51871)
Land under production	β_1	0.54603*** (0.08823)	0.6268*** (0.8546)
Seed used (Kgs)	β_2	0.3287** (0.06347)	0.1467*** (0.0321)
Both hired and family labour	β_3	0.071726 (0.07831)	0.4566** (0.40346)
Fertilizer used (Kg)	β_4	0.52732* (0.11802)	0.32863*** (0.0725)
Pesticides used (Kg)	β_5	0.08252 (0.07975)	-0.08675 (0.07314)
Diagnostic statistics			
Total variance ($\sigma^2_v + \sigma^2_\mu$)	σ^2	0.884513	388.5477
Gama (σ^2_v / σ^2)	γ	0.801463	0.982
No. of observations	n	129	132
Wald Chi2 (4)		44.04	544.49
Prob > chi2		0.0000	0.000
Log-likelihood		-133.0495	-172.7954
Log-likelihood ratio test (1restriction)		22.2534***	58.33032***

(..) Indicate the computed standard errors, the symbols ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Source: Author, 2019.

4.7.3 Distribution of technical efficiency levels

The distribution levels of technical efficiency is shown on table 4.8 below. Male farmers have a technical efficiency level ranging between 0.10 and 0.90 with a mean of 0.54 whereas that of female farmers ranges between 0.00 and 0.88 with a mean of 0.49. This results imply that male farmers can improve their output by 46% without increasing inputs and females can improve theirs by 51% without increasing level of inputs. The distribution table shows that 24% of the female farmers were operating at a technical efficiency level of below 0.29 compared to 15% of male farmers. According to Bagamba (2007), farms managed by women were less technical efficient compared to farms managed by men. Majority of the respondents are married but married females

have more family responsibilities to attend to and this affects farm efficiency among female farmers engaged in production (Adewuyi and Adebayo, 2014)

Table 4.8: Distribution of farmers as per technical efficiency levels

Technical efficiency ranges	Male Percentages	Female Percentages
0.00 – 0.19	6	17
0.20 – 0.29	9	7
0.30 – 0.39	13	11
0.40 – 0.49	11	12
0.50 – 0.59	19	15
0.60 – 0.69	19	12
0.70 – 0.79	21	14
0.80 – 0.89	1.2	12
0.90 – 0.99	0.8	0
Total	100	100
Maximum	0.90	0.88
Mean	0.54	0.49
Minimum	0.10	0.00

Source: Author, 2019

4.7.4 Determinants of technical inefficiency

The socioeconomic characteristics of individual farmers affect their decisions to produce and overall technical efficacy in production process. Sources of inefficiency in the estimated model is explained in this section. The parameter estimates show how a variable affects the technical inefficiency and a negative sign on the parameter implies that a variable lowers technical inefficiency and vice versa. The findings discussed below are found in table 4.9.

Table 4.9: Estimates of technical inefficiency and socioeconomic characteristics

Variable	Parameter	Male	Female
Constant	α_0	1.9838 ^{***} (1.0709)	1.5644 (0.5055)
Age	α_1	0.0291 (0.0180)	0.3265 (0.3956)
No. of children	α_2	-0.0465 ^{**} (0.1272)	-0.1079 [*] (0.3380)
Education level	α_3	-0.6526 ^{**} (0.2517)	0.24781 (1.6722)
Experience	α_4	-0.3074 ^{**} (0.0425)	0.5657 (1.0520)
Farm size	α_5	0.0056 ^{**} (0.4487)	-0.2631 ^{**} (0.7660)
Marital status	α_6	-0.3706 ^{***} (0.3392)	0.1319 ^{***} (0.3956)
Credit access	α_7	0.0993 (0.7460)	-0.4305 (0.1580)
Extension service access	α_8	-0.4907 ^{***} (0.1883)	-0.2724 ^{***} (0.7616)
Market availability	α_9	0.0838 (1.0709)	0.15645 (0.1054)

(.) Indicate the computed standard errors, the symbols ^{***}, ^{**} and ^{*} indicate significance levels at 1%, 5% and 10% respectively.

Source: Author, 2019.

The coefficient on the number of children were negative and significant at 5% and 10% for male and female groups respectively meaning that the more the number of children a farmer has, the more technical efficient he/she becomes. This can be attributed to increased family food requirements and therefore members within a given family unit strive to meet this demand and hence increased efficiency. This result agrees with findings of Gatemberezi (2011) who found out similar results, therefore, larger households are more technical efficient than the smaller households. For the male farmers, the findings are in agreement with findings by Nwaru and Ndukwu (2012) who found out that household size and technical efficiency are positively related while the findings for female farmers are contrary to their findings since they found out an inverse association between household size and the level of technical efficiency among the female farmers.

Findings revealed a positive significant ($p=0.027$) association between education level and technical efficiency the male farmers and a negative insignificant correlation between education level and technical efficiency among the female farmers. This difference can be attributed to the different levels of education acquired by male and female farmers where 48% of male farmers

have attained secondary education and above compared to females farmers at 44%. Education is associated with skill acquisition and adoption of technologies thus people with higher levels of education are more likely to acquire skills and adopt agricultural technologies faster than individuals with low level of education. The findings on education for the female findings is in agreement with that of Gatemberezi (2011) and Mukami (2018) who found out that there no correlation in technical efficiency and education level.

There was a positive and significant (p -value = 0.0143) correlation in experience and technical efficiency for male farmers whereas there was a negative relationship and insignificant relationship for female farmers. The findings for male farmers are in line with the findings by Nwaru and Ndukwu (2012) who established a positive significant relationship between experience and technical efficiency for male sweet potato producers, however, the female findings are however contrary to their findings since they found a significant positive relationship for the sweet potato female farmers. Experience signifies the skills and knowledge gained over time and how this is applied to overcome challenges around production, processing and marketing (Nwaru and Ndukwu, 2012). In order to enhance efficiency therefore, programs and policies should be directed towards the experienced farmers.

The findings show a negative and significant ($p = 0.0237$) effect of farm size and technical efficacy for male farmers whereas there was a positive and significant ($p = 0.0377$) relation for female farmers. These findings are in line with the findings by Nwaru and Ndukwu (2010 and that of male are in agreement with that of Gatemberezi (2011). Farm size is an important asset in the production process and since the major form of land ownership is inheritance, the ownership and access to land tend to favour men. With a positive link on farm size and women's technical efficiency, there is need therefore to put mechanisms in place to ensure that allocation of land should favor women in order to improve efficiency and ensure optimal land use. The findings on men could depict an overuse of land beyond its marginal product value and thus decreasing returns to scale.

In regard to marital status, most responses showed that respondents were married with responses at 87% and 76% for male and female farmers respectively. The marital status was significant ($P = 0.000$) for both farmer groups although the relationship was positive for male and negative for female farmers. The findings for male farmers were in agreement with the findings by Gatemberezi (2011) were marital status is positively related to technical efficiency. The married men had more

responsibility to provide for family, have more access to productive resources and can make decisions around production and marketing of potatoes unlike married women whose decision on what and where to produce and even sale lies on their spouses. To enhance efficiency therefore, policies and programs should target the married men.

Credit access is insignificant and positive for female farmers and negative and insignificant for male farmers. The findings for both groups are in agreement with the findings by Gatemberezi (2011) and Mukami (2018) but are contrary to the findings by Nwaru and Ndukwu (2012). There is very limited access to credit in the study area both for male (10%) and female (13%) and this can be attributed to high interest rates charges and other collateral requirements for securing credit. Farmers are also uncertain on returns to investment especially in the productions process and therefore shy off from accessing credit.

Results indicate that extension services access and technical efficiency was positive and significant ($p = 0.000$) for both farmer groups. The findings for female farmers were in agreement with that of Nwaru and Ndukwu (2012), however, the findings for male farmers are contrary to their findings. Similar findings were found by Gathemberezi (2012), Nyagaka *et al* (2010) and Mukami (2018). Proper dissemination of agricultural information to farmers by extension services is crucial since this will help to improve farmers' level of technical efficacy.

CHAPTER 5: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of findings, the conclusion drawn from the study, recommendations and points out areas for further research.

5.1 Summary of findings

In the course of study, cross-section primary data was obtained from 288 farmers, 99 traders and 39 processors across six wards of Kinangop sub-County through personal interviews. Stratified and purposive sampling technique was applied to select farmers whereas snowball technique was applied for traders and processors.

Data collected was disaggregated in terms of gender for producers and traders and descriptive statistics was used and give the socioeconomic characteristics of farmers. The findings showed that majority of the actors at the production and marketing level were at the active working bracket of between 35 and 50 years with over 50% of each the respondents in each category having attained primary education with processors having high the highest level of education qualifications. Over 60% of the respondents among farmers, traders and processors are married with an average number of two children per individual. Findings reveal that producers comprise of both men and women while at the trading level, women comprise a majority of the retailers 95% and men comprise a majority of wholesalers and middlemen at 40% and 99% respectively. Processors comprise of both men and women in equals numbers of 50%.

The study employed gross margin analysis to analyze the gross margin differences between male and female producers, retailers and wholesalers and processors in the Irish potato value chain. The findings reveal that female producers earn a lower profit of Ksh 5907 while male producers earn a profit of Ksh 9240 per month on average. Retailers earn a profit of Ksh 10407 while wholesalers earn a profit of Ksh 245,258 per month on average. Processors on the other end earn a profit of Ksh 63513 on average. In addition to this, the findings showed that farmers received lowest level of gross margins of Ksh 7585, followed by traders at Ksh 38874 and processors at Ksh 63513.

Furthermore, the study analyzed technical efficiency for male and female farmers involved in producing Irish potatoes. In the stochastic frontier model, the findings revealed that the estimates for land under potato production, seeds used and fertilizer used were positive and significant for all the farmers groups. The distribution of technical efficiencies showed that women had a mean technical efficiency level of 0.49 with a minimum of 0.00 and a maximum of 0.88 and men had a mean technical efficiency of 0.54 with a minimum of 0.10 and a maximum of 0.90. The findings also showed that about 24% of female farmers are operating below 0.29 level of technical efficiency compared to 15% of male farmers who were operating at the same level of technical efficiency. In the estimation of the determinants of technical efficiency, number of children and extension service access is positive and significant for both farmer groups while education level, experience and marital status is positive and significant for male farmers and farm size and access to credit is positive and significant for female farmers. Gama (γ) of 0.80 and 0.98 for male and female respectively implies that 80% and 98% of the variation in output of male and female farmers from the frontier output is due to technical inefficiency among farmers producing Irish potatoes in Kinangop.

The main challenges experienced by farmers are lack of market, weather changes, pests and diseases and poor seed quality. Traders were mainly affected by lack of market, price fluctuation and weather changes. Processors experience challenges that include lack of market, price fluctuation of potato produce and poor quality of potatoes.

5.2 Conclusion

The purpose of this study is to assess if there exists any significant differences in gross margins and technical efficiency levels among men and women acting on Irish potato value chain in Kinangop Sub-County, Nyandarua County. From the first objective, the study disaggregated the study in terms of gender and assessed the differences across actors. The findings showed that, female farmers owned less land, had lower levels of education and applied less inputs to their farms compared to men. Female traders also comprised mainly of retailers compared to men who mainly comprised of wholesalers and middlemen. Processors however comprise of both men and women.

In the second objective, the results showed that the gross margins levels varied between men and women producers, between retailers and traders, male and female traders and among farmers, traders and processors. Women received lower gross margins both at the production and marketing levels owing to the small farm sizes they own and cultivate potatoes and their involvement mainly in retailing potato produce. Farmers received the lowest gross margin compared to all actors in the value chain because of high costs involved in production, effects of weather changes and low farm gate prices they receive for their produce. Processors received the highest gross margins among actors in the value chain and this can be attributed to low costs of adding value to the product and the ability to negotiate for price of Irish potato produce and dictate price of product.

The third objective was to assess the differences in technical efficiency levels among male and female farmers. The findings showed that technical efficiency levels were low for both men and women suggesting the presence of technical inefficiency. Female farmers had lower levels of technical efficiency compared to male farmers. In the determinants of technical efficiency, the effects of variables that affected technical efficiency varied between men and women except number of children and extension service access whose effect was the same for both men and women.

5.3 Recommendations

The study recommends enhancing access to extension facilities among farmers. The positive relationship between technical efficiency and extension service implies that farmer access to extension services will not only improve efficiency but also enhance productivity in Irish potatoes in the area. Extension services can be used to promote technologies and avail information to farmers on how to improve productivity through means such as proper ways of crop establishment and management and appropriate application of inputs that increase production. Development agencies and policy makers should therefore ensure that they work hand in hand with extension officers in order to ensure that there is access to information and realization of adoption of technologies being promoted.

Market availability is a major challenge that farmers face because they are highly exploited by middlemen. Stakeholders and policy makers should not only strive to focus on promoting efficiency and productivity but also focus on policies that strengthen market access especially at

farmer level. Some of the policies would include the setting up of cold facilities where farmer and development agency can negotiate on how the potato produce can be stored during seasons of glut and be sold when production is low. There should be a focus on establishment or strengthening of linkages between farmers and urban traders so that exploitation by middlemen is minimized.

Development programs and policies should focus on how women should be highly integrated into agricultural programs that help to enhance efficiency and productivity. This can be achieved through capacity building and trainings that ensure that women have access to productive resources such as land and capital and have access to information that enables them to improve on their production and efficiency. At the marketing level, women should be enlightened on how to market their produce as well as the need to engage in large scale business operations and value addition of produce so that they can fetch high prices and improve their earnings.

Stakeholders should also consider setting up of processing units where farmers are not only trained on how to meet quality of potatoes produced but also avail market for the for the farmer produce. This can be achieved because the processing firms will source for market to sell processed Irish potato product but ensure that they buy produce from farmers at better prices.

In order to promote uptake of credit by farmers especially for crop production, micro-financial institutions should strive to promote financial literacy among farmers. This should be accompanied by crop insurance programs that help to cushion farmers against crop failure. Increased productivity and earnings among actors in the value chain can be realized when challenges affecting farmers, traders and processors are adequately addressed by stakeholders and development agencies working to promote potato production in the study area, the country and beyond.

5.4 Suggestions for further research

This study focused on analyzing gender difference in gross margins and technical efficiency among Irish potato actors, other researches can analyze the allocative and economic efficiency differences among Irish potato farmers in Kinangop sub County. A comprehensive analysis of Irish potato value chain can help to bring out the reasons why its production has been declining over time.

Extension services have a significant and positive effect in promoting efficiency and productivity. There is need therefore to bring the economics of offering extension service through evaluation of costs and benefits of offering these services as this will help policy makers in designing the roles of extension service providers and ensure that greater effectiveness is realized.

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5. What types of inputs are used?

Input	Type	Quantity	Cost per Kg or Ltr
a. Fertilizer: Inorganic:	DAP	-----	-----
	CAN	-----	-----
	Others(Specify)	-----	-----
Organic: Manure		-----	-----
b. Pesticides/Herbicides (i)-----	(i)-----	-----	-----
	(ii)-----	-----	-----
	(iii)-----	-----	-----
c. Other inputs (Specify) -----		-----	-----

6. What is the cost of transporting inputs to your farm? -----Ksh

7. Labour/costs used in Irish Potato Production

Activity	Man-days (Labour)	Contractual arrangement	Machinery	Cost Ksh
Plowing				
Harrowing				
Planting				
Weeding				
Harvesting				

8. How much potato was harvested last season? -----Kgs

9. Did source for market to sell your produce during the last season? Yes [] No []

10. Where did you sell your output? : Farm gate [] Market Place []

11. What was the market/farm-gate price of yield per Kg? -----Ksh

12. Are there middlemen/brokers who purchase potato yields at your farm? Yes [] No [].

13. If the answer in (11) above is yes, are they mostly Men [] or Women []

14. Do you have access to any off-farm incomes? Yes [] No []. If yes, tick the appropriate off farm incomes.

- a. Employment []
- b. Business []
- c. Pension []
- d. Remittances []

e. Other (Specify) -----

15. Do you use the off-farm income in (13) above to finance potato production? Yes [] No []
16. Did you access formal or informal credit in the last season? Yes [] No []
17. Did you access extension services in the previous season? Yes [] No []
18. Do you know where you will sell you Irish potato produce this season? Yes [] No []
19. Are you a member of any cooperative, association or group Yes [] No []
20. If the answer in (18) above is yes, does the group, cooperative or association help you in accessing services that promote Irish potato production or marketing? Yes [] No []
21. Is your group among the groups being trained by CARE Kenya on the EGIA project? Yes [] No []
22. What factors affect your Irish Potato farming enterprise?

Factor	Tick	Rank
Pests and diseases	[]	-----
Lack of capital	[]	-----
Poor soils	[]	-----
Lack of land	[]	-----
Weather changes	[]	-----
Access to credit	[]	-----
Access to extension services	[]	-----
Poor seed quality	[]	-----
Lack of market	[]	-----

11. What was the unit cost of Irish potato produce -----Ksh/Kg/bag

12. What mode of transport did you use to transport the potato yield to the point of sale?

Mode of Transport	Cost/trip/bags/Kgs
a. Individual []	-----
b. Motorbike []	-----
c. Public means []	-----
d. Truck []	-----

13. Do you keep daily records of purchases and sales? Yes [] No []

14. Where do you store your produce awaiting sell? -----

15. What other marketing costs do you incur?

Type of cost	Amounts (Ksh)
a. Security costs []	-----
b. Marketing charges []	-----
c. County government charges []	-----
d. Storage costs []	-----
e. Other charges (specify) -----	-----

16. Did the price of selling Irish potato vary during the one month? Yes [] No []

17. If the answer is yes in (16) above, what was the:

- a. Highest price -----Ksh/Kg/bag
- b. Lowest price -----Ksh/Kg/bag

18. What is the total quantity of potato produces that you sold during the last one month? -----
----- Bags/Kgs.

19. Are you a member of any marketing cooperative? Yes [] No []

20. Do you access any form of credit that you use to undertaking trade on Irish Potato produce?

21. What are the major constraints that you face while undertaking business on Irish marketing?

- i. -----
- ii. -----
- iii. -----
- iv. -----

10. What is the total amount of Irish potato produce that you bought in the last one month? ---
-----bgs/kgs

11. What was the unit price for the produce you bought? -----Ksh per -----Kg/bag/ debe

12. How much portions/plates of potato produce do you make from a bag or a debe ----
plates/portions.

13. Does the price of the potato produce vary over time? Yes [] No []

14. What is the price of the potato produce during

a. peak season (when potato yield is low) -----Ksh

b. Off peak (when potato produce is readily available) -----Ksh

15. Where do you obtain the Irish potato produce from?

a. Farmers []

b. Traders []

c. Suppliers []

d. Others (specify)-----

16. What costs do you incur on the crop produce?

Costs incurred	Tick	Amount (Kshs)
a. Transport	[]	-----
b. Labour	[]	-----
c. Security costs	[]	-----
d. County government charges	[]	-----
e. Storage costs	[]	-----

17. Does the price of the processed Irish potato product vary within the last one month?

a. Highest Price -----Ksh/Kg/bag

b. Lowest price -----Ksh/kg/bag

18. What total quantity of potato produce did you process in the last one month? -----
bags/Kgs

19. What constraints do you face in the Irish potato processing enterprise?

i. -----

ii. -----

iii. -----

Appendix 4: MLE for the stochastic frontier model

Variable	Parameter	Male	Female
Land under production	β_1	0.54603*** (0.08823)	0.6268*** (0.8546)
Seed used (Kgs)	β_2	0.3287** (0.06347)	0.1467*** (0.0321)
Both hired and family labour	β_3	0.071726 (0.07831)	0.4566** (0.40346)
Fertilizer used (Kg)	β_4	0.52732* (0.11802)	0.32863*** (0.0725)
Pesticides used (Kg)	β_5	0.08252 (0.07975)	-0.08675 (0.07314)
Age	α_1	0.0291 (0.0180)	0.3265 (0.3956)
No. of children	α_2	-0.0465** (0.1272)	-0.1079* (0.3380)
Education level	α_3	-0.6526** (0.2517)	0.24781 (1.6722)
Experience	α_4	-0.3074** (0.0425)	0.5657 (1.0520)
Farm size	α_5	0.0056** (0.4487)	-0.2631** (0.7660)
Marital status	α_6	-0.3706*** (0.3392)	0.1319*** (0.3956)
Credit access	α_7	0.0993 (0.7460)	-0.4305 (0.1580)
Extension service access	α_8	-0.4907*** (0.1883)	-0.2724*** (0.7616)
Market availability	α_9	0.0838 (1.0709)	0.15645 (0.1054)

The coefficients of the parameters are all < 0.8 suggesting the absence of multicollinearity

Appendix 5: Comparison of LR tests for the different models estimated for Heteroscedasticity

Variable	Male	Female
<i>Model 1: Both sigma-u and sigma-v are treated as constants</i>		
Log-likelihood	-133.0495	-172.7954
Likelihood ratio (LR) test	22.2534***	58.3303***
<i>Model 2: Sigma-u depends on explanatory variables</i>		
Log-likelihood	-130.4351	-173.4995
LR test	21.9144***	58.5751***
<i>Model 3: Sigma-v depends on explanatory variables</i>		
Log-likelihood	-134.5147	-171.8491
LR test	22.5943***	57.9837***
<i>Model 4: Sigma-u and sigma-v depends on explanatory variables</i>		
Log-likelihood	-129.8734	-170.5481
LR test	21.4874***	57.1438***

There is no significant differences in LR tests for all models hence no evidence of heteroscedasticity.