PARTICIPATION IN CONTRACT FARMING AND ITS EFFECTS ON TECHNICAL EFFICIENCY AND INCOME OF VEGETABLE FARMERS IN WESTERN KENYA

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A56/9487/2017

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

2020

DECLARATION

This thesis is my original work and has not been submitted to any other University for any other award.

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DEDICATION

This thesis is dedicated to my parents, Mr. Paul James Alulu and Mrs. Florence Kadeiza, who have been of great support throughout my entire academic journey.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to God for granting me mercies and strength during the entire period of working on this thesis. Special appreciation to my supervisors; Dr. David Jakinda Otieno, Prof. Willis Oluoch-Kosura and Dr. Justus Ochieng' whose contribution and suggestions helped me to improve my thesis. Furthermore, I would like to thank my parents and siblings for their moral support while I was working on this thesis.

I am grateful to the African Economic Research Consortium (AERC) and German Academic Exchange Service (DAAD) for the financial support offered through funding my postgraduate programme and research.

Lastly, I would like to acknowledge my friends Sally Mukami Kimathi, Philip Miriti, Arnold Musungu, Billy Okemer Ipara, Dennis Olumeh, Mohammed Saada, Kevin Maina, Arnold Kwesi, Sylvester Ojwang', Amos Tirra and Mary Mulandi Kaveke for their continuous motivation and value addition to my work.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIVs	African Indigenous Vegetables
ASDS	Agricultural Sector Development Plan
CIDP	County Integrated Development Plan
FFS	Farmers' Field School
FGD	Focus Group Discussion
GDP	Gross Domestic Product
Kshs	Kenya Shillings
MPP	Marginal Physical Product
MT	Metric Tones
PPF	Production Possibility Frontier
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
TE	Technical Efficiency
TGR	Technology Gap Ratio
USD	United States Dollar
USSD	Unstructured Supplementary Service Data

ABSTRACT

Contract farming is becoming popular in most developing countries. Most African farmers operate relatively smaller farm sizes and are resource-poor, characterized by poor access to farm and financial inputs and operate in unreliable inputs and output markets. Extant literature shows that contract farming offers solutions to most of these constraints. However, not all smallholder farmers participate in contracts and those who do, often violate the contracts. Empirical research on effect of contract farming on smallholder livelihoods show inconclusive results; some studies have shown that contract farming improves farmers' productivity and income, while others find it having a negative effect on income and productivity. This study therefore analyzed participation in contract farming and its effects on technical efficiency (TE) and smallholder farmers' income in Bungoma and Busia counties in Western Kenya. The present study focused on chili and spider plants as the targeted vegetables due to their richness in vitamins and phytochemicals. Primary data was collected from 300 smallholder vegetable farmers in Bungoma and Busia counties. A Probit model was used to analyze the determinants of participation in contract farming while stochastic production frontier and metafrontier models were applied in analyzing TE and technology gaps. Endogenous treatment regression model was used to analyze the effect of participating in contract farming on farm income. Results revealed that, land size had a positive effect on participation in contract farming for both spider plant and pooled farmers. Contract farming had a positive effect on TE and technology gap ratios (TGRs) for both crops. Participation in contract farming had a positive effect on farm income for spider plant, chili and pooled vegetable farmers. The incentives and disincentives of contracting firms should be put into account when designing programmes and policies for promoting contract farming to ensure that there is a balance in benefits between the contracting and contracted parties.

Key words: Contract farming, chili, spider plant, TE, TGR, income.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

The horticulture sub-sector is important to Kenya's economy due to its contribution of about 40% to agricultural Gross Domestic Product (GDP). Vegetables contribute about 36% of the total value of horticulture (Republic of Kenya, 2016). Vegetable farmers however, face various challenges in production and marketing. These include high production cost due to high input costs, low prices for outputs, unstable markets for inputs and outputs, inadequate infrastructure, poor market information due to high transaction costs, limited access to financial resources and poor institutional environment characterized by inefficient property rights and market regulations.

Participating in horticultural global value chains has become an important link between the rural farmers and the global economy where local suppliers interact with global buyers in trading fresh produce, for instance fruits and vegetables (Byerlee et al., 2009). This study focused on chili pepper (*Capsicum species*) and African Indigenous Vegetables (AIVs) specifically spider plant (*Cleome gynandra*), which are widely grown by smallholder farmers in Western Kenya. According to the Republic of Kenya (2019), Bungoma and Busia are among the top ten counties leading in production of spider plant; with Bungoma producing about 800 metric tons (MT) while Busia about 400 MT. Both chili and spider plant are rich in vitamins and minerals, hence important components for a nutritionally diversified diet (Ochieng et al., 2016). The AIVs are also considered more nutritious in terms of micronutrients and phytochemicals necessary for a healthy living than exotic vegetables (Dube et al., 2017).

Chili is used in rural households as well as urban settings as spices due to its color, pungency and flavor. Chili is also used in the preparation of different palatable delicacies for instance chili chicken, chili sauce and chili jam. Chili pepper is consumed fresh, dried or in powder form (El-Ghoraba et al., 2013). The medicinal and nutritional importance of chili gives it more relevance. Chili has high amount of vitamin C among others for instance vitamin B6, vitamin K, vitamin A and minerals such as magnesium, calcium, potassium, iron, thiamin, copper and folate. Chili has diverse medicinal uses such as relief of pain, anti-bacterial, anti-arthritic, anti-rhinitis, analgesic properties and anti-inflammatory. Chili has special roles in boosting immunity for the management of cardiovascular diseases, obesity, type-2 diabetes and also manages spread of prostrate cancer. The consumption of chili is related with reduction in human deaths hence it is a beneficial component of daily diet (Swapan et al., 2017). Globally, chili is one of the fruit vegetables that generate high incomes for producers and therefore contribute a lot to the alleviation of poverty and improvement of social status of farmers especially female farmers (Karungi et al., 2013).

The importance of spider plant has been emphasized in the food security and biodiversity conservation contexts due to its richness in phytochemicals and micronutrients, which are associated with anti-malaria, antioxidant and anti-microbial properties. Spider plant plays a key role in food security and nutrition of people in SSA, Kenya included (Onyango, 2013). In Kenya, 57% of the spider plant is produced for home consumption while 43% is produced for income generation. Spider plant is rich in vitamin A and C and other minerals such as iron and calcium (Venter et al., 2007). Studies focusing on nutrition report that spider plant is superior nutritionally compared to other exotic leafy vegetables like cabbage due to its higher content of vitamin C, protein, iron, calcium and magnesium that are vital in addressing deficiency related diseases (Mbugua et al., 2009). Many SSA countries are threatened by food and nutritional insecurity. Consumption of AIVs like spider plant has been instrumental in most African countries as far as health, food security and income generation are concerned.

Chili and spider plant have shorter growing cycles compared to other major crops like maize and are able to make maximum utilization of soil nutrients and scarce water supplies (Weinberger and Lumpkin 2007). Empirical evidence reveals that traditional vegetables give the smallholder farmer a higher return per unit area compared to other major crops like maize (Afari-Sefa et al., 2015). Some traditional vegetables for instance spider plant are also known for their ease of cooking, production and processing (Kansiime et al., 2016). Smallholder farmers earn on average about USD$1000 per annum from vegetable farming (FAO, 2015). Nationally, the area under chili is about 1,322 hectares (ha), producing a total of 11,133 metric tons (MT) with a monetary value of Kenyan shillings (Kshs) 444,778,506.[1] The area under indigenous vegetables is 45,099 ha with a total volume of 224,751 MT valued at Ksh 5,621, 514, 888 (Republic of Kenya, 2019).

Contract farming reduces price risk and ensures stable demand; hence, it serves as an important institutional arrangement in horticultural production and marketing (Minot, 2011). Contract farming has been viewed as the best way to overcome the constraints caused by market failure. It is a platform that forms the institutional environment, which facilitates the integration of primary producer's into agro-industry (Saenz, 2006). Contract farming is an agreement between farmers and buyers. It requires farmers' obligation to produce and supply produce as specified in terms of quality, quantities and time. On the other hand, the buyers are obliged to facilitate upfront delivery of inputs and where specified provide other non-financial services such as extension, training, transport, logistics and securing markets for farmers' produce while paying an agreed price (Prowse, 2012).

Bijman (2008) classified contracts into the following models: informal, centralized, multipartite and intermediary models. The informal model involves casual oral agreements characterized by

[1] 1USD = Kshs 101.16 (Central Bank of Kenya, indicative exchange rates, as at 07-01-2020).

absence of written binding documents. A centralized model involves a system where operations are consolidated such that one buyer procures commodities from small-scale farmers and provides most of the inputs and extension services. The multipartite contract farming involves a combination of two or more organizations that coordinate the corporation. An intermediary model is a mediated system where an agent organizes all activities on behalf of the final buyer right away from input supply, extension services provision, farmers' payment and final transportation and delivery of the product.

Contracts can be further classified into three groups: market specification contracts, production management contracts and resource-providing contracts. Market specification is a pre-harvest agreement where the buyer (firm) commits to buy the output from the producer. Production management contract involves farmers adopting a specific technology, input regimes and post-harvest practices as directed by the firm. In a resource-providing contract, the firm avails inputs, supervision over production and output market (Prowse, 2012).

There are several determinants of smallholder farmers' participation in contract farming. Key among these include: the need to access inputs and services which cannot be obtained from the spot (traditional) markets because of lack of adequate capacities to invest in these inputs, the need to reach markets that are more remunerative and a price premium which serves as an important component of contractual package due to its impact on farmers' income (Ton et al., 2018). World Bank (2007) and Da Silva and Rankin (2013) found that smallholder farmers are motivated to participate in contract farming in order to connect to output markets and access credit and extension services.

Technical efficiency (TE) refers to the measure of how a farm can produce maximum output using a given amount of inputs and technology (Coelli et al., 2005). A technically efficient farm will therefore produce at the highest production possibility frontier (PPF). The TE can as well be achieved in a situation where a given quantity of output is produced using the least amount of inputs subject to available technology. According to Briec et al. (2006), a farm is considered to be technically efficient when it produces the same amount of output using less or reduced inputs.

Smallholder farmers in the SSA region experience low technical efficiencies (PingSun et al., 2008). The low levels of TE can be attributed to unsupportive market structures in the insurance, credit, product and information services, making it difficult for farmers to optimally use the available resources (Henningsen, 2015). This leads to smallholder farmers having a huge gap between the actual and potential output with income levels remaining low. A higher TE leads to higher productivity, improved output and increased income without necessarily changing technology (Dobrowsky, 2013).

In the study sites considered in this study, chili is planted in October at the onset of short-rains and harvested in late December or early January when the weather is dry. Chili is grown between these months because it is a warm seasoned crop whose yield increase with warm temperatures. There are various cultivars of chili grown in Kenya for instance; *cayenne*, *serenade*, *African bird* eye and *jalapeno* but *cayenne* and *African bird eye* are the common varieties in the study area. Chili does well in areas with medium rainfall of about 600-1200mm per annum, optimum temperatures of 20 to 30 degrees Celsius and non-acidic, loamy and well-drained soils with *PH* of 6.0 to 6.5. Harvesting of the fruits takes place 3 months after transplanting and the fruit picking continues up to 4 months. Harvesting is done once or twice a week to ensure that all red fruits are harvested. Spider plant on the other hand, grows well during warmer seasons since it is sensitive to cold. It performs well with a temperature of above 15 degrees Celsius. It grows from 2400 meters above sea level. Spider plant seeds should be sown at the onset of rainfall for maximum utilization of water. Vegetable farmers in the study area encounter challenges such as inadequate access to credit and stable markets. Contract farming is gaining popularity and is expected to address these constraints through upfront provision of inputs and assurance of ready markets.

Several studies for instance; Bellemare (2012), Sokchea and Culas (2015) and, Bellemare and Novak (2017), show that contract farming is beneficial to the smallholder farmers by enabling them gain better access to ready markets, both local and global thus enhancing farmers' income hence better livelihoods in the long run. Contract farmers benefit from high and steady incomes that come about due to increased productivity and training on good agricultural practices. Farmers receive quality recommended inputs on credit and technical skills and guidance from the contractor hence, improving yield and quality thus improving contracted households' incomes. However, contract farming is threatened by breach of contract where smallholder farmers engage in side selling while contractors fail to honor payments.

Smallholder farmers violate contracts in cases where buyers (firms) portray unfavorable behavior for instance, when buyers: provide poor extension services, offer low prices for produce, overprice their services, pass their risks to producers, delay in payments for produce, favor larger farmers, fail to provide compensation for calamity loss and fail to explain the pricing method. This leads to loss of trust and friction in the previously established relationship between the contracting parties. Farmers who violate contracts also end up facing uncertainties in income due to unstable markets in subsequent cropping seasons (Singh, 2002). For decades, there has been a major concern about power imbalance between smallholder farmers and buyers (firms) due to the large size of buyers where in some instances buyers collude to control terms of contracts hence the questioning of the benefits of contract farming arrangements (Von Hagan and Alvarez, 2011).

Smallholder farmers in SSA continue to experience low farm efficiencies. This could be attributed to poor land tenure, lack of access to inputs like seeds and fertilizer, low level of education of household heads and too small land sizes (Mburu et al., 2014). Several studies for example Ramaswami et al. (2006) and Chakraborty (2009) showed that contract farming has a significant positive effect on farm efficiency and productivity while other studies such as Miyata et al. (2009) found no significant difference in farm efficiencies of farmers in contract farming and non-participants. A considerable amount of literature has focused on determinants of farm efficiency but only few studies have assessed the effect of contract farming on farm efficiency. This study therefore sought to analyze the determinants of participating in contract farming and its effects on TE and income of chili and spider plant farmers in western Kenya.

1.2 Statement of the research problem

From previous literature, it is evident that farmers in Busia and Bungoma counties are vulnerable to food insecurity due to their low farm productivity. This is attributed to poor access to credit, poor infrastructure, high input costs and climate change (Wabwoba, 2017). Most farmers in both counties are thus resource-poor with limited access to reliable markets just like other farmers in most parts of SSA (Gramzow et al., 2018). Smallholder farmers in SSA continue to experience low farm efficiencies. This could be attributed to poor land tenure, lack of access to inputs like seeds and fertilizer, low level of education of household heads and too small land sizes (Mburu et al., 2014). Extant literature shows that contract farming offers a solution to most of these constraints through input supply and creation of market linkages to the resource- poor smallholder farmers. However, contract farming still faces the threat of violation. In addition, there exists inconclusive results about the effect of contract farming on income and efficiency. Some studies find positive effect while others find negative or no significant effect. Despite the perceived benefits of AIVs, most of the previous studies have ignored the exploration of these vegetables as targeted enterprises in contract farming. The present study therefore fills this knowledge gap by assessing the effect of contract farming on chili and spider plant farmers' TE and income. In addition, unlike previous studies that explore the effect of contract farming separately, the present study addresses the collective effect of contract farming on TE and livelihood using farm incomes of the targeted vegetables as the indicator.

1.3 Research objectives

The main objective of this study was to analyze participation in contract farming and its effects on TE and income of vegetable farmers in western Kenya. The specific objectives were to:

i. Assess determinants of smallholder farmers' participation in vegetable contract farming.
ii. Determine the differences in TE between contracted and non-contracted vegetable farmers.
iii. Analyze the effect of participation in contract farming on farm income from chili and spider plant.

1.4 Research hypotheses

The following hypotheses were tested:

i. Socio-economic and institutional factors do not affect smallholder farmers' participation in vegetable contract farming.
ii. There are no significant differences in TE between contracted and non-contracted vegetable farmers.
iii. There is no significant difference in farm income from chili and spider plants between contract participants and non-participants.

1.5 Justification of the study

Contract violation has become common in many SSA countries for instance Kenya (Simmons et al., 2005). Assessing determinants of participation in contract farming will give relevant insights as to why farmers participate in contract farming and what leads them to violating the contracts. This information will be useful to the county governments and other stakeholders who influence decisions to increase efficiency and effectiveness of contracts in the counties. Analyzing determinants of participation in contract farming will provide development partners, contracting firms and the county governments with vital information on how to improve smallholder farmers' access to and participation in markets as one of the major strategies of increasing value in agriculture and enhancing food security. This pursuit is in line with the goals enshrined Kenya's Vision 2030 (Republic of Kenya, 2019) and Kenya Nutrition Action Plan (Republic of Kenya, 2018).

Determining the relationship between contract farming and TE provides information that will assist the county and national governments to develop feasible policies that will improve smallholder famers' efficiency, hence improving output, income and living standards and reducing poverty as outlined in the African union's agenda 2063 (African Union Commission, 2015). This is in line with the sustainable development goal (SDG) number 1 that aims at ending poverty and the SDG number 2 that seeks to achieve food security, end hunger and improve nutrition (Republic of Kenya, 2019). Assessing the effect of contract farming on efficiency will help the county governments of Bungoma and Busia to best articulate strategies aimed at increasing farm efficiencies in order to achieve improved farm productivity as outlined in the Agricultural Sector Development Strategy (ASDS).

Analyzing how contract farming affects farmers' income will help the county governments in devising policies aimed at achieving agricultural productivity and increased income among the smallholder farmers within the county according to the nutrition report by WHO (2018). The findings will also be useful to other value chain actors of chili and spider plant for instance input suppliers and buyers on how to strategically position themselves in the value chain.

1.6 Study area

This study was conducted in two counties in western Kenya: Bungoma and Busia, which were selected purposively (Figure 1).

Figure 1: Map of the study sites in western Kenya

Source: https://www.maps-streetview.com/Kenya/Bungoma.

Apart from the high agricultural potential in Bungoma and Busia counties, they were selected due to their strategic positioning geographically at the boarder of Kenya and Uganda. This was of interest to this study due to the opportunity for cross-broader trade in horticulture, more so the targeted vegetables in this study. Understanding how contract farming affects productivity and livelihoods of smallholder vegetable farmers will be useful in making strategies of fully exploiting the opportunities that lie in cross border trade within the region.

Bungoma county has a population of about 3.5 million, while Busia county has a population of about 800,000 people (Republic of Kenya, 2019). Both counties' economies are driven by agriculture, which is the main occupation and source of income for the population. Agriculture serves as the main source of food for households and supports the agro-based industries through provision of raw materials. The average annual rainfall in the study sites is about 1100mm on average while the temperature ranges from 0 to 32 ^{0}C for both counties. Among the crops grown are; maize, beans, sweet potato, Irish potato, banana and vegetables in which chili and spider plant are included.

According to the Republic of Kenya (2013), among the major challenges facing agricultural productivity in Bungoma and Busia counties are inadequate access to farm inputs for instance, fertilizer and certified seed, poor infrastructure, inadequate extension services caused by high farmer to staff ratio, lack of access to new knowledge on modern farming practices and poor access to market due to low productivity and poor access to adequate and timely information. Wabwoba (2017) reveals that smallholder farmers in Bungoma county suffer from disorganized markets, high cost of inputs with high levels of poverty. Malnutrition is a key challenge in Bungoma county for instance, only 22% of the children in the county eat a balanced and diversified diet (World Bank, 2016). The malnutrition and underweight levels in Busia counties stand at 26.6% and 16%, respectively (Wasike et al., 2018). The average poverty index in Bungoma and Busia counties are 52.9% and 66.7% compared to 46% national index, with food insecurity level at about 40% (Republic of Kenya, 2019). Previous studies have focused on crops grown by large-scale farmers while little has been done on crops like spider plants and chili that are mainly grown by the resource-poor smallholder farmers. This motivated this study to be conducted in Bungoma and Busia where poverty levels are high, to draw recommendations that will be useful in improving the smallholder farmer's welfare.

1.7 Organization of the thesis

This thesis is structured into six chapters. The first chapter has provided the introduction, statement of the research problem, objectives, description of the study area and justification. The literature review is described in chapter two. Subsequent chapters three, four and five are presented in paper format. Characterization of the respondents is contained in chapter three. Chapter four addresses the first and the third objective combined, while chapter five provides methodology and results for the second objective. Finally, the overall conclusions and recommendations are offered in chapter six.

CHAPTER TWO: LITERATURE REVIEW

2.1 A review of contract farming and its relevance to smallholder farmers' livelihoods

Contract farming can be understood as an arrangement where a firm lends inputs to farmers in exchange for exclusive purchasing rights. Contract farming can also be viewed as a form of vertical integration in the value chain of agricultural commodities where the firm has much control over the process of production, the timing of the produce and the quality and quantity. Catelo and Costales (2008) define contract farming as a binding arrangement between a contractor and the contracted, taking the form of a forward agreement with clearly defined roles and rewards for tasks, with product specifications in terms of quality, quantity and delivery timing.

Contract farming is increasingly becoming popular in the developing countries. The need for market access is a key factor that stimulates the growth of contract farming (Oya, 2012). The need to reduce the direct involvement of the government in provision of services, the growing number of supermarkets and the high level of interest and attention of donors are the other reasons that explain why contract farming is becoming more popular (Birthal et al., 2008).

Since the colonial period, there has been investor rush for land in SSA and international development agencies have increasingly advocated for contract farming as an alternative development opportunity for inclusion of smallholder farmers. Cai et al. (2008) and Sethboonsarng (2008) showed that contract farming helps farmers to improve production and marketing. Through contract farming, farmers are able to get access to credit line, farm machinery and equipment, training on agricultural production and improved technology in production.

Bellemare and Novak (2017) showed that contract farming has a positive impact on the smallholder farmers by enabling them to gain better access to ready local and global markets.

Studies on effects of participating in contract farming reveal that participating farmers benefit in terms of high incomes (Barrett et al., 2012; Bellemare, 2012). Other studies for instance Pari (2000) found that contract farming increases the cost of production as well as the gross returns. This is due to high level of differentiation and high input costs.

Despite previous literature showing that contract farming increases the income of the participating farmers, contract farming does not always work for farmers due to imbalance of bargaining power among the contracting parties. Firms can create manipulations for example raising quality standards for the produce in order to regulate the quantity purchased, changing prices and portraying dishonest behavior (Cai et al., 2008). In addition, Otsuka et al. (2016) argued that although a reasonable number of empirical studies found positive impact of contract farming on income, the evidence is not convincing because most crops under contract farming are labor-intensive, hence income from other enterprises (farm or non-farm) ends up being foregone thus affecting the net income gain. In addition, Masakure and Henson (2005) argued that contract farming is advantageous to large-scale farmers only and it is a tool to drive smallholder farmers from the market resulting into rural poverty and causing inequality among the smallholder farmers. Self-selection and firm-selection bias postulate that participants of contract farming have special characteristics thus contract farming is heterogeneous in effects. Some farmers benefit more while others may end up making losses for instance due to failure to meet minimum requirements set by firms for example produce quality and land ownership (Minot et al., 2015). Generally, contract farming is viewed as a remedy to most constraints faced by farmers through provision of stable demand, counteracting information asymmetry problem and reducing the risk of price volatility (Minot, 2011; Narayanan, 2014).

2.2 Factors affecting participation in contract farming

The theory and insights of contract farming have a special importance to the analysis of smallholder farmers' development in SSA. In addition, contract farming has proved to be an attractive and viable option for various policy makers who have an interest in transforming the poor in SSA into industrialized sector through enabling them get access to significant gains from farms that characterize successful contract farming.

Previous studies such as Barrett et al. (2012) focused on factors such as access to productive assets for instance water for irrigation, labor and tools and production technologies while ignoring the importance of institutional factors. The present study incorporates important institutional factors such as access to extension services, access to agricultural credit and social capital through membership to agricultural development groups. In the review of contract farming literature, there is a knowledge gap whereby most authors elaborated the relevance of attributes of the contract designs while giving very little attention to the measure of these attributes from the perspective of the smallholder farmers. The current study incorporates *ex-ante* factors that motivate smallholder farmers to make the decision to participate in contract farming.

According to Arumugam et al. (2011), there are four important factors determining farmers' participation in contract farming. These factors include stability of the market, access to market information, transfer of production technology that improves farming practices and indirect benefits. However, the above overlooked individual characteristics and institutional factors. There is a thin literature that quantitatively and qualitatively reports on the determinants of participation in contract farming especially in horticultural sub-sector. Land ownership, land size level of education and perceived benefits had a positive influence on participation in contract farming.

Farmers who owned land had more probability of participating in contract farming due to tenure security. On the other hand, price risks negatively affected participation in contract farming.

From previous studies, several factors have been found to be of relevance when farmers are making the decision to participate in contract farming. Among these are socio-economic, institutional and transaction cost factors. A study by Barret et al. (2012) found that, as years of farming experience increase, the likelihood of participating in contract farming also increases. However, Sáenz-Segura (2006) revealed that younger farmers with less farming experience have a high likelihood of participating in contract farming. Some studies argue that contract firms or rather buyers would go for farmers with larger farms than those with small farms due to the fact that transaction costs reduce with increase in farm size (Abebe et al., 2013). Moyo (2011) showed that trust and confidence in the buyer, knowledge of difference in prices and delay in payment significantly influenced probability of farmers participating in contract farming.

2.3 Contract farming and efficiency

About half of smallholder farmers in Bungoma county are resource-poor with limited access to credit services and this makes it hard for them to purchase the required inputs to enhance productivity (Ayinde et al., 2017). Shrestha et al. (2014) found that technical support to farmers improves the level of TE. Technical support is one element included in the contractual package where in most cases the buyer provides extension services to the farmers to monitor the crop and enhance high yield.

A reasonable amount of literature has focused on the impact of contract farming on the welfare of farmers using food security indicator, while relatively little has been done on its effects on efficiency. Studies like Bellemere (2017) and Narayan (2014) used aggregate on farm income which could lead to misappropriation of the benefits of contract farming since it is difficult to attribute whether the income increase is actually from contract farming or other factors. In order to overcome this challenge, the present study fills this gap by using income from the target crop under contract farming. An exception such as the study on the effects of contract farming on efficiency and productivity by Henningsen et al. (2015) revealed that contract farming improves potential yield levels but leads to a decline in TE.

Bidogeza et al. (2017) used the stochastic frontier approach to analyze TE and its determinants among vegetable farmers and found that female and educated farmers were significantly more technically efficient than the male and non-educated ones. The study also showed that access to farm inputs increases TE. Improving efficiency in agricultural production is a key strategy towards achieving economic development. Contract farming has been found to be a useful tool in enhancing farmers' welfare and productivity as well.

Dube and Mugwagwa (2017) found that contract farming had a significant positive effect on efficiency of smallholder farmers in Zimbabwe. The study revealed that, farmers who do not participate in contracts are about 10% more inefficient than contract farmers are. In addition, Chang (2006) noted that a contract farmer on average is 20% more efficient than a farmer not in contract. Other studies such as Miyata et al. (2009) found no significant difference in TE of farmers in contract farming and non-participants.

In their study, Ogundari et al. (2006) applied the stochastic frontier model to measure efficiency. The study found that the coefficients for farming experience and the age of the farmer were negative. This implied that the aged and most experienced farmers are more technical efficient as compared to young farmers thus the technical inefficiency of farmers decreases as the age and years of farming experience increase. The study however, found that the level of education had a positive coefficient meaning that the cost inefficiency of farmers increases with the years of education. This contradicts the ideal assumption that education empowers farmers with knowledge and skills to improve their overall farm efficiency.

Lubis et al. (2014) estimated allocative, technical and economic efficiency using Data Envelopment Analysis (DEA) and Tobit regression model to analyze determinants of horticultural economic and TE. The study found that farmers registered low allocative, technical and economic efficiency levels. Land productivity showed a positive and significant effect on both economic and TE. Productivity of capital and distance to the market had significant positive influence on TE. Ogundari (2006) used stochastic Cobb-Douglas profit frontier model to estimate factors that determine profit efficiency and found that unlike other inputs, fertilizer negatively affected profitability. This was attributed to lack of knowledge to apply the right quantities and type of inputs. These results differ with those from other studies for instance Coelli et al. (2005) and Shanmugam et al. (2006) which show a positive relationship between fertilizer and profitability. Ogundari (2006) suggested further studies on effects of credit accessibility on profit efficiency.

As outlined before, to appropriately determine the effect of contract farming on income, unlike the previous studies, the present study uses only income from the target crops and not aggregate income so as to correctly attribute the benefits to contract farming. Most of the previous studies have used deterministic production functions to estimate the effect of contract farming on efficiency, using such approaches has however brought in inherent limitations in statistical inferences. The present study therefore uses the parametric stochastic frontier estimation of efficiency using input variables; fertilizer quantity, seed quantity, paid labor and land size. In measurement of labor, unlike previous studies (Lubis et al., 2014), the present study uses labor directly involved in the production of the target crops to overcome bias.

2.4 Conceptual framework

Following the canonical complete contract theory, it is assumed that contracts govern all performance aspects under all contingencies hence contracting parties are able to foresee all relevant contingencies. This theory postulates that no party will tend to divert from the contractual agreement, all factors held constant (Maskin and Tirole, 1999). Contract farming has been found to create market linkages, foster infrastructural development, minimize food losses, reduce transaction costs and cater for price risks thus improving value-chain governance. Farmers who engage in contract farming gain access to inputs, and new technology thereby improving their farm efficiency and farm productivity. Contract farming improves smallholder farmers' income, nutritional security and contribute to poverty reduction hence improving livelihoods. Contract farming is therefore expected to improve production and productivity through increasing TE as shown in Figure 2.

Socio-economic factors such as age, education level, farming experience and house hold size taken together with institutional factors such as access to credit, access to extension services and group membership plays a role in motivating farmers to participate in contract farming. Farmers can have motivated by incentives like market access, expectation of high incomes, access to inputs or shy off due to risks like production, price and financial risks. Once farmers enter into contract, there are arrangements like price determination, pre-financing, quality requirements and resolution of disputes. Farmers in contract farming expect intermediate outcome such as improved technical efficiency and reduced input costs. The ultimate outcome is expected to be improved livelihoods denoted by improved household income the development impact is poverty reduction.

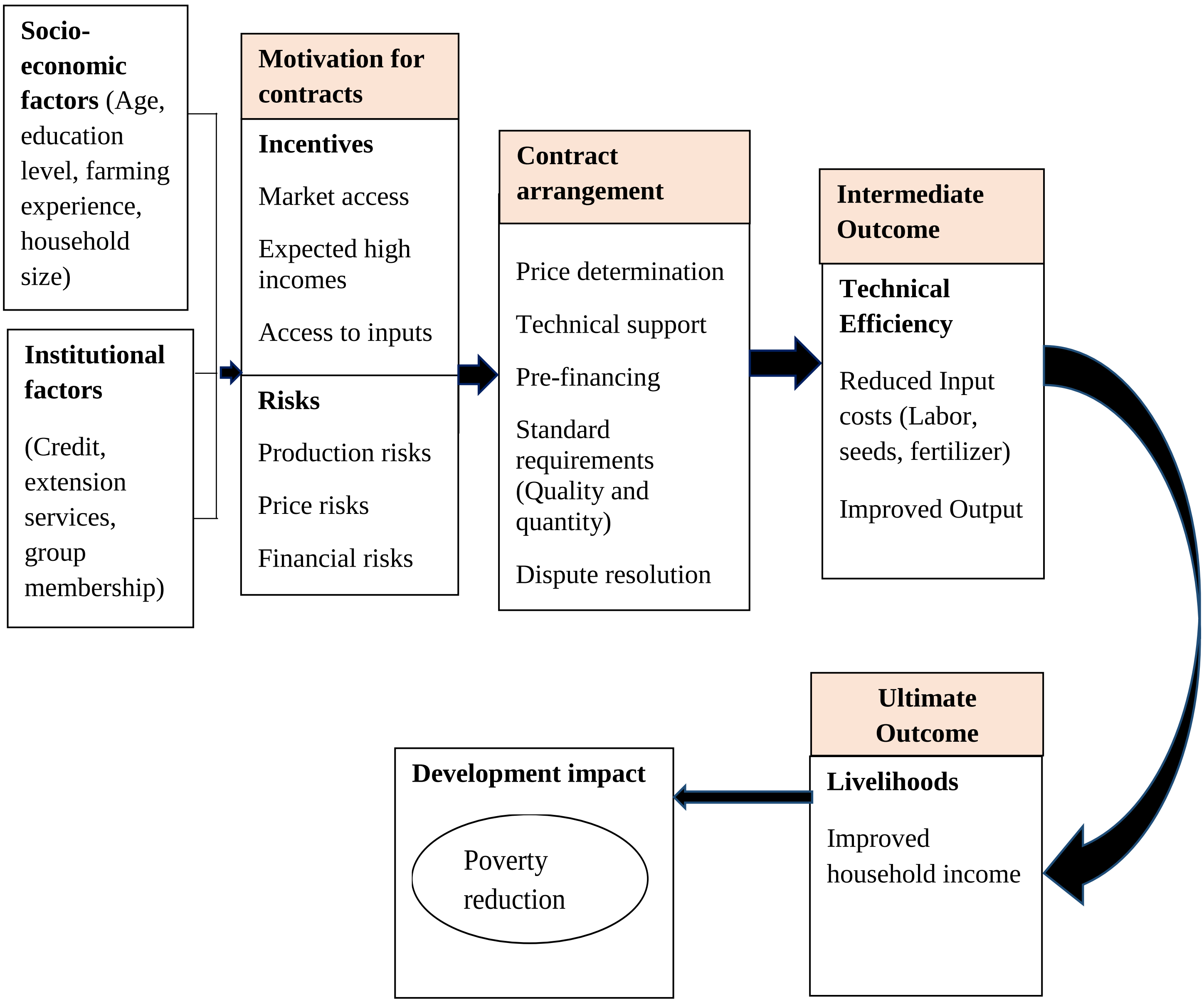

Figure 2: Illustration of farmers' motivation for contract farming and implications on livelihoods

Source: Author's conceptualization.

2.5 Theoretical framework

This study is anchored on three key theories: convention, agency and agricultural household theories.

2.5.1 Convention theory

This theory focuses on product attributes. In markets with perfect information, the price reflects the quality attributes. There are several types of coordination in conventional theory for instance: industrial, market, domestic and civil coordination. In industrial coordination, one independent party is responsible for setting threshold. Market coordination on the other hand is characterized by specific quality conventions that regulate exchange. Domestic coordination is based on trust and building long-term relationships while civil coordination calls for all firms to come together and set quality standards to reduce and avoid conflicts (Young and Hobbs, 2002). This theory was used to analyze motivation for contract farming and factors that lead to violation of the contracts by incorporating the institutional factors.

2.5.2 Principal-agent theory

Agency theory explains relationships among actors in a given context. It describes the relationship between principals or agents and delegation of control. It gives strategies to best structure relationships where one party determines what is to be done and the other performs decisions on behalf of the principal (Belot and Schroder, 2013). This theory forms the basis for showing relationships between contracted farmers and firms.

Boland and Marsh (2006) point out that it is difficult to account for uncertainties in contracts; hence, this increases transaction costs as a result. Uncertainties could be caused by climate change and other production shocks in agriculture. This implies that there is a possibility of opportunism between the parties involved in a contract especially after the contractual period. The level of agents' efforts is concealed by the uncertainties and the principals may suffer from information asymmetry hence there is likelihood of the agents exploiting the principal.

Uncertainty and information asymmetry result into two main types of agency problems, which are moral hazard and adverse selection. Moral hazard implies that in any contractual agreement, one party has the opportunity to gain by choosing not to observe the agreement principles. Moral hazard means that one party might choose to take higher risks knowing that the other party will bear the costs of the risks. Adverse selection is a situation whereby there exists asymmetric information on the agent's side and the principal lacks information making it difficult to make an accurate determination of whether the agent is adhering to the contractual agreement by performing what they are facilitated and will be paid for.

2.5.3 Agricultural household model

Following Azam (2012), this study employed agricultural household model whereby it is considered that a household produces a variety of output to consume and/or market. A household is thus faced with utility maximization problem. Rationally, a household maximizes utility by going for goods at a level where they produce (Q_i); using inputs (X_i), consume (C_i), buy (N_i) and sell (S_i). The household is thus required to maximize utility subject to several constraints for instance production technology, income and resources. Following the assumption that markets are perfect (with zero transaction costs), the household will have the following constrained optimization problem.

$$Max\ u\ (C_i, Z^c) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

Subject to:

$\sum_{i=1}^{J} P_i^m S_i + B \geq \sum_{i=1}^{J} P_i^m N_i$ Income constraint ………………………………...…...(2)

$Qi + E + N \geq X_i + C_i + S_i$ Resource constraint ...…………………………………….(3)

$G(Q, X, Zq) = 0$ Production technology constraint…………………………...(4)

$Ci, Qi, Xi, Ni, Si \geq 0$ Non-negativity constraint…….………………………………(5)

where:

P_i^m represents the market price, E_i denotes household endowment in a good, *B* is the exogenous income, Z^c denotes household attributes and Z_q represents technology attributes.

The income constraint (Equation 2) states that total transfers and revenue should be greater or equal to expenditures. The resource constraint (Equation 3) shows that the quantities of goods used as inputs, consumed, and sold should not be more than the total amount of output produced. The production constraint (Equation 4) shows the kind of technology used in production, which is the interaction of inputs and outputs.

Contracts as institutions are markets by nature and therefore the current study employs this theory to explore farmers' choice of market channels to sell produce in the pursuit of utility maximization. This study uses efficiency as a measure that fits in this theory whereby technology gaps are computed across farms to compare how farmers in contract and those not in contracts combine their inputs in the production process. Markets (contracts included) are not perfect in the real world thus, regardless of the quantity of goods marketed; households incur transaction costs during participation in markets.

CHAPTER THREE: CHARACTERIZATION OF CHILI AND SPIDER PLANT FARMERS IN WESTERN KENYA

3.1 Abstract

This chapter characterizes chili and spider plant farmers in Western Kenya and is based on qualitative and quantitative data collected from 300 smallholder chili and spider plant farmers in Bungoma and Busia counties. Respondents who comprised producers of chili pepper and spider plant were sampled using multi-stage sampling procedure. The descriptive analysis was done using STATA software and results presented in tables and charts. The pooled for the two counties results showed that women dominate in vegetable production at 63%. The pooled data for the two counties also show that about 60% of the vegetable farmers accessed agricultural extension services with the proportion being almost the same in Bungoma and Busia counties. Less than half of the respondents (39%) accessed agricultural credit. The low level of access to credit could be attributed to poor institutional arrangements and lack of collateral. About half of the respondents participated in chili and spider contract farming. The findings showed that, for both chili and spider plant, the proportion of farmers who accessed agricultural credit was two-thirds for both contract participants and non-participants. The difference is attributed to the fact that contractors offer credit to the contracted farmers in terms of farm inputs for instance seeds, agro-chemicals and fertilizer. Contrary to expectation, the proportion of vegetable farmers who accessed agricultural extension services was lower among contract participants (55%) compared to non-participants (65%). Slightly over one-third of contracted chili and spider plant farmers are motivated to participate in contract farming by expectation of an assured market.

Key words: Smallholder farmers, chili, spider plant, contract farming.

3.2 Introduction

Vegetables contribute significantly to the Kenyan horticultural GDP. However, vegetable farmers still face various constraints during production and marketing. Such constraints are; high production cost due to high input costs, unstable markets for both inputs and outputs, low prices for outputs, poorly developed infrastructure, inadequate market information due to high transaction costs, limited access to financial resources, and weak institutional environment. Moreover, malnutrition is a key challenge in Western Kenya where for instance about half of the children under 5 years lack a diversified diet (World Bank, 2016). Both chili and spider plant are rich in vitamins and minerals, hence important components for a nutritionally diversified diet. African Indigenous Vegetables (AIVs) are also considered more nutritious than exotic vegetables. Chili and spider plant have shorter growing cycles compared to other major crops like maize. Extant literature reveals that traditional vegetables give the smallholder farmers a relatively higher return per unit area than other major crops. Participating in horticultural inclusive value chains can provide an important link between the rural farmers and the global economy where local suppliers interact with global institutional buyers in trading fresh produce for instance, fruits and vegetables (Byerlee et al., 2009). African indigenous vegetables are rich in vitamins and minerals, hence important components for a nutritionally diversified diet (Ochieng et al., 2016). Such vegetables have shorter growing cycles as compared to other major crops like maize and they are able to make maximum utilization of soil nutrients and scarce water supplies (Weinberger and Lumpkin, 2007). Empirical evidence reveals that AIVs give smallholder farmers higher returns per unit area as compared to other crops like maize (Afari-Sefa et al., 2015). Some AIVs for instance, the spider plants are also known for their ease of cooking, production and processing (Kansiime et al., 2016). The AIVs also have medicinal value and are highly nutritious (Ngenoh et al., 2019). In Bungoma county for instance, spider plant is grown under 358 ha and spider plant 164 ha Agricultural activities account for about 60% of all the economic activities contributing to gross county product in Bungoma County, of which vegetables contribute about 30%.

3.3 Methodology

Data was collected from a survey of chili and spider plant farmers in Bungoma and Busia counties in Western Kenya. Bungoma and Busia counties were purposively selected because of the high agricultural potential in the region and their strategic geographical position at the boarder of Kenya and Uganda, as they are potential avenues for improving cross-border trade. Contract farming is an upcoming institutional arrangement in this area hence it is of interest to know factors determining its uptake and its effect on livelihoods.

This study employed Cochran (1963:75) formula to compute the sample size. The formula is as follows:

$$n_0 = \frac{Z^2pq}{e^2} \quad \ldots\ldots(6)$$

where,

n_0 = sample size

Z = Abscissa of normal curve that cuts off an area α at the tail (1- α is the desired confidence level for this case, 95%)

e = desired level of precision

p = estimated proportion of an attribute present in the population (0.5 for this case)

q = (1-p)

$$\text{Expected sample size} = \frac{(1.96)^2\,(0.5)\,(0.5)}{0.05^2} = 385 \quad \ldots\ldots(7)$$

Eventually, the present study ended up using a sample size of 300 instead of the expected 385 vegetable farmers because 85 incomplete questionnaires were removed due to missing crucial data for key variables such as input use and income, which form the basis of this study leading to a 78% valid response rate.

A multistage sampling procedure (Bakshi et al., 2019) was used in the selection of the respondents. First, two sub-counties, Bumula and Matayos were purposively selected in Bungoma and Busia counties respectively due to the reasonable concentration of chili and spider plant farmers. The two counties were also selected due to their strategic geographic location at the Kenya-Uganda boarder that provides an opportunity for cross-border trade in the two value chains. Despite the fact that there are other areas like central Kenya where contract farming is much common, these counties were of interest in order to observe how vegetable farmers pick up contracts, even if it is a new institutional arrangement. In the second stage two wards were selected from each sub-county using simple random sampling, the third stage had two villages selected from each ward using simple random sampling method. In the fourth stage, contracted farmers were selected from lists provided by farmers' field school (FFS) officers from each sub-county using systematic random sampling method; where every second responded was selected. The list for Bumula sub-county had 225 contracted farmers while that for Matayos had 90. A total of 110 and 39 contracted farmers were selected from Bumula and Matayos sub-counties, respectively. Non-contracted farmers were selected from a sampling frame provided using systematic random sampling method where every second and fifth respondent was interviewed. Selection of both participants and non-participating farmers from the FFS lists could be a source of bias hence future studies should work to overcome this weakness by diversifying sampling frames for the treatment and control groups.

It is important to note that, there were several contracting firms in the study area but they all had similar contractual terms of delivering inputs upfront, offering support services and buying the crop at relatively close prices. The contracting firms included; exporters, supermarkets, institutions like schools and hotels and domestic traders such as hotels. The exporting companies included MACE foods, which contracts farmers in both Busia and Bungoma counties and exports vegetables to Europe; schools include Bungoma High School and Cardinal Otunga Girls High school; supermarkets include Tesia and Khetias supermarkets and hotels include Tourist hotel in Bungoma. This implies that there was no heterogeneity in contracting firms to affect the smallholder farmer's decision to participate in contract farming. In addition, farmers' field school members were farmers producing vegetables, including chili and spider plant, besides poultry. Though not all members of field schools were contracted, there was a clear documentation of the market channels for the members since the field schools also link their members to markets.

The study also employed a combination of participatory approaches, specifically key informant interviews and a focus group discussion (FGD). The informant interviews involved consultations with 4 input suppliers, 2 agricultural extension officers, 2 value addition experts and 2 local administrators summing up to 10 participants. This was useful in obtaining insights on evolution of contracts and other production techniques over the years. An FGD was conducted to capture trends in challenges, opportunities and their drivers along the vegetable value chain. The stakeholders involved in the FGD included; 2 input suppliers, 2 producers of vegetables, 1 private and 1 government extension officer, 1 broker, 1 farm laborer, 2 vegetables assemblers, 1 distributor of vegetables, 1 value addition expert, 1 local administrator, 1 vegetables trader and 1 vegetable consumer making a total of 15 participants. Focus group discussion enhances a broader perspective of the research issues and eliminates individual bias in data collection (Boateng, 2012). The aim of the FGD was to get insights concerning the determinants of participating in contract farming, its effects on farm efficiency and income. The information from the FGD was used in restructuring, designing and reviewing the survey questionnaire as well as capturing the thoughts and opinions about the issues in the study.

Semi-structured questionnaires were used for collecting primary data. The questionnaire had five major sections. First, questions on household identification, then the second section had questions on land ownership and vegetable production including input use. The third section had questions concerning vegetable marketing, the fourth section dealt with institutional support with questions on social capital and extension services. Finally, the last section had questions on livelihoods and socio-demographic aspects. Minhat (2015) considered semi-structure questionnaire suitable because of its flexibility in giving enumerators a chance to validate the responses and probe for clarification where possible.

3.4 Results and discussion

3.4.1 General socio-economic characteristics of vegetable farmers in Bungoma and Busia

Table 1 shows the characteristics of farmers growing vegetables in Bungoma and Busia counties. The pooled results reveal that 58% of the respondents were female and 8.7% of the households were female-headed and these women were widows and single mothers. Female-headed households were defined as those households whose major decision maker was a female person. This observation conforms to the low level of female leadership and the power dynamics in African settings where most of the households are male-headed.

Table 1: Characteristics of chili and spider plant farmers in Busia and Bungoma counties

Variable	*Bungoma (a) (n = 201)*	*Busia (b) (n = 99)*	*Pooled (n = 300)*	*Test of statistically significant differences*
Categorical Variables				χ^2 ***test***
Gender of the farmer (% male)	62.7	48.5	58.0	0.019**
Household type (% female-headed)	10.5	5.0	8.7	0.118
Fertilizer use (% yes)	87.5	85.8	87.0	0.680
Membership to agricultural development group (% yes)	55.7	69.7	60.3	0.020**
Farmer's access to extension (% yes)	59.2	60.6	59.7	0.816
Farmer's access to credit (yes %)	35.8	45.5	39.0	0.100*
Participation in contract farming (% yes)	54.7	39.4	49.6	0.013**
Type of vegetable (% Chili)	43.8	39.4	42.3	0.470
Continuous variables				***t-test (a-b)***
Average years of formal education of the farmer	9.1(3.6)	8.5(4.3)	8.9 (3.8)	0.093
Average age of the farmer (years)	48(14)	50(13)	49 (14)	-0.053
Distance from home to market (Kms)	3.7(3.8)	3.7(1.6)	3.8(3.2)	-0.066
Average total land size (acres)	3.0(5.2)	2.6(1.7)	2.9(4.4)	-0.064
Average years of farming experience	8.7(9.0)	10.6(10.3)	9.3(9.5)	0.284**
Average on-farm income (Kshs)	7,379(5,540)	7,574(5,202)	7,453(5,422)	0.005
Average off-farm income (Kshs)	1,848(1,385)	1,893(1,300)	1,863(1,355)	-45.410

Note: Standard deviations are in parentheses: 1USD = Kshs 101.16 at the time of survey.

Source: Survey Data (2019).

Women get involved in subsistence agriculture for instance vegetable production due to gender roles within the rural households. Bungoma county has a higher proportion of female-headed households compared to that of Busia. From the focus group discussions, some of the female-headed households were attributed to death of male heads and family break-ups. The pooled results reveal that 87% of the vegetable farmers use organic fertilizer in vegetable production to boost yield. This could be an evidence of a decline in soil fertility hence there is need to replenish the soil and increase the level of soil nutrients through use of fertilizer. The proportion of farmers using fertilizer use is almost equal in both counties. About 60% of the vegetable farmers are members of agricultural development groups.

The proportion of farmers in agricultural development groups in Busia is higher compared to that of Bungoma. This is explained by the fact that there was low concentration of agricultural development groups in part of Bungoma though contracts are active. Studies such as Frankenberger et al. (2013) reveal that farmers who are members of agricultural development groups gain access to inputs and group credits to improve their production. Membership to agricultural groups also improves access to market linkages and provides an avenue to lobby for better produce prices by increasing farmers' bargaining power due to their ability to control volumes. This is consistent with some other studies for instance, Franken et al. (2014) who found a positive relationship between social capital and access to high value markets.

The pooled data also shows that about 60% of the vegetable farmers accessed agricultural extension services in form of training. Access to agricultural extension services increases dissemination of agricultural knowledge and farming technology, which helps farmers to improve their productivity. In addition, increasing extension services among smallholder producers, increases chances of market linkages (Quisumbing and Pandolfelli, 2010). Access to agricultural extension service was measured by whether the farmer actually received technical advice from private or government extension officers.

Less than half of the respondents (39%) accessed agricultural credit. The proportion of farmers who accessed agricultural credit is higher in Busia than Bungoma. The low level of access to credit could be attributed to lack of collateral to secure credit. In most cases, various lenders use land title deed as a requirement for credit. Fischer and Qaim (2012) asserted that the low access to agricultural credit services is caused by the need for collateral by formal lending institutions.

Access to agricultural credit was defined as whether the farmer actually received credit in cash or inputs.

For the years of farming experience, the standard deviation was higher than the mean. This implies that the distribution of the variable was not normal as shown in Figure 3. This is an evidence of wide distribution of the data among the respondents due to heterogeneity of respondents' characteristics. As a remedy mode, which is the most appearing number in a data set was used. Farming experience therefore had a mode of 5 years for the pooled sample. The same applied to total land size and distance from home to the local market.

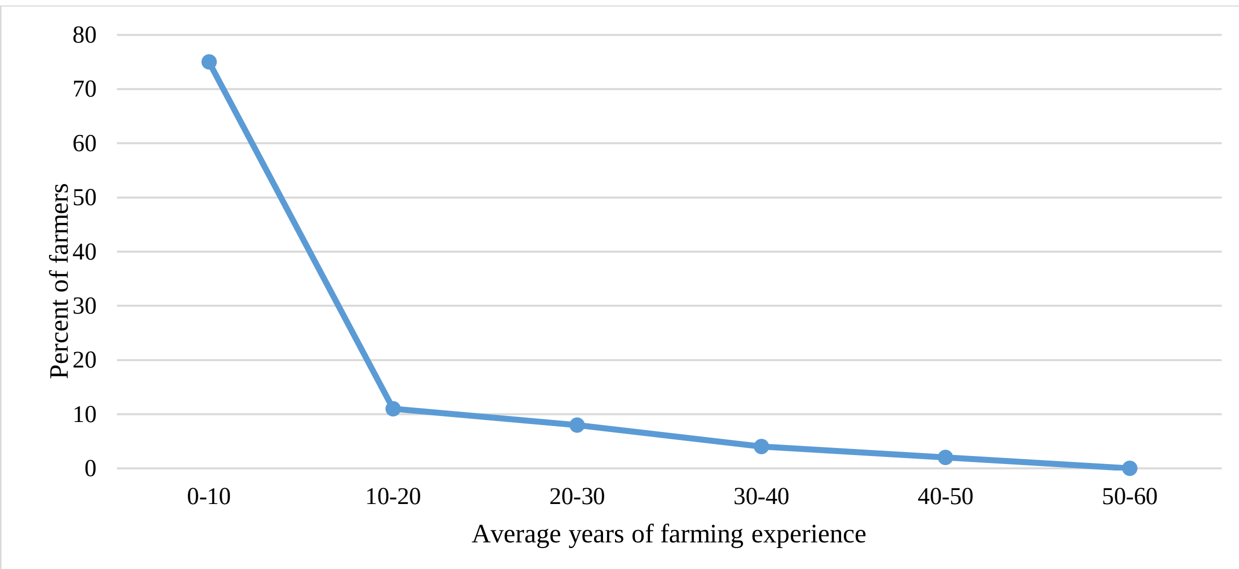

Figure 3: Frequency distribution graph for years of farming experience

Source: Survey Data (2019).

About half of the respondents participated in vegetable contract farming. Farmers are motivated to participate in contract farming by the desire to access farm inputs in form of credit, acquire technical know-how and stable market for their produce (Bellemare, 2012; Sokchea and Culas, 2015; and Bellemare and Novak, 2017). The FGD results show that, low contract prices, lack of trust, overpricing of services by contractors and delay in payments lead to violation of contracts.

The respondents had an average of about 9 years of formal education implying that they had at least attained basic primary literacy levels useful for understanding the terms of the contracts.

The average age of the respondents was 49 years. The pooled results indicate that the average distance from the farm to the nearest open air market is 3.8 kilometers. However as explained earlier, the standard deviation was higher than the mean and the distribution was not normal as shown in Figure 4. The modal distance to the nearest market for the pooled sample was 3 kilometres.

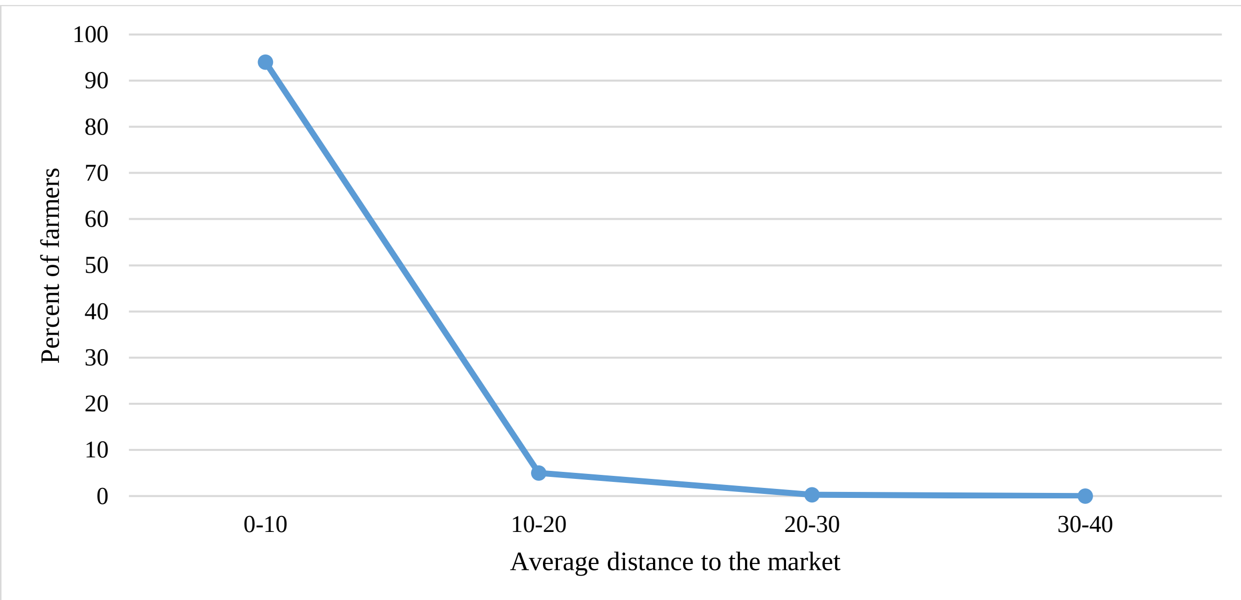

Figure 4: A frequency distribution graph for distance from home to the nearest local market

Source: Survey Data (2019).

This implies that farmers have to move longer distance to deliver their produce to the main market, hence perishability and high transport costs sets in unless the buyer picks from the farm.

Results from the FGD revealed that, the major sources of extension services were farmer-to-farmer extension, government extension officers, contracting firms, researchers and media. Contrary to expectation, the proportion of vegetable farmers who accessed agricultural extension services was lower among contract participants compared to non-participants. The contracting companies or firms are expected to do follow ups to ensure that the farmers deliver the produce in required amounts and standards. They are supposed to offer extension services to vegetable farmers through coaching and guiding farmers on good agricultural practices. However, this is not the case due to failure of contracts as institutions. Contracted farmers wait for the extension services from the contractors, which in some cases ultimately never comes. Studies have shown that there is a positive relationship between access to agricultural extension and agricultural productivity (Ngeno et al., 2019). On average, the total land size was about 2.9 acres. The small land sizes can be attributed to the growing population that leads to land fragmentation in both counties. However the distribution of this variable was not normal due to the huge variations in land sizes among the study population as shown in Figure 5. The mode was therefore used as a remedy and the mode land size for the pooled sample was 2 acres. These graphs (Figure 3, 4 and 5) apply to the same variables in Table 2 for the pooled sample.

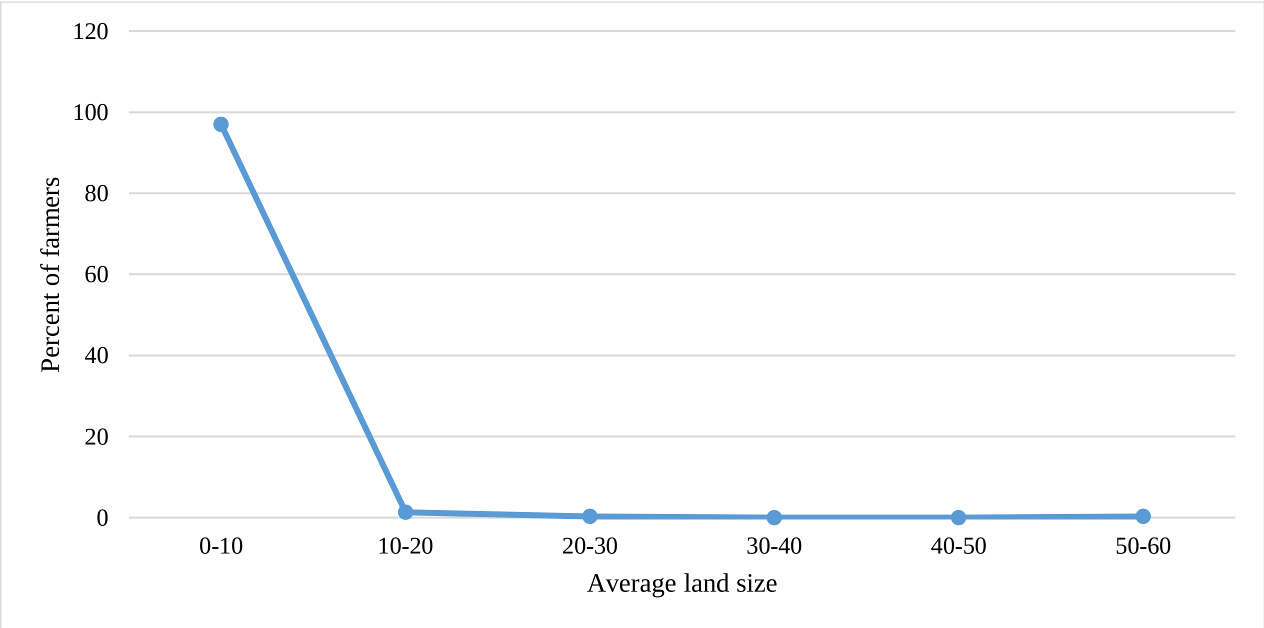

Figure 5: A frequency distribution graph for average land size

Source: Survey Data (2019).

3.4.2 Comparison of socio-economic characteristics of spider plant and chili farmers

Table 2 below shows the socio-economic characteristics of spider plant and chili farmers. It was revealed that there was a higher proportion of female farmers growing chili (66.1%) compared to that growing spider plant (52%). For both vegetables, the proportion of female-headed households is very low (8.6% for spider plant and 8.7% for chili).

The proportion of farmers who use fertilizer is higher among chili farmers (92.9%) than spider plant (82.6%). This could be attributed to the difference in the nutritional requirements of chili and spider plant and the need to improve chili yield to meet contractors' standards. There is no significant difference in the proportion of membership to agricultural development group among chili and spider plant farmers. Farmers growing chili have a higher access to credit (43%) compared to those growing spider plant (35%). This is because most of the farmers growing Chili participate in contract farming which to some extent increases their access to credit in form of farm inputs (Rao and Qaim, 2011).

Slightly more than half (55%) of the farmers growing chili participate in contract farming compared to only 45% of spider plant farmers. This is explained by the fact that most contracting firms in the study area have a higher demand for chili than spider plant. The average number of years of completed formal education is higher (9.4) among chili farmers compared to spider plant (8.5). The level of formal education is directly related to effective utilization and combination of production resources and rational decision making to maximize output. The average level of experience of farmers growing spider plant is higher (10.1) compared to that of spider plant farmers (8.4). The more the years of experience, the more the farmers have technical skills about the crop they are producing.

Table 2: Socio-economic characteristics of spider plant and chili farmers

Variable	*Spider plant (n = 173)*	*Chili (n = 127)*	*Pooled sampler (n = 300)*	*Test of statistically significance differences*
Categorical Variables				***χ^2 test***
Gender of the farmer (% male)	52.0	66.1	58.0	0.014**
HH type (% female-headed)	8.6	8.7	8.7	0.998
Fertilizer use (% yes)	82.6	92.9	87.0	0.009***
Membership to agricultural development group (% yes)	60.1	60.6	60.3	0.928
Access to agricultural extension (% yes)	59.4	59.8	59.7	0.958
Access to credit (% yes)	35.84	43.3	39.0	0.190
Participation in contract Farming (%yes)	45.6	55.1	49.6	0.100*
Continuous variables				***t-test (a-b)***
Average years of formal education	8.5(4.1)	9.4(3.3)	8.9 (3.8)	-0.189***
Average age (years)	49.0(14.0)	47.0(13.0)	49.0(14.0)	0.039
Distance to market (Km)	3.6(2.3)	4.2(4.1)	3.8(3.2)	-0.020
Average land size (acres)	2.9(5.1)	2.8(3.1)	2.9(4.4)	-0.041
Average years of farming experience	10.1(10.4)	8.4(8.2)	9.3(9.5)	0.170*
Average on-farm income (Kshs)	6,620(5,111)	8,586(5,645)	7,453(5,422)	-0.245***
Average off-farm income (Kshs)	1,655(1,277)	2,146(1,411)	1,863(1,355)	-0.491***

Note: Standard deviations are in parenthesis: 1USD = Kshs 101.16 at the time of survey.

Source: Survey Data (2019).

Chili farmers earn an average of Kshs. 8,586 (USD 84.95) on-farm income per season that is higher compared to that of spider farmers, Kshs. 6,620 (USD 65.51). This indicates that chili is a higher value crop compared to spider plant. On the other hand, for both chili and spider plant farmers, the proportion of those who accessed agricultural credit was slightly higher among contract participants (62%) compared to non-participants (60%). The difference is attributed to the fact that contractors offer credit to the contracted farmers in terms of farm inputs for instance seeds, agro-chemicals and fertilizer. Farmers participating in contracts are likely to achieve high productivity and welfare gains (Barrett et al., 2012; Ma and Abdulai, 2016). Farmers who do not participate in contracts have lesser privilege when it comes to accessing agricultural credit that specifically comes in a contractor's package.

3.5 Nature of contract farming and farmers' motivations

3.5.1 Nature of contracts

The proportion of contracted vegetable farmers under formal contracts is higher (64%) compared to those under informal contracts as shown in Figure 6. Informal contracts involve oral agreements with no written binding documents. From the FGD, it was revealed that in earlier days (1980s and 1990s), informal contracts were common, they involved oral agreements with relatives, and friends to provide labor, inputs, buy and sell vegetables. The contract's duration ranged from a week to several years and the contract terms were rarely violated.

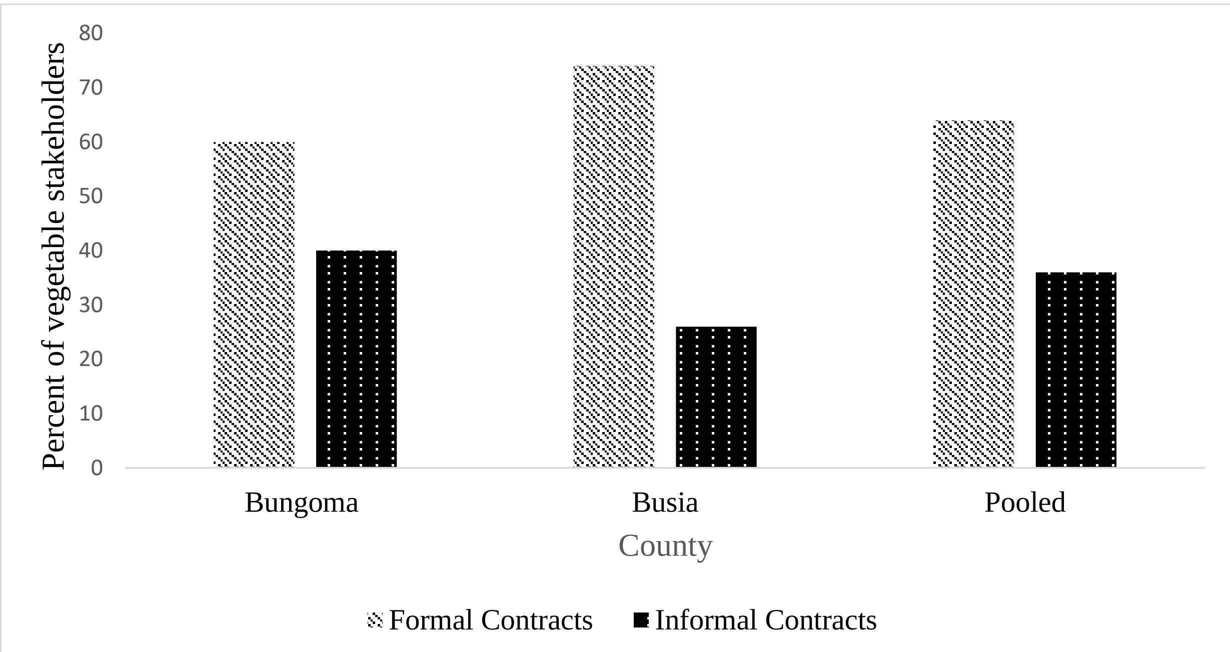

Figure 6: Comparison of nature of contracts between Bungoma and Busia counties

Source: Survey Data (2019).

From the FGD findings, it was revealed that, there were a few cases of violation due to lack of trust. In case of violation, the community could impose a fine on the party that violated. The informal contracts begun to lose trust and violation became a great challenge in early 2000s. This necessitated the need for formal contracts, which were written and binding with sanctions involved. In most cases, buyers set the price while sellers become price takers. This explains why formal contracts are more popular than informal contracts among buyers.

3.5.2 Motivation for contract farming

From Figure 7, a bigger proportion of contracted vegetable farmers (37%) are motivated to participate in contract farming by the expectation of an assured market. This is explained by the desire to access stable market linkages by smallholder vegetable farmers. Another one-third of the farmers are motivated to participate in contract farming by expectation of good prices. Some contracting firms and supermarkets offer relatively higher prices than the prices in local open-air markets.

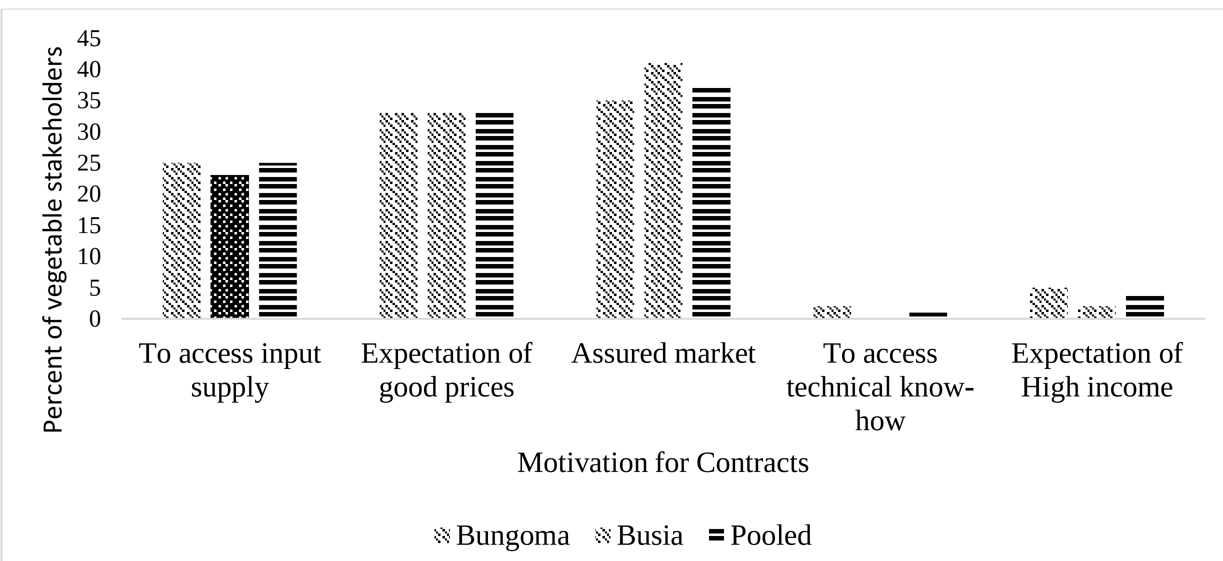

Figure 7: Comparison of motivation for contracts between Bungoma and Busia counties

Source: Survey Data (2019).

More chili farmers (43%) were motivated to join contract farming by assurance of market compared to spider plant farmers (32%) as shown in Figure 8. This is in line with Jalang'o et al. (2018) who pointed out that vegetable farmers are attracted to stable high-value markets in order to maintain their income levels.

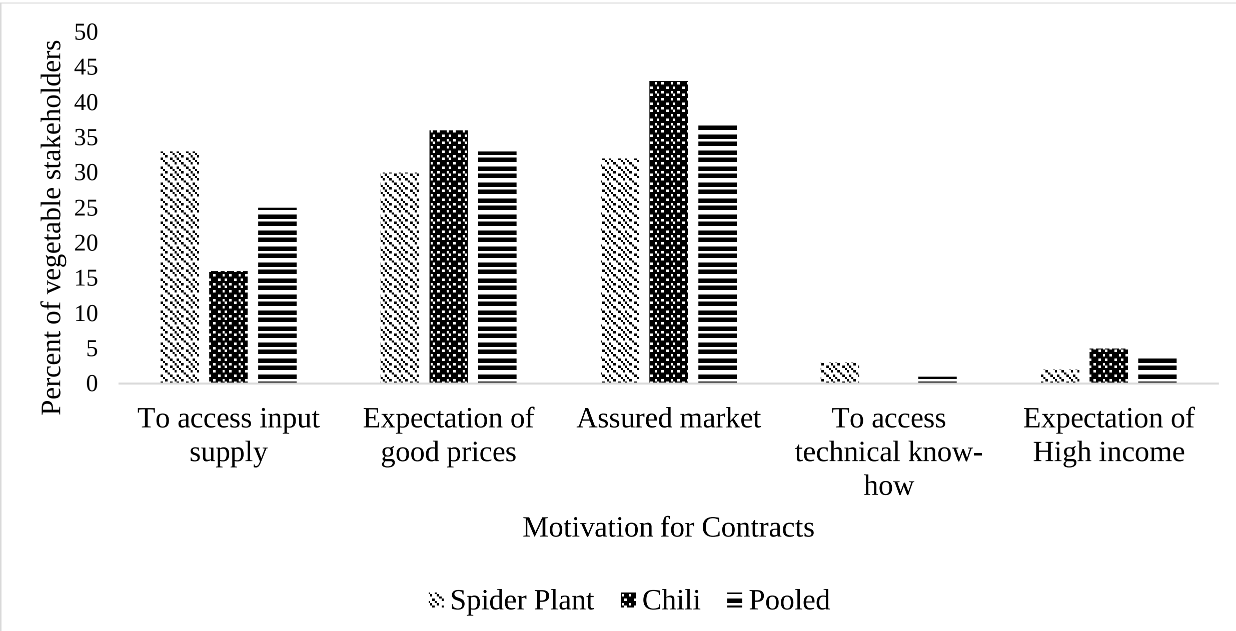

Figure 8: Comparison of motivation for contracts between spider plant and chili farmers

Source: Survey Data (2019).

3.5.3 Reasons for not participating in contract farming

From Figure 9 below, 45% of farmers failed to participate in contracts due to lack of a reliable contractor. This calls for attention that there is a lot of willingness to participate in contract farming among smallholder vegetable farmers only if there are reliable contractors who offer friendly contractual terms.

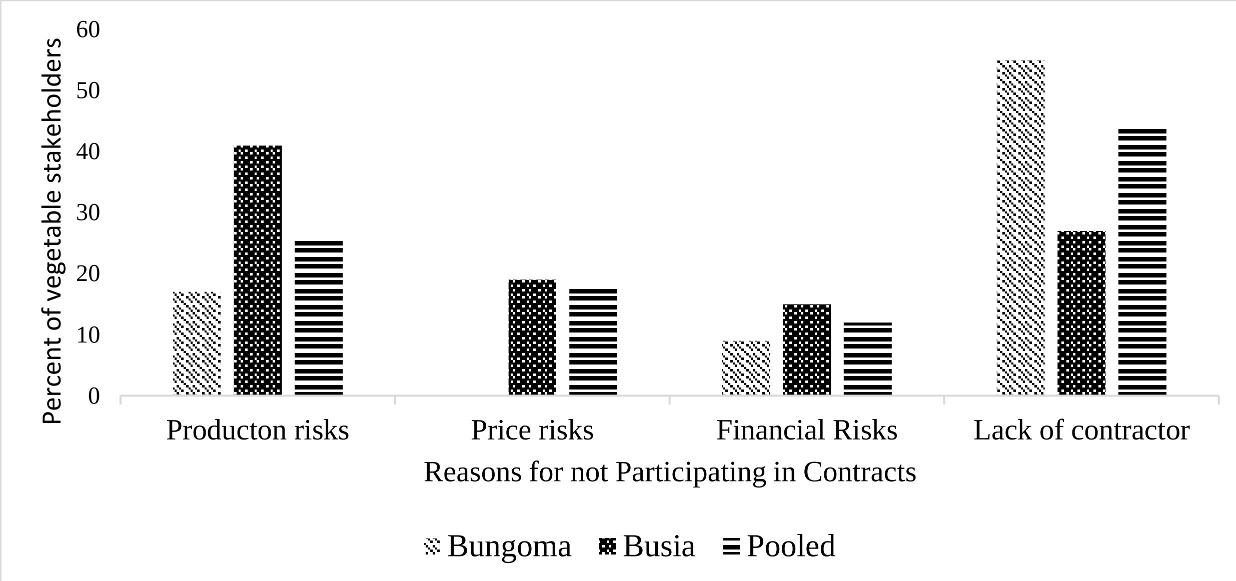

Figure 9: A comparison of reasons for not participating in contract farming between Bungoma and Busia counties

Source: Survey Data (2019).

The proportion was higher in Bungoma county compared to Busia county. Production risk was also reported as a key factor for not participating in contract farming especially in Busia (40%). Production risks include unreliable rainfall patterns. Drought is becoming a threat in the study area and so farmers may fear to commit to a contract due to expectation of poor harvest.

Figure 10 below shows similar results among chili and spider plant farmers where lack of contractor happens to hinder most farmers (43%) from participating in contract farming. This proportion is higher among spider plant farmers compared to chili farmers. Price risk was found to be another major hindrance to participation among chili farmers (27%).

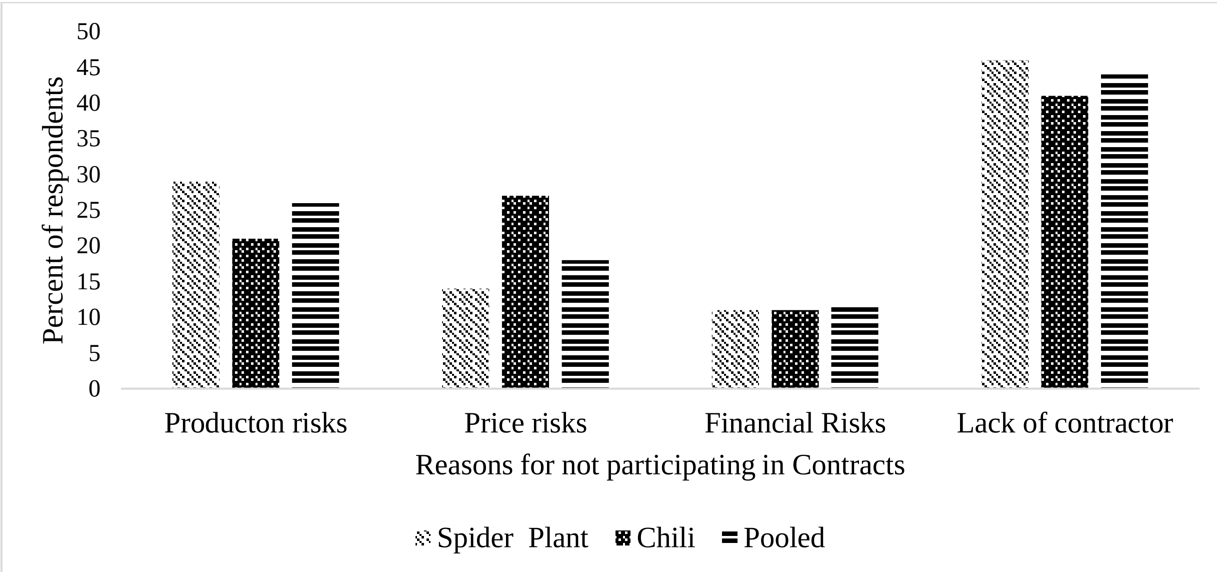

Figure 10: A comparison of reasons for not participating in contract farming between spider plant and chili farmers.

Source: Survey Data (2019).

Price risks entail fluctuation and volatility in prices whereby at times contractors tend to offer lower prices than the price existing in the local markets. This discourages farmers from participating in contracts as it ties them to deliver at lower prices.

3.5.4 Production variables

The main production variables and output for chili and spider plant enterprises are summarized in Table 3 below.

Table 3: Average annual output and inputs

Variable	*Spider plant (n = 173)*	*Chili (n = 127)*
Output (kgs)	239.5	409.3
Quantity of seeds (kgs)	5.0	0.7
Quantity of inorganic fertilizer (kgs)	63.8	54.9
Hired labor (man-days)	1.6	2.7
Average land size(acres)	2.9	2.8

Source: Survey Data (2019).

The average land sizes for both spider plant and chili farmers is almost the same. The average hired labor for chili was higher (2.7 man-days) compared to that of spider plant (1.6 man-days). This implies that chili is more labor-intensive than spider-plant due to the nature of the crop. The quantity of inorganic fertilizer used is higher among spider plant farmers compared to chili farmers. This suggests that spider plant has higher nutritional requirements than chili. Table 4 below shows the value of the outputs and variable inputs used in production for both chili and spider plant farmers.

Table 4: Value of average annual output and inputs

Variable	*Spider plant (n=173)*	*Chili (n=127)*
Value of output (Kshs)	11,975	16,372
Value of seeds (Kshs)	3,500	980
Value of inorganic fertilizer (Kshs)	3,780	3,294
Value of hired Labor (Kshs)	480	810

1USD = Ksh 101.16 at the time of survey.

Source: Survey Data (2019).

Partial input shares (Table 5) were computed in order to provide an indication of the variations in production technologies across the two enterprises.

Table 5: Partial input shares

Variable	*Spider plant (n = 173)*	*Chili (n =127)*
Seeds cost	0.45	0.19
Fertilizer expense	0.49	0.65
Hired labor Expense	0.06	0.16

Source: Survey Data (2019).

The expense ratio of seeds and fertilizer for spider were relatively high in value compared to that of hired labor. Chili farmers however record the highest expense ratio for fertilizer compared to all other ratios. Spider plant farmers had the least labor expense ratio implying that spider production is less labor intensive compared to chili.

CHAPTER FOUR: DETERMINANTS OF SMALLHOLDER FARMERS' PARTICIPATION IN CONTRACT FARMING AND ITS FFECT ON INCOME IN WESTERN KENYA

4.1 Abstract

The transition from selling in spot markets to complex institutional layouts such as contractual arrangements is viewed as a crucial driver towards structural transformation. In SSA, contract farming is considered as one of the most effective example of such pattern, both from buyers and producers' perspectives. The need to access inputs, market linkages and high incomes are some of the factors thought to affect participation in contract farming. This study analyzed determinants of participation in contract farming among vegetable farmers in Western Kenya. The study used both qualitative and quantitative data. A focus group discussion was conducted to provide information on the factors that determine farmers' participation in contract farming and reasons for violation of contracts. Interviews were conducted with 300 smallholder vegetable farmers using semi-structured questionnaires. A binary probit model was used to analyze the determinants of participation in contract farming. A two-step endogenous treatment regression model was used to analyze the effect of contract farming on farm income. The probit results indicate that distance to the market place had a positive effect on participation in contract farming for chili farmers and pooled farmers as well. Land size was found to have a positive influence on participation in contract farming for both spider plant and pooled farmers. Off-farm income had a positive influence on participation in contract farming. Results also revealed that membership to agricultural development groups had a negative influence on participation in contract farming for both spider plant and pooled farmers. Contrary to expectations, farming experience had a negative effect on participation in contract farming for spider plant and pooled farmers. Endogenous treatment regression model results show that participation in contract farming has a positive effect

on income for spider plant, chili and pooled vegetable farmers. Public institutions and development practitioners which purpose to intervene through strengthening contract farming should seek to understand the dynamics of determinants of participation in order to improve the welfare of vegetable farmers by improving on-farm incomes.

Key words: Contract farming, chili, spider plant, income.

4.2 Introduction

In developing countries, most of the policies are geared towards increasing agricultural productivity. This is through increasing the access of smallholder farmers to inputs and the efficiency in utilization of those inputs. Some institutions for instance contract farming are being adopted in order to improve smallholder farmers' efficiency and income. This happens through the improvement of access to agricultural extension services, agricultural credit, effective and productive inputs, output markets and better output prices (Bellemare, 2017). Contract farming is one of the potential strategies for improving the welfare of smallholder farmers through increased income. Contract farming turns out to be an attractive and viable option for various policy makers who have an interest in transforming the poor farmers in SSA into industrialized producers by enabling them get access to significant gains from farms that characterize successful contract farming.

Despite the perceived benefits of contract farming in developing countries, there has been documented evidence of violation of farming contracts among smallholder farmers. This study analyzed the determinants of participation in contract farming in order to provide viable recommendations to governments and private stakeholders on how best to articulate policies to strengthen contract framing.

There is a thin literature that quantitatively and qualitatively reports on the determinants of participation in contract farming especially in indigenous vegetables like spider and chili in specific. For instance, Arumugam (2010) found that there are four important factors determining farmers' participation in contract farming. These factors include stability of the market, access to market information, transfer of production technology that improves farming practices and indirect benefits. However, the study overlooked individual characteristics and institutional factors. The present study incorporates important institutional factors such as access to extension services, access to agricultural credit and social capital membership to agricultural development groups.

The need for market access is a key factor that stimulates the spread of contract farming. The need to reduce the involvement of the government in provision of services, the growing number of supermarkets and the high level of interest and attention of donors are the other reasons that explain why contract farming is becoming more popular. Literature shows that contract farming has a positive impact on the smallholder farmers by enabling them to gain better access to ready local markets and global markets. Studies on effect of participating in contract farming for instance, Bijman (2008) reveal that participating farmers benefit in terms of high incomes. Other scholars who focused on economic benefits from contract farming to the participants across various value chains found that contract farming increases the cost of production as well as the gross returns. This is due to high level of differentiation and high input costs. Some studies also reveal that contract farming has a negative effect on income. To address the inconclusiveness of the perceived benefits of contract farming, this study aimed at analyzing the effect of participating in contract farming on farm income.

4.3 Methodology

4.3.1 Estimation of probit model for determinants of participation in contract farming

A probit model was used to analyze factors determining participation in contract farming. The basic assumption of the probit model is that the error term has normal distribution. A probit model was chosen over logit due to its normal distribution as compared to logit's logistic distribution (Berry et al., 2010). In addition, following Jacque Bera's test of normality, the probit model was found to best fit the data.

It is assumed that there is a latent variable P_i^* that the decides the value of P_i in that;

$$P_i^* = \alpha Z_i + \varepsilon; \quad \ldots\ldots (8)$$

Where,

$$P_i = \begin{cases} 1 & if\ P_i^* > 0 \\ 0, & if\ P_i^* \leq 0 \end{cases} \quad \ldots\ldots (9)$$

where Z_i represents a vector of exogenous variables; α is a vector of unknown parameters to be estimated and ε is a normally distributed error term. The probability that an individual belongs to a group *j* is expressed as;

$$\Pr(Pi = 1|Zi) =, \ for\ i = 0, 1 \quad \ldots\ldots (10)$$

The parameter estimates of the probit model only indicate the direction of the effect of the explanatory variables on the dependent variable. The magnitude of the change in the dependent variable following a unit change in an explanatory variable can be attained by computing marginal effects of the explanatory variables. The marginal effects are calculated as;

$$\frac{\partial P((Pi = 1|Zi)}{\partial Zi} = \frac{\partial E(Pi|Zi}{\partial Zi} = \varphi(Zi'\beta)\beta \quad \ldots\ldots (11)$$

The regression model was empirically estimated as shown below;

$$Y_i = \beta_o + \beta_1 X_{1i} + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \mathcal{E} \quad \ldots.(12)$$

where,

Y = Participation in contract farming (1 = yes, 0 = No)

X_1 = Age of the farmer (years)

X_2 = Total land size (ha)

X_3 = Farming experience of the farmer (years)

X_4 = Level of formal education of the farmer (years)

X_5 = Membership to agricultural development group by the farmer (1 = yes, 0 = No)

X_6 = Off-farm income of the household (Kshs)

X_7 = Distance from home to the market (Km)

X_8 = Gender of the farmer (1 = male, 0 = female)

X_9 = Farmer's access to agricultural credit in the last one year (1 = Yes, 0 = No)

X_{10} = Farmer's access to agricultural extension (1 = yes, 0 = No)

$\mathcal{E}$ = The error term

4.3.2 Expected signs of variables for determinants of participation in contract farming

Table 6 below shows the expected signs of determinants of participation in contract farming.

Table 6: The expected signs of determinants of participation in contract farming

Variable	Description of the variable	Expected sign
X_1 = Age	Age of the farmer involved in production and marketing of the target crop in years	+/-
X_2 = Land size	Total land size owned in acres	+
X_3 = Farming experience	Farming experience of the farmer involved in production and marketing of the target crop	+
X_4 = Level of education	Years of formal education of the farmer involved in production and marketing of the target crop	+
X_5 = Membership to group	Dummy(1=Yes,0 = No)	+
X_6 = Access to formal agricultural credit	Dummy(1=Yes,0 = N0)	+
X_7 = Access to government extension	Dummy(1=Yes,0 = N0)	+
X_8 = Gender of the farmer	Dummy(1=Yes,0 = N0)	+/-
X_9 = Off-farm income	Off-farm income of the household in Kshs	+
X_{10} = Distance to the market	Distance from home to the nearest local market in Km	+/-
X_{11} = Household size	Number of members living in a household	+/-
X_{12} = Household type	Male-headed or female-headed household	+/-

Source: Survey Data (2019).

Age was expected to have either negative or positive effect on participation in contract farming due to the inconclusively of previous findings. Gender was expected to have either negative or positive effect on participation in contract farming due to documented variations in preferences for contract farming among males and females. Farming experience was expected to be positive since farmers who have been in farming for long have a better perception of benefits of contract farming and are well acquainted with risk management skills (Barrett et al., 2012). The level of education was expected to have a positive sign since it plays a key role in improving the quality of decisions that are made by the farmer and act as an empowerment tool (Abdallah, 2016). The more educated a farmer is the more likely he is to embrace innovations such as contract farming.

Access to agricultural credit was expected to have a positive effect on contract farming since most farmers in SSA are resource-poor and would go for any interventions or opportunities that enable them to access credit for to fund production (Arumugam et al., 2011). The effect of access to agricultural extension was also expected to be positive according to Barret et al. (2011). This is because, some contractual arrangements are in a way that the contracting party offers extension services through making farm visits and offering technical advice. Off-farm income was expected to have a positive sign due to the relationship between financial stability and the capacity to participate in contract farming.

Land size owned was expected to have a positive effect on participation in contract farming due to motivation to meet the buyers' demand. Distance from home to the nearest market is expected to have a positive sign following the findings of Narrod et al. (2009) and Trebbin (2014). This is owed to the fact that the longer the distance the more willingness of the farmer to go for higher value markets such as contract farming to save on transportation costs especially when the contractor covers transport costs. Both household size and household type were expected to have either negative or positive effect on contract farming due to varied views laid out in previous literature.

4.3.3 Endogenous treatment effect regression model for effect of contract farming on income

A two-step Endogenous Treatment Regression Model was applied because the purpose of the model is to estimate the effect of undergoing treatment while accounting for its endogeneity and selection bias (Vella, 2011). To control for endogeneity and selection bias, the control function makes use of two steps estimation procedure. The model would make use of the predicted probability of participation in contract farming on obtained in the first step in equation 13 to estimate the effect of contract farming on income in equation 14. The decision to participate in contract farming is estimated as a selection equation (13) in the first step to generate the control function. The control function is thereafter included as one of the explanatory variables representing the predicted probability of participating in contract farming in the second step in equation 14.

A binary probit model was used to estimate the first step and the second step was regressed using predicted value from the first stage. From the theoretical model, there must be factors that determine choice of a production intervention, and then decisions on consumption level follow based on the effect of the intervention on productivity whose proxy is income in this case. The beginning of the empirical analysis is therefore a two-stage approach as shown below:

$$P_i^* = \alpha Z_i + \varepsilon; \quad \ldots\ldots (13)$$

$$X_i = \beta Y_i + \psi P_i + e_i \quad \ldots\ldots (14)$$

Equation (13) is the first step showing determinants of participation in contract farming and equation (14) illustrates the effect of participation in contract farming among other factors on income (second step).

where, P_i is participation in contract farming, captured as a dummy variable indicating whether or not a household participated in contract farming; X_i is the level of household income. The vectors Z_i and Y_i represent exogenous factors hypothesized to affect participation in contract farming, and income levels, respectively. The unknown parameters to be estimated are $\alpha,$ β, and ψ; while ε_i, and e_i represent error terms of the respective equations.

A binary probit model was applied in this first step because the dependent variable, participation in contract farming (P_i) was binary; coded as one (1) and zero (0) for 'yes' and 'no' responses respectively. The second step (Equation 14) aimed at obtaining the predicted estimates of factors affecting income, participation in contract farming included. Ordinary least squares (OLS) was applied as it is suitable for investigating issues that are cross-section in nature. It is crucial to note that interactions between X_i and P_i are allowed in equation 14.

Previous studies have used aggregate income from on farm activities. However, this study used income from target crops, that is spider plant and chili whereby gross margins were calculated for each value chain where the production costs (input costs) was deducted from the total revenue from sale of chili and spider plants to get of farm income for chili and spider plant.

4.3.4 Expected signs of variables for the endogenous treatment regression model

Table 7 shows expected signs of factors affecting income of vegetable farmers. Participation in contract farming was expected to have either negative or positive sign given that previous studies found inconclusive results. For instance Ballamere (2017) found a positive sign for participation in contract farming while others such as Von Hagan and Alvarez (2011) found a negative sign.

Table 7: The expected signs of factors affecting farm income of smallholder farmers

Variable	Description of the Variable	Expected sign
X_1 = Participation in contract farming (1=yes, 0=No)	Dummy (1 = Yes, 0 = No)	+/-
X_2 = Age of the farmer (years)	Age of the farmer in years	+/-
X_3 = Total land size (acres)	Total land size in acres	+
X_4 = Farming experience of the farmer (years)	Farming experience in years	+
X_5 = Level of education of the farmer (years)	Years of formal education	+
X_6 = Farmer's membership to agricultural development group (1 = yes, 0 = No)	Dummy (1 = Yes, 0 = No)	+
X_7= Farmers access to credit (1= yes, 0 = No)	Dummy (1 = Yes, 0 = N0)	+
X_8 = Farmer's access to agricultural extension (1 = yes, 0 = No)	Dummy (1 = Yes, 0 = N0)	+
X_9 = Gender of the farmer (1=male,0=female)	Dummy (1=Yes, 0 = N0)	+/-
X_{10} = Off-farm income of the household (Kshs)	Off-farm income in Kshs	+
X_{11}= Distance from home to the market (Km)	Distance to the nearest market in Km	+/-

Source: Survey Data (2019).

Farming experience was expected to have a positive sign following Bijman (2008) findings that farmers with more years of experience have learnt to manage risks and can therefore maintain high farm incomes. Years of formal education is expected to have a positive sign since educated farmers are believed to have best knowledge on input combination to enhance productivity (Prowse, 2012).

4.3.5 Model diagnostics

4.3.5.1 Multicollinearity tests

All the variables that were included in the models were tested for multicollinearity, which is a problem that is mostly associated with cross-sectional data, and it refers to association between the independent variables. This leads to the widening of the confidence interval and unreliability of the inferences due to the inflation of the variance of coefficients and the model in general.

The multicollinearity test was conducted by use of variance inflation factor (VIFs) shown in equation 15 and partial correlation analysis.

$$VIF_i = \frac{1}{1 - R_i^2} \quad \text{...} (15)$$

where, R_i^2 is the multiple R^2 for the regression of a variable on the other covariates.

According to Gujarati and Porter (2009), VIF values above 5 indicates that there is evidence of severe multicollinearity. The models did not have any evidence of multicollinearity as shown in Appendices 2 and 3.

In order to further rule out correlation, a partial correlation test was conducted for the Endogenous Treatment Regression Model. Partial correlation is the measure of association between two variables, while controlling or adjusting the effect of one or more additional variables. Partial correlation analysis explores the linear relationship between two variables after excluding the effect of one or more independent factors (Baba et al., 2004). The results showed that there was no serious correlation as the magnitude of all the correlation of all the variables were below 0.5 as shown in Appendix 4.

4.3.5.2 Heteroscedasticity

Heteroscedasticity is the variance of the error term varying across observations and results in inefficient estimators, incorrect confidence interval and incorrect t-statistics in linear regression. The Breusch-Pagan/Cook-Weisberg test was applied in testing for the presence of heterogeneity in the Endogenous Treatment Regression Model. There was no presence of heteroscedasticity in the two steps.

4.3.5.3 Test for poolability of data from Bungoma and Busia counties

The Chow test was employed in testing for poolability to determine whether to pool the data or split it into individual counties during data analysis. Chow test was calculated as shown below:

$$CHOW = \frac{(RSSP_p - RSSP_1 - RSSP_2 - RSSP_3)/K}{(RSSP_p + RSSP_1 + RSSP_2 + RSSP_3)/(N - 2K)} \quad \text{.......................................} \;(16)$$

where,

RSS_p is the residual sum of squares for the pooled regression model, $RSS_{1\ldots n}$ is the Residual Sum of squares for the regression model of the split data, K is the degrees of freedom and N is the sample size for the pooled sample.

In this test, the F calculated values are compared with the F critical values. The null hypothesis that data can be pooled in a single regression is rejected when the F calculated value is greater than the F critical value. This leads to splitting of the data and analysis of sub-samples.

In this study, the F calculated value for the farmers' probit model was 0.978. This showed that estimating the regression with pooled data had significant improvement in the model; hence, separate models for contract participation in the two counties are not presented and thus subsequent discussions are based on the pooled model, though with a county dummy variable. This is consistent with the observations of Barasa et al. (2018) in their malnutrition management study in Busia and Bungoma that there are no statistical differences in the farmer characteristics in the two counties.

4.4 Results and discussion

4.4.1 Results and discussions for probit model

Table 8 below shows results from the binary probit regression model on for determinants of participation in contract farming. Distance to the market, total land size, and off-farm income were found to positively influence participation in contract farming. The distance to the market place had a positive influence on participation in contract farming for Chili farmers and to pooled farmers as well. This is attributed to the fact that the farmers are motivated because of savings on transportation costs especially when the buyer comes to pick the produce. Narrod et al. (2009) and Trebbin (2014) also found that distance had a positive relationship with access to high–value markets.

Contrary to the expectation, farming experience had a negative effect on participation in contract farming for spider plant farmers and pooled farmers. As indicated by the findings from the FGD farmers with more farming experience are reluctant to embrace new technology including contract farming, which is an institutional innovation. On the other hand, farmers with less farming experience have high expectations and interest in trying out new ways of farming as part of exploration.

Table 8: Factors influencing farmers' participation in contract farming in Western Kenya

	Spider plant (n = 173)		***Chili (n = 127)***		***Pooled sample (n = 300)***		
Variable	***Coefficient***	***RSE***	***Coefficient***	***RES***	***Coefficient***	***RES***	***dy/dx***
Distance from home to the market (Kms)	0.401	0.348	0.466**	0.234	0.379**	0.175	0.111
Farming experience of the farmer (years)	-0.407***	0.157	0.028	0.132	-0.177*	0.090	-0.052
Farmer's age (years)	-0.861	0.612	-0.074	0.486	-0.470	0.355	-0.137
Total land size (acres)	0.567***	0.203	-0.023	0.168	0.252**	0.117	0.074
HH size	0.018	0.063	0.052	0.044	0.017	0.339	0.005
Gender of the farmer (male)	-0.053	0.301	-0.314	0.305	-0.032	0.187	-0.009
Farmer's membership to agricultural development group	-0.559*	0.332	-0.434	0.315	-0.510**	0.206	-0.152
Farmer's access to agricultural extension (yes)	0.064	0.323	-0.205	0.281	-0.064	0.206	-0.019
Farmer's access to agricultural credit	0.328	0.321	0.221	0.294	0.256	0.193	0.074
Household type (female-headed)	0.540	0.535	-0.669	0.528	0.023	0.198	0.007
County (Busia)	-0.590*	0.319	-0.631**	0.299	-0.480**	0.336	-0.141
Off-farm income of the household (Kshs)	0.001***	0.000	0.0001***	0.0001	0.001***	0.0001	0.001
Constant	-2.123	0.641	1.042	0.540	-0.895	0.641	
Prob > Chi2	0.0000		0.0034		0.0000		
Log likelihood	-60.1482		-72.6552		-150.7353		
Pseudo-R^2	0.4957		0.1684		0.2751		
F-value from Chow test:					0.978		

*Significance levels: *** 1%; ** 5%; * 10%.1USD = Kshs 101.16 at the time of survey*

Source: Survey Data (2019).

Land size had a positive influence on participation in contract farming for spider plant farmers and for all farmers combined. Farmers with more land have the incentive to participate in contract farming due to the capacity to meet the buyer's demand in terms of volume. Some farmers with larger parcels of land go for contract farming in order to access farming inputs and support provided by some buyers or contracting firms. These findings concur with Khan et al. (2019) who found a positive relationship between land size and participation in contract farming among potato and maize farmers in Pakistan.

Membership to agricultural development groups had a negative influence on participation in contract farming for both spider plant and pooled farmers. Similar findings were reported during FGD that most groups try to secure alternative local markets with better prices as compared to contracting firms who tend to offer low prices. Group members also tend to influence each other especially individuals within the group who have been victims of violation of contracts by contracting firms or buyers.

Location of the farmer influences participation in contract farming especially Busia county (which was used as the reference county), had low participation in contract farming compared to Bungoma county. The economic status of Bungoma county gives it an added advantage over Busia county in that poverty levels in Busia are so high as compared to Bungoma (Republic of Kenya, 2019) hence; farmers in Busia county have low capacities in terms of minimum resources of production to participate in contract farming. There is also evidence of low extension services in Busia county hence poor dissemination of information among smallholder farmers.

Off-farm income had a positive influence on participation in contract farming. This is explained by the fact that farmers with high off-farm income have the resources and the incentive to invest in contract farming and ensure timely delivery of the vegetables. In addition, farmers with a higher off-farm income are more willing to take part in contract farming due to the assurance of income in case the contract farming fails. On the other hand, farmers with low off-farm income are reluctant to take the risk of contract farming since on-farm production is their main source of income hence they feel they have low security. These results contradict those of Azumah et al. (2016) who found that off-firm income had a negative effect on contract farming meaning that a decrease in one unit of off-firm income would increase the probability of a farmer participating in contract farming as a compensatory mechanism. These results therefore lead to rejection of the null hypothesis that socio-economic and institutional factors do not affect smallholder farmers' participation in contract farming.

4.4.2 Results and discussion for endogenous treatment regression model

Tables 9 below show results for endogenous treatment model. From Table 9, participation in contract farming was found to have a positive significant effect on income for spider plant, chili and pooled vegetable farmers. Vegetable farmers participating in contract farming have higher income than those not participating. This is due to benefits of high yields especially for farmers contracted by firms that offer technical support and agricultural inputs, which is, inform of credit to farmers. These results lead to the rejection of the null hypothesis that there is no difference in income between contract participants and non-participants.

Household type had a negative effect on income. Female-headed households have low income as compared to male-headed households. Females who head households are sometimes overwhelmed by other household duties in terms of labor distribution and thus end up having limited time to dedicate to farming thus they become inefficient in production resulting into low incomes

(Bidzakin et al., 2028). Male-headed households on the other side recorded higher incomes efficiency in production and marketing.

Distance to the market had a negative influence on income for pooled vegetable farmers. This is attributed to several factors for instance; when the market place is very far from the farm, there is a tendency of vegetables perishing before they reach the market and this leads to deterioration of quality of the vegetable that end up fetching very low prices. The longer the distance the more the farmers incur higher transportation costs and this reduces profit margins. In addition, farmers located away from market place, especially those not in contracts end up selling their vegetables locally at farm gates at very low prices hence resulting into low incomes.

Land size also had a negative effect on income for spider plant and pooled vegetable farmers. As land increases in size, the income of the farmers declines. This is explained by the fact that the more the size of the land increases the more inefficient a farmer becomes. Smaller pieces of land are easier to manage as compared to larger ones. Rural farmers are resource-poor hence; those with smaller pieces of land tend to be more efficient due to proportional use of resources hence productivity and production is higher, resulting to high incomes. On the other hand, farmers with large pieces of land tend to be inefficient due to inappropriate allocation of resources. Larger pieces of land require more effort and management skills to enhance efficiency, productivity and improve production. Most farmers with large pieces of land tend to be reluctant in enhancing efficiency thus leading to low incomes.

Table 9 shows the OLS results for the second step of the endogenous treatment regression.

Table 9: Linear regression results of the effect of participation in contract farming on income

	Spider Plant (n = 173)		***Chili (n = 127)***		***Pooled Farmers (n = 300)***	
Variable	***Coefficient***	***p-value***	***Coefficient***	***p-value***	***Coefficient***	***p-value***
Household type (female-headed)	-0.285	0.236	0.466**	0.047	-0.088	0.707
Distance from home to market (Kms)	-0.233	0.118	0.028	0.834	-0.234*	0.074
Total land size (acres)	-0.232**	0.012	-0.074	0.879	-0.161*	0.068
Age of the farmer (years)	0.358	0.183	-0.023	0.889	0.227	0.360
Household Size	-0.056	0.742	0.052	0.242	-0.077	0.611
Farming experience of the farmer (years)	0.192**	0.012	-0.314	0.303	0.147**	0.030
Years of formal education of the farmer	0.047	0.552	-0.434	0.168	0.019	0.800
County (Busia)	0.184	0.205	-0.205	0.465	0.339**	0.015
Farmer's membership to development group (yes)	0.265*	0.091	0.221	0.452	0.262*	0.084
Farmer's access to agricultural extension (yes)	-0.012	0.939	-0.669	0.205	0.096	0.508
Farmer's access to agricultural credit (yes)	-0.107	0.468	-0.631**	0.035	-0.154	0.277
Participation in contract farming	2.142***	0.000	2.621***	0.000	2.593***	0.000
Constant	-1.498	0.000	-0.258	0.633	-1.763	0.000
Prob > Chi2	0.0000		0.0060		0.0000	
Rho	-1.0000		-1.0000		-1.0000	
Sigma	0.81389		1.2333		1.0567	
Lambda	-1.2509		-1.5939		-1.424254	

*Statistical significance levels: *** 1%; ** 5%; * 10%.*

Source: Survey Data (2019).

As expected, farming experience had a positive effect on income for spider and pooled vegetable farmers. More experienced farmers who have been farming for many years have higher incomes as compared to farmers with less farming experience. These farmers have learned risk management skills, they have a better understanding of the production management practices like correct land preparation, timely weed and pest management, appropriate fertilizer application, irrigation techniques, pre and post-harvest management. These farmers also have better marketing strategies and market linkages as compared to less experienced farmers (Beckman and Schimmelpfennig, 2015).

Busia county had a positive effect on income for pooled vegetable farmers. Membership to agricultural development group had a positive effect on income for spider and pooled vegetable farmers. Farmers who are members of agricultural development group are exposed to crop production trainings, agricultural credit, extensional services and marketing information thus, high productivity and income from agricultural produce, vegetable for this case. Farmers who are not members of agricultural development groups have low incomes as they miss benefits that arise from having social capital as pointed out by Oya (2009).

Access to agricultural credit had a positive effect on income for Chili farmers. This is owed to the fact that credit enables farmers to purchase the required inputs for instance seeds, fertilizer and chemicals to facilitate production of vegetables. These farmers end up having high yields that increases their incomes, unlike farmers who do not have access to agricultural credit. These results concur with those of Randela et al. (2008) who found that access to credit had a positive effect on participation in high-value markets for instance contract farming.

CHAPTER FIVE: COMPARISON OF TECHNICAL EFFICIENCY BETWEEN CONTRACTED AND NON-CONTRACTED FARMERS

5.1 Abstract

The level of technical efficiency (TE) shows how well farmers combine the inputs that are available in the production process. Farm output increases as the increase in TE and technology gap ratio (TGR). This study estimated and compared TE and TGRs between contracted and non-contracted farmers. The study used both qualitative and quantitative data from a sample size of 300 vegetable farmers. Interviews were conducted using semi-structured questionnaires. The stochastic frontier approach was applied to compute TE scores and metafrontier method to estimate TGRs. Results showed that, for spider plant farmers, contract participants had a higher mean TE (0.79) compared to their non-participating counterparts (0.45). Chili contract participants also registered a higher TE of 0.68, which was twice that of the non-participants. For both spider plant and chili, contract participants had higher mean TE with respect to the metafrontier (0.66) and (0.24) compared to non-participants (0.12 and 0.15, respectively). Chili contract participants recorded a slightly higher mean TGR (0.35) compared to non-participants (0.33). For spider plant, the TGRs were 0.82 for contract participants and 0.27 for non-participants. This study concludes that contract farming has a positive effect on TE and therefore development practitioners and government agencies should promote contract farming to enable farmers efficiently use the available inputs to increase their output and welfare at large.

Key words: Contract farming, TE, chili, spider plant.

5.2 Introduction

Improving efficiency in agricultural production is a key strategy towards achieving economic development. Contract farming has been found to be a useful tool in enhancing farmers' welfare and productivity as well. This happens when big firms contract smallholder rural farmers providing inputs and ready markets translating to high efficiency and contributing to reduction of rural poverty (Huy and Nguyen, 2019). It has been found that contract farming improves smallholder farmers' efficiency and productivity through enhancing coordination among farmers and other actors in the value chain in terms of production, processing and marketing (Nguyen et al., 2015).

Changes in the agricultural systems in the globe have led to the expansion of contract farming in most of the developing countries. Extant literature focuses on the welfare impact of contract farming while overlooking its effect on TE. This chapter addresses this salient gap through the estimation and comparison of TE and TGRs between contracted and non-contracted vegetable farmers. Generally, agricultural production in the developing countries records low efficiency compared to non-agricultural production. The low agricultural efficiency could be attributed to several factors for instance, limited access to high yielding varieties, low technology and knowledge about how to improve output, low access to agricultural credit, variability in output price, production risks and unreliable markets.

According to Bellemare (2017), contract farming is considered as an institution for improving agricultural productivity in the developing countries due to its ability to address the above mentioned challenges for example through improving access to market, better technology, positive information, inputs that enhance productivity and provision of predictable output prices.

5.3 Methodology

5.3.1 Estimating technical efficiency and technology gap ratios

5.3.1.1 The stochastic frontier analysis

The analysis is relevant to policy since it will provide information needed to improve technical performance of farmers by adopting better farming practices. It could be misleading to compare performance of various value chains based on yield per acre or hectare alone. Bringing in contract farming in the efficiency analysis will help in appreciating value chain-based innovations and their role in enhancing efficiency and improved welfare.

Previous studies focused on measurement of TE using deterministic production functions. Due to inherent limitations on the statistical inferences from such approaches, this study adopted the parametric stochastic frontier advanced by Meeusen and Van den Broeck (1977). This is empirically specified as follows:

$$Y_i = f(X_i; \beta) + \varepsilon_i \quad i = 1,2,\ldots n \qquad \ldots\ldots (17)$$

where Y_i is output, X_i represents the input vector, β denotes the vector of production parameters and ε represents the error term that consists of two components, shown in Equation 18:

$$\varepsilon = V_i - U_i \qquad \ldots\ldots (18)$$

The first term V_i is the random error while the second component U_i represents the inefficiency component. According to Jondrow et al. (1982), the TE estimation is given by the mean of the conditional distribution of inefficiency term, $U_{i,\varepsilon}$ as follows:

$$E(U_i|\varepsilon_i) = \frac{\sigma_u \cdot \sigma_v}{\sigma} \cdot \left[\frac{f(\varepsilon_i \lambda \mid \sigma)}{1-F(\varepsilon_i \lambda|\sigma)} - \frac{\varepsilon_i \lambda}{\sigma} \right] \quad \ldots\ldots\ldots\ldots\ldots (19)$$

where,

$\lambda = \sigma_u/\sigma_{v2}, = \sigma^2{}_u + \sigma^2{}_v$ .... (20)

F represents the cumulative distribution function and f the standard normal density which are determined at, $\varepsilon\lambda/\sigma$.

Using the readily available technology , the farm-specific TE is defined in terms of the observed output which is given by Y_i to the corresponding frontier output given by Y^* as shown below. From the stochastic frontier, the TE of ith farmer can be calculated as:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(X_i;\beta)exp(Vi-U_i)}{f(X_i;\beta)\exp(Vi)} = \exp(-U_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots (21)$$

Following Jondrow et al. (1982), the conditional mean of U is given as

$$E(U_i|\varepsilon_i) = \sigma_*^2 \left[\frac{f^*(\varepsilon_i\lambda/\sigma)}{1-F^*(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots (22)$$

where,

$\lambda = \sigma_u/\sigma_v$; $\sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$; $\sigma_*^2 = \sigma_v^2\sigma_u^2/\sigma^2.f^*F^*(\varepsilon_i\lambda/\sigma)$

The TE takes values ranging from 0 to 1, whereby 1 represents a fully efficient farm.

5.3.1.2 Metafrontier estimation

This approach is applicable in estimating TE among different groups with varying levels of technology. The groups used in this study were contract participants and non-participants for chili and spider plant independently. This method involved estimation of separate stochastic frontiers for the groups. It was assumed that vegetable farmers had different levels of technology in operation. A likelihood ratio (LR) test was first conducted to determine whether differences in technology between contract participants and non-participants for each vegetable were statistically significant to form a basis for constructing the metafrontier. Assuming there are z locations, the stochastic frontiers of contract participants and non-participants are specified as**:**

$Q_{ik}^{z} = f\left(X_{ijk}^{z}; \beta_{k}^{z}\right)e^{\epsilon k} \quad i = 1,2 \ldots N; j\ ; k = \text{contract participant}(1), \text{Contract} -$

$\text{non participant}(2)$……………………………………………………………………….(23)

Q_{ik}^{z}represents vegetable output of z^{th} location from the i^{th} farm for the k^{th} farmer X_{ijk}^{z} represents a vector for the j^{th} variable input used in z^{th} location by the k^{th} farmer in the i^{th} farm, β_{k}^{z} is a vector of coefficients associated with the independent variables for the stochastic frontier for the k^{th} farmer involved in z^{th} location, $e^{\epsilon k} = v_{ik}^{z} - u_{ik}^{z}$ denote an error term that is decomposed to statistical noise v_{ik}^{z} and inefficiency term u_{ik}^{z} according to Aigner et al. (1977).

According to Battese and Corra (1977), output variation from the frontier due to u_{ik}^{z}can be defined as:

$\gamma = \frac{\sigma_{u_{ik}^{z}}^{2}}{\sigma_{ik}^{2}}$ and $0 \leq \gamma \geq 1$ ……………………………………………………………..…. (24)

where $\sigma^{2} = \sigma_{uik}^{2} + \sigma_{vik}^{2}$

The LR test was conducted to establish the most appropriate functional form; the Cobb-Douglas form fitted the data better and was established as follows;

$$LnQ_{ik}^{z} = \beta_{0k}^{z} + \sum_{j=1}^{6} \beta_{ik}^{z} LnX_{ijk}^{z} + v_{ik}^{z} - u_{ik}^{z}: k = \text{contract participants (1), contract} - \text{non participants (2)} \quad \ldots \ldots (25)$$

where Q_{ik}^{z} represents vegetable output (kg), X_{ijk}^{z} denotes vectors for variable inputs used on farms such as vegetable seeds (kg), land size (acres), labor (man-days) and fertilizer (kg), $\beta_{0k}^{z}$is the constant term, β_{ik}^{z} denote the estimated coefficients of the inputs used which were estimated, v_{ik}^{z} represents statistical noise and $u_{ik}^{z}$is the technical inefficiency. The TE of the i^{th} farm in the z^{th} region with respect to the stochastic frontier is defined as the ratio of the observed output Q_{ik}^{z} to Q_{ik}^{z*} given that there are no inefficiencies in the production (Battese et al., 2004). This is given as:

$$TE_{ik}^{z} = \frac{Q_{ik}^{z}}{Q_{ik}^{z*}} = \frac{f(X_{ik}^{z}\,;\beta_{k}^{z})e^{u_{ik}^{z}-v_{ik}^{z}}}{f(X_{ik}^{z}\,;\beta_{k}^{z})e^{v_{ik}^{z}}} = e^{-u_{ik}^{z}} \quad \ldots \ldots (26)$$

According to Battese and Coelli (1988), the most appropriate predictor of TE is derived as follows;

$$TE_{ik}^{z} = E[\exp(-u_{ik}^{z})] \quad 0 \leq TE_{ik}^{z} \leq 1 \quad \ldots \ldots (27)$$

Table 10 shows hypotheses tests on the production structure.

Table 10: Hypothesis tests on the production structure

Test	Parameter restriction	LR test statistic	Degrees of Freedom	Chi-square critical value at 5%	Decision
Spider plant					
Poolability of group frontier	H_0: Pooled = Participants = Non-participants = 0	576.6	14	23.06	H_0 Rejected
There is inefficiency	H_0: Participants = 0	181.2	4	8.76	H_0 Rejected
	H_0: Participants = 0	239.9	4	8.76	H_0 Rejected
Chili					
Poolability of group frontier	H_0 :Pooled = Participants = Non-participants = 0	371.6	14	23.06	H_0 Rejected
There is inefficiency	H_0: Participants = 0	158.2	4	8.76	H_0 Rejected
	H_0: Participants = 0	172.6	4	8.76	H_0 Rejected

Source: Survey Data (2019).

The likelihood ratio (LR) test was used to test the existence of technology gaps between contract participants and non-participants among vegetable farmers. Janaedi et al. (2016) to assess existence of technology gaps between different groups have used the test. The test involves estimation of specific stochastic frontiers for the two groups separately followed by a pooled sample from the two groups and assumes a null hypothesis that the stochastic frontiers (technologies) for the participants and non-participants are equal.

The critical value for the distribution was derived from the statistical table of Kodde and Palm (1986). For the two groups (participants and non-participants) for both spider plant and chili, the null hypothesis that the stochastic frontiers (technologies) for the participants and non-participants are equal was rejected meaning that there were differences in technologies among the farmers (groups) thus a justification for the use of metafrontier estimation.

The LR test is given by;

$$LR = -2\left\{ln\left(\frac{LH_0}{LH_1}\right)\right\} = -2\{Ln(LH_0) - Ln(LH_1)\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(28)}$$

where $Ln(LH_0)$ denotes log likelihood function value for stochastic frontier of the pooled sample and $Ln(LH_1)$are the summed functions for the stochastic frontiers estimated separately for the contract participants and non-participants. The null hypothesis is rejected (Table 10) implying that there are differences in production technologies across farms thus a justification for the estimation of the metafrontier (Battese et al., 2004).

Technology differences between contract participants and non-participants were addressed by the metafrontier, which is assumed to be a smooth function that envelopes the specific participants' and non-participants' stochastic frontiers (Battese and Rao, 2002). The metafrontier of the pooled vegetable farmers is given by:

$$lnQ_i^{z*} = \beta_0^{z*} + \sum_{j=1}^{6} \beta_j^{z*}\, lnX_{ij}^{z*} + \varepsilon_{ij}^{z}, j = 1,2,3, \ldots, j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(29)}$$

Where;

Q_i^{z*}represents the metafrontier output from z^{th} regions

X_{ij}^{z*} is the vector of variable inputs used in the farms such as vegetable seeds (kg), land size (acres), labor (man days) and fertilizer (kg),

β_0^{z*} is the constant,

β_j^{z*} are the parameters to be estimated,

Asterisk (*) represents the metafrontier

ε_{ij}^{z} is the error term.

In this model, only the output and input variables were fitted. The metafrontier approach accounts for deviation between an observed level of output and the highest output that is realized in the group frontiers given a specific input level as well as accounting for the differences in technology (Battese et al., 2004).

The parameters β_j^{z*} of the metafrontier were estimated through solving a linear minimization problem, expressed as:

$$min \sum_{i=1}^{N} \left| \ln f(X_i^z, \beta^{z*}) - lnf(X_i^z, \beta^{z^\wedge}) \right| \ldots\ldots (30)$$

$$s.t. \ln f(X_i^z, \beta^{z*}) \geq \ lnf(X_i^z, \beta^{z^\wedge})$$

where $\ln f(X_i^z, \beta^{z*})$ denotes the metafrontier and $lnf(X_i^z, \beta^{z^\wedge})$are the farmers' frontiers (Battese et al., 2004).

In reference to the metafrontier, the observed vegetable output in z^{th} region of the i^{th} farm in the k^{th}farmer measured using the stochastic frontier is specified as;

$$Q_i^{z*} = e^{-u_{ik}^z} . \frac{f(x_{ijk}^z; \beta_k^z)}{f(x_{ijk}^z; \beta_k^{z*})} . f(x_{ijk}^z; \beta_k^{z*})\ e^{v_{ik}^z} \qquad \ldots\ldots (31)$$

In equation 31, $\frac{f(x_{ijk}^z; \beta_k^z)}{f(x_{ijk}^z; \beta_k^{z*})}$ refers to the TGR and it is a measure that lies between 0 and 1, hence:

$$TGR_{ik}^z = \ \frac{f(x_{ijk}^z; \beta_k^z)}{f(x_{ijk}^z; \beta_k^{z*})} \qquad \ldots\ldots (32)$$

Therefore mathematically, TE_{ik}^{z*}can be derived by multiplying the TE in relation to the stochastic frontier of the individual group and the TGR such that:

$$TE_{ik}^{z*} = TE_{ik}^z \times TGR_{ik}^z \qquad \ldots\ldots (33)$$

5.4 Results and Discussion

5.4.1 Stochastic frontier estimates

Table11 below shows stochastic frontier TE estimates for spider plant farmers.

Table 11: Stochastic frontier TE results for spider plant farmers

	Participants (n = 79)			**Non-participants (n = 94)**			**Pooled sample (n = 173)**		
Variable	Coefficient	Standard Error	t-ratio	Coefficient	Standard Error	t-ratio	Coefficient	Standard Error	t-ratio
Constant	5.939***	2.316	2.564	4.580***	0.423	10.838	5.093***	0.994	5.124
Land	0.103***	0.035	2.972	0.139	0.115	1.214	0.176***	0.053	3.303
Labor	0.875***	0.159	5.522	0.002	0.170	0.014	0.313*	0.187	1.675
Fertilizer	-0.003	0.052	-0.067	-0.071	0.046	-1.563	-0.145***	0.051	-2.842
Seeds	0.077	0.101	0.755	0.105*	0.058	1.821	0.145**	0.071	2.045
Sigma Squared	0.640	1.039	0.616	1.874***	0.698	2.685	2.067*	1.199	1.724
Gamma	0.145**	2.307	0.063	0.892***	0.158	5.643	0.323	0.708	0.456
Mean TE	0.80			0.45			0.58		
Log Likelihood function	-90.66			-119.98			-288.30		

*Statistical significance levels: *** 1%; ** 5%; * 10%.*

Source: Survey Data (2019).

From the results, among spider plant farmers, contract participants had higher TE scores (0.80) as compared to non-participants (0.45). This is attributed to the fact that contract participants have a better access to inputs such as fertilizer and seeds as compared to non-participants. Land and labor had positive coefficients among spider plant contract participants implying that increased used of the inputs increased output. In the pooled results, fertilizer had a negative coefficient showing an inverse relationship with output. This could be due to application of the wrong fertilizers on the soil. This happens when soil characteristics conflict with the fertilizer applied.

Table12 below shows stochastic frontier TE coefficient estimates for chili farmers.

Table 12: Stochastic frontier TE results for chili farmers

	Participants (n = 70)			**Non-participants (n = 57)**			**Pooled sample (n = 127)**		
Variable	Coefficient	Standard Error	t-ratio	Coefficient	Standard Error	t-ratio	Coefficient	Standard Error	t-ratio
Constant	6.119***	0.776	7.889	7.799***	0.247	31.584	6.878***	0.289	23.827
Land	0.108***	0.035	3.127	0.113	0.110	1.029	0.136***	0.049	2.787
Labor	0.861***	0.155	5.561	-0.677	0.477	-1.421	0.451***	0.166	2.723
Fertilizer	-0.004	0.053	-0.080	0.377***	0.085	4.442	0.057	0.054	1.047
Seeds	0.051	0.102	0.501	0.511***	0.120	4.269	0.152*	0.081	1.877
Sigma Squared	0.758	0.540	1.403	5.442	0.241	22.559	2.537	0.548	4.628
Gamma	0.408	0.789	0.517	1.000	0.000	1.258	0.856	0.089	9.658
Mean TE	0.675			0.338			0.419		
Log Likelihood function	-79.047			-86.322			-185.800		

*Statistical significance levels: *** 1%; ** 5%; * 10%.*

Source: Survey Data (2019).

It was found that chili contract participants recorded higher TE scores (0.675) than contract non-participants (0.338). The lower TE of non-participants is attributed to imbalanced use of inputs. Land and labor had positive coefficients showing a direct relationship with output among chili contract participants. For non-participants, fertilizer and seeds had a positive relationship with output. The mean TE remains low because farmers were not able to optimally apply the inputs due to inaccessibility to the inputs.

5.4.2 Regularity of production function parameters

In the theory of production, fulfillment of concavity test is a very crucial regularity condition. This test requires that the second order derivatives of all the subject parameters should be negative. This is to imply that the slope of the marginal physical product (MPP) should be negative.

Table 13: Second-order derivatives for production parameters of chili

Change in variable	Participants (n = 70)	Non- participants (n = 57)	Pooled (n = 127)
Land	-0.00005***	-0.0022***	-0.0003***
	(10.9)	(6.0)	(9.2)
Labor	-0.00108***	-0.0128***	-0.0047***
	(6.3)	(3.4)	(4.7)
Fertilizer	-0.00015***	-0.0008***	-0.0004***
	(9.4)	(7.6)	(8.4)
Seed	-0.00027***	-0.0014***	-0.0007***
	(8.4)	(6.7)	(7.6)

*Notes: statistical significance levels:***1%; **5% ; 10%. Absolute values of the corresponding t-ratios are shown in parenthesis*

Source: Survey Data (2019).

According to Sauer et al. (2006), the MPP of each production factor must be diminishing at the sample average. The present study fulfils the concavity requirement for all the inputs and for both vegetables as shown in Table 13 and 14.

The fulfillment of concavity requirement and the significance of the parameters imply that both chili and spider plant farmers are rational in the utilization of their inputs on farm.

$$\Psi:\ \frac{\partial MPP_{X_i}}{\partial X_i} = \frac{\partial\left(Q\beta_{X_i}/X_i\right)}{\partial X_i} < 0 \qquad \text{(34)}$$

where, Q is output, X_i denotes the i^{th} production factor and β the corresponding elasticity (Coelli et al., 2005).

Table 14 shows the second order derivatives for production parameters of spider plant farmers. All the production parameters are significant except for land and labor among contract non-participants. This shows that majority of the farmers are rational in input allocation.

Table 14: Second-order derivatives for production parameters for spider plant

Change in variable	Contract participants (n = 79)	Non-participants (n = 94)	Pooled (n = 173)
Land	-0.0001***	-0.9	-0.0003***
	(10.2)	(0.1)	(8.7)
Labor	-0.0030***	-2.0	-0.0032***
	(5.3)	(0.5)	(5.2)
Fertilizer	-0.0003***	-0.3*	-0.0003***
	(8.7)	(1.9)	(8.8)
Seed	-0.0009***	-0.26*	-0.0005***
	(7.2)	(1.86)	(7.9)

*Notes: statistical significance levels: ***1%; **5%; 10%. Absolute values of the corresponding t-ratios are shown in parenthesis.*

Source: Survey Data (2019).

5.4.3 Technical efficiency and technology gap ratios for vegetable contract participants and non-participants

Table 15 below shows metafrontier results for vegetable farmers.

Table 15: Metafrontier-based TE and TGRs

		Chili			Spider Plant		
Model		**Contract participants (n = 70)**	**Non-participants (n = 57)**	**Pooled (n = 127)**	**Contract participants (n = 79)**	**Non-participants (n = 94)**	**Pooled (n = 173)**
TE *w.r.t* stochastic frontier	Mean	0.675	0.338	0.419	0.797	0.450	0.578
	Min	0.382	0.006	0.033	0.683	0.066	0.321
	Max	0.827	0.999	0.828	0.859	0.837	0.740
	SD	0.088	0.300	0.206	0.033	0.220	0.087
TE *w.r.t* to metafrontier							
	Mean	0.236	0.147	0.136	0.655	0.123	0.262
	Min	0.009	0.001	0.002	0.240	0.009	0.084
	Max	0.662	0.678	0.739	0.840	0.425	0.592
	SD	0.219	0.104	0.151	0.092	0.093	0.122
TGRs							
	Mean	0.349	0.303	0.329	0.821	0.270	0.454
	Min	0.012	0.009	0.009	0.302	0.100	0.184
	Max	1.000	1.000	1.000	1.000	0.764	1.000
	SD	0.323	0.260	0.296	0.109	0.136	0.202

Source: Survey Data (2019).

From the results above, contract participants among chili farmers had higher TE scores (0.236) with respect metafrontier compared to contract non-participants (0.147). This suggests that contract participants are more efficient in utilization of inputs. Chili contract participants also had higher standard deviation (SD), 0.219 compared to non-participants (0.104). Higher SD implies use of varied technologies such as irrigation and improved varieties among contract participants compared to non-participants (Chang et al., 2015).

Results showed that, for spider plant farmers, contract participants had a higher TE mean (0.79) compared to their non-participating counterparts (0.45). Chili contract participants also registered a higher TE mean of 0.68 compared to non-participants who had 0.34. This is because farmers in contracts have a better access to production inputs and technical advice hence translating to higher TE (Barrett et al., 2012). For both spider plant and chili, contract participants had higher TE with respect to metafrontier (0.655), (0.236) compared to non-participants (0.123), (0.147). Chili contract participants recorded a slightly higher mean TGR (0.349) compared to non-participants (0.329) while the TGRs for spider plant, were 0.821 for participants and 0.270 for non-participants.

Figure 11 below shows the distribution of TGRs for spider plant farmers in Bungoma and Busia Counties. For spider plant contracted farmers, the maximum TGR is 1. This implies that their frontiers are tangent to the metafrontier according to Battese (2004). Given that the group frontier is tangent to the metafrontier, it means to further increase production of spider plant a better technology should be introduced for those farmers who have fully exhausted the productive potential of available technology.

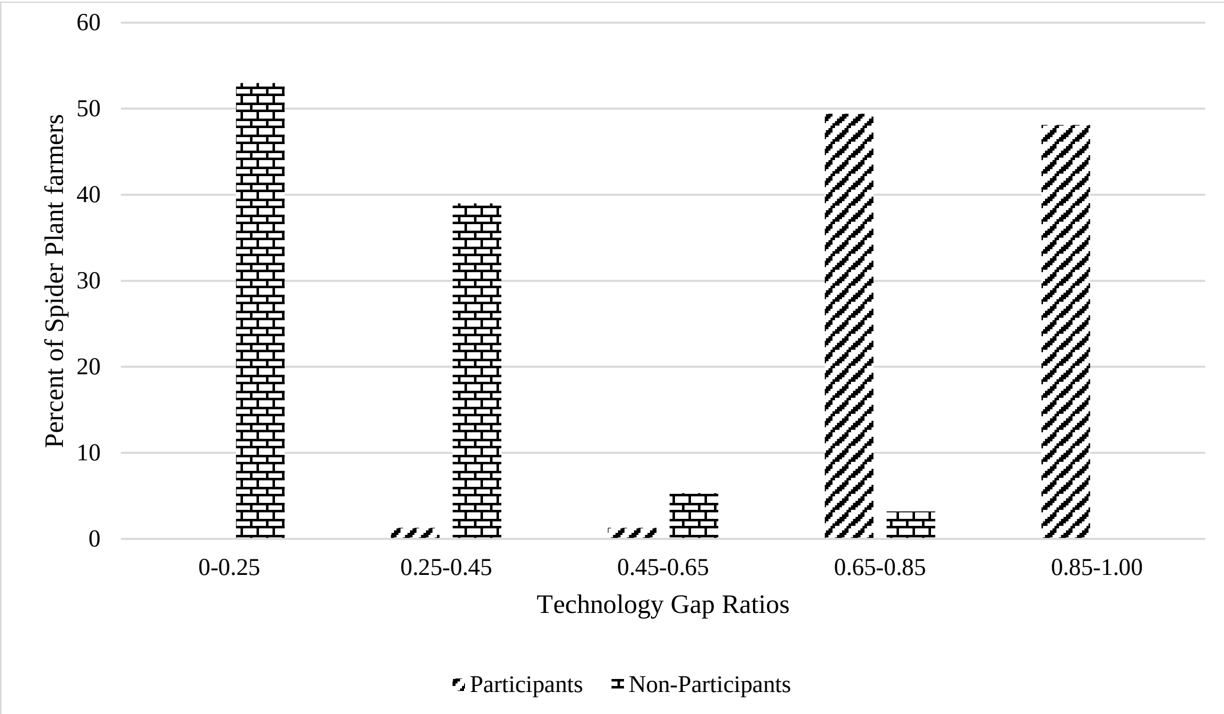

Figure 11: Distribution of technology gap ratios among spider plant farmers

Source: Survey Data (2019).

The highest number of contracted spider plant farmers had their TGRs ranging from 0.65 to 0.85 while a majority of their uncontracted counterparts had their TGRs ranging from 0 to 0.25.

Figure 12 shows the TGRs for chili farmers in Bungoma and Busia Counties. For both contract participants and non-participants chili farmers, majority of the farmers had their TGRs ranging from 0 to 0.25. The least number of both contracted and non-contracted chili farmers had their TGRs between 0.45 and 0.65. However, for both contracted and non-contracted farmers, their maximum TGR was 1 implying tangency of their farm's frontier to the metafrontier.

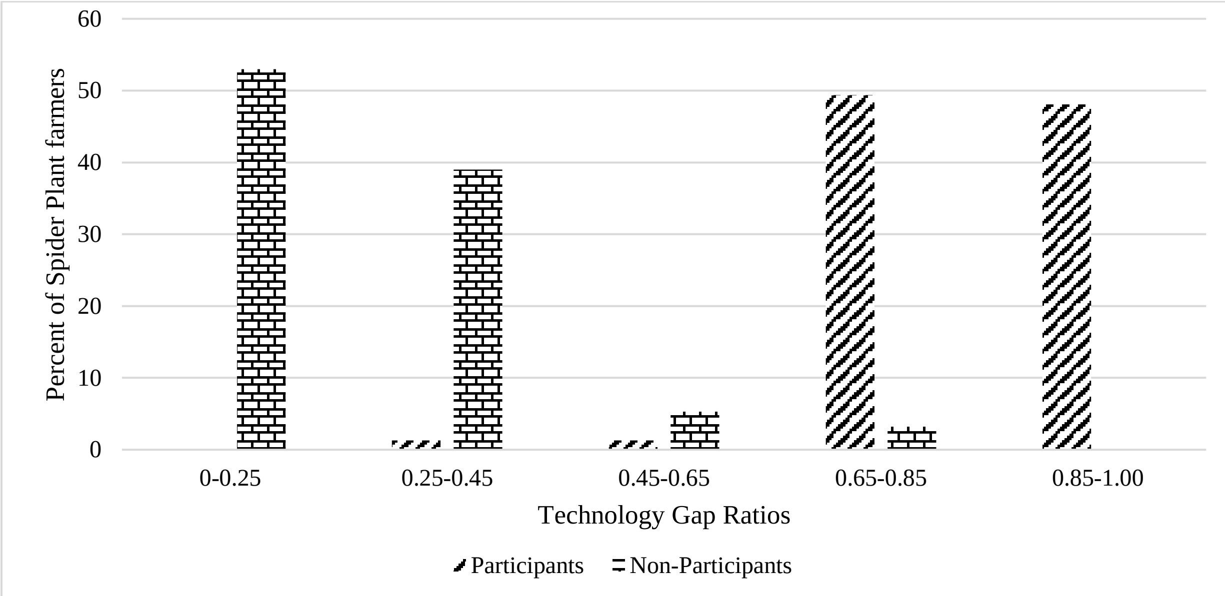

Figure 12: Distribution of technology gap ratios among chili farmers

Source: Survey Data (2019).

Figure 13 shows comparative distribution of TE with respect to stochastic frontier among spider plant farmers.

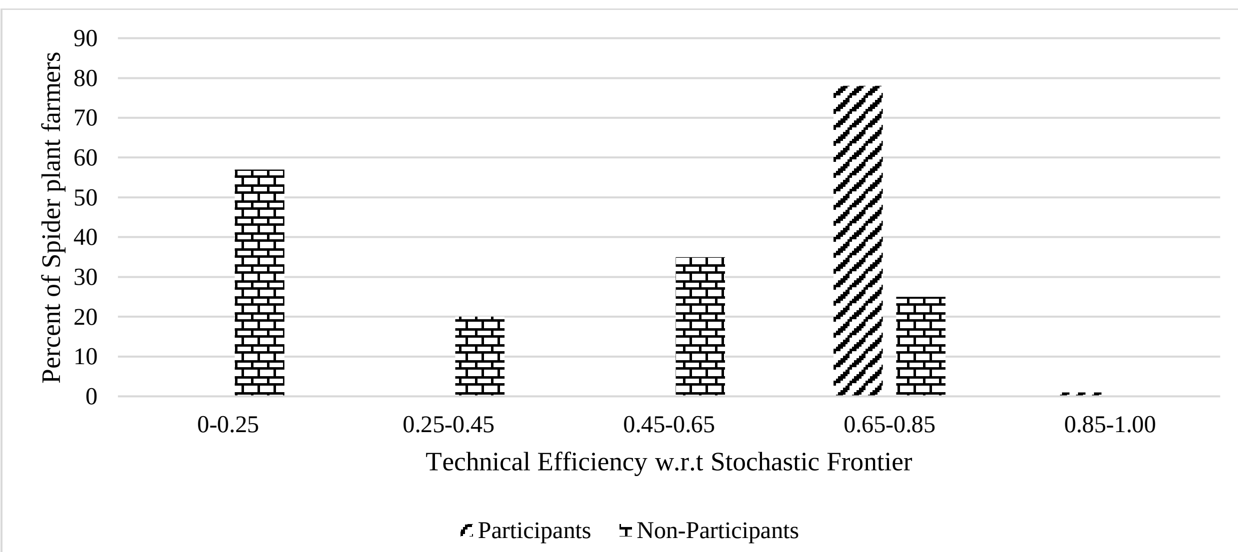

Figure 13: Distribution of technical efficiency for spider plant farmers

Source: Survey Data (2019).

There were no contracted spider plant farmers who had TE scores ranging from 0 to 0.25, 0.25 to 0.45 and 0.45 to 0.65. There were also no contract non-participating spider plant farmers who had TE scores ranging from 0.85 to 1. The majority of contract participants among spider plant farmers had their TE scores ranging from 0.65 to 0.85.

Figure 14 shows distribution of TE with respect to stochastic frontier for chili farmers. There were no chili-contracted farmers whose TE scores ranged from 0 to 0.25 and 0.85 to 1 as well.

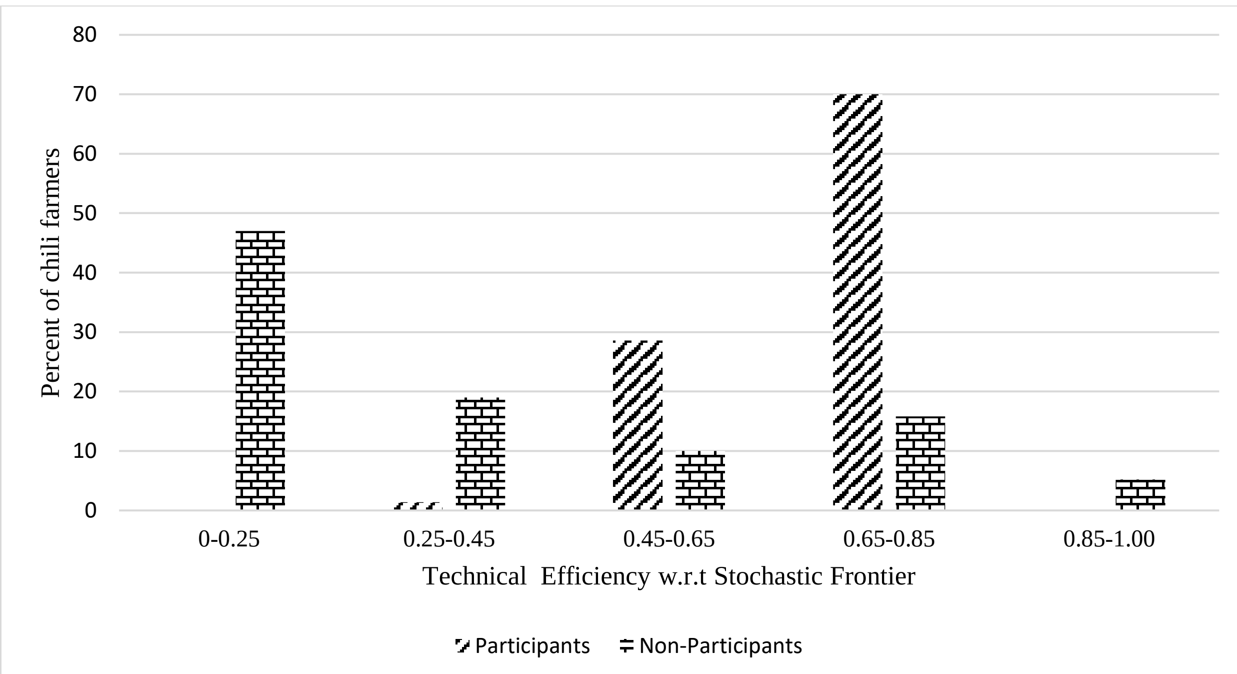

Figure 14: Distribution of technical efficiency for chili farmers

Source: Survey Data (2019).

However, the majority of chili contract participating farmers had their TE scores ranging from 0.65 to 0.85. These results therefore lead to the rejection of the null hypothesis that there are no significant differences in TE between contracted and non-contracted vegetable farmers.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study-analyzed participation in contract farming and its effects on technical efficiency and income of vegetable farmers. Characterization results revealed that about half of the respondents participated in contract farming. Vegetable production and marketing was highly dominated by women due to gender roles within the rural households and more than a half of the vegetable farmers were members of agricultural development groups where the proportion of farmers in agricultural development groups was higher in Busia compared to that of Bungoma. More than half of the vegetable farmers accessed agricultural extension services with the proportion being almost the same in Bungoma and Busia counties. Access to agricultural extension services increases dissemination of agricultural knowledge and farming technology, which helps farmers to improve their productivity. Slightly above a third of the farmers accessed agricultural credit and this proportion was higher in Busia compared to Bungoma. It was established that distance from home to local market; total land size and off-farm income had a positive effect on participation in contract farming. Contrary to expectations, farming experience and membership to agricultural development groups, had a negative effect on participation in contract farming. Contrary to the expectation, farming experience had a negative effect on participation in contract farming for spider plant farmers and pooled farmers because famers with more years of experience were skeptical due to cases of breaching contracts by the contracting parties. Contracted farmers for both spider plant and chili had higher TE and TGR score implying that they were more technically efficient compared to their non-contracted counterparts. Contract farming had a positive effect on income, leading to rejection of the null hypotheses. It is therefore concluded that contract farming has a positive effect on technical efficiency and income of smallholder vegetable farmers.

6.2 Recommendations

6.2.1 Policy Recommendations

Most of the contracting firms provide agricultural extension services by visiting the contracted smallholder farmers to offer training and knowledge on good agricultural practices. However, this has not been very efficient as shown by the evidence of technical inefficiency levels. The contracting firms should therefore incorporate information computer technology by developing extension services applications and use of test messages or unstructured supplementary service data (USSD) codes for smallholder farmers who may not afford smart phones. This technology will help the contracting firms to consistently share important agricultural information with farmers and enhance effective monitoring of the farmers' progress concerning the various value chains involved to further improve technical efficiency and income levels of smallholder farmers.

Membership to agricultural development groups increases the probability of participating in contract farming. There has been reasonable publicity and awareness of the importance of agricultural development groups by the county governments in the study area. However, there is need to strengthen the functionality of these agricultural development groups in order to augment innovations like contract farming and other services like access to agricultural credit which can be provided by groups at reasonable rates, friendly to the smallholder farmers.

The county governments are investing in physical infrastructure like roads and market structures in the two counties. This is crucial in augmenting trade by making it easier to transport and market agricultural produce, vegetables included. In additional to investing in physical infrastructure, the county governments and regulatory bodies should further strengthened the existing institutional infrastructure for instance putting into account the incentives and disincentives of contracting firms and farmers when designing programmes and policies of promoting contract farming to ensure that there is a balance in benefits between the contracting and contracted parties.

6.2.2 Recommendations for further research

Given the narrow analysis of the smallholder farmers' resource allocation, future research should explore the effect of contract farming on various types of efficiencies alongside the evaluation of governance structures to establish the effect of value chain governance on smallholder farmers' productivity. Better knowledge on the effect of contract farming on livelihoods is necessary; therefore, further research should assess other indicators of livelihoods for instance food and nutrition security apart from income.

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APPENDICES

Appendix 1: Household survey questionnaire

UNIVERSITY OF NAIROBI
PARTICIPATION IN CONTRACT FARMING AND ITS EFFECTS ON TECHNICAL EFFICIENCY AND INCOME OF VEGETABLE FARMERS IN WESTERN KENYA

JUNE 2019

The University of Nairobi is carrying out research on determinants of participation in contract farming and its effects on value chain governance, efficiency and livelihoods of vegetable farmers in Bungoma and Busia Counties, Kenya. The purpose of this study is to get views and perspectives of vegetable farmers on the role played by contract farming in value chain governance, farm's allocative, technical, profit and cost efficiencies, farm income and nutritional security. Respondents of this survey should be vegetable (chili and spider plant) farmers who must have attained a minimum age of 18 years. You have been randomly selected and your participation in this survey is voluntary. The findings of this study will be primarily used to inform policy on improving contract farming for better performance in terms of value chain governance, farm efficiency and livelihoods. The interview will require about one hour completing. I now request your permission to begin the interview.

Respondent screening: Does your household **normally** grow chili or spider plant? **0. NO_______ 1. Yes_______ . If NO** terminate the interview
RESPONDENT ID.............................
Enumerator Code............................. Date of the interview....................................

County :			
Region (1= Rural, 2=Peri-urban)			
Location		Village	

SECTION A

1. Household Identification

Type of Household (1= Male Headed Household, 0=Female Headed Household)	
Name of the respondent	
Gender of the respondent (1=male 0= female)	
Relationship to household head? (1= hhold head, 2=spouse, 3=son/daughter, 4=son/daughter in-law, 5= grandson/daughter, 6= other (specify_________________________)	

2. For how long have you been growing vegetables? ………. Years

3. Are you contracted to grow vegetables? 1= yes, 2 = No (If No, skip to Question 5)

4. If yes,

a) Who has contracted you? 1= private company, 2 = restaurant, 3 = school, 4 = county government, 5 = Any other (specify)___________________________

b) What is the nature of the contract? 1= Formal, 2 = Informal

c) What motivated you to participate in contract? 1= to access input supply, 2 = expectation of good prices, 3 = assured market, 4 = to access technical know-how, 5 = expectation of high income, 6 = Any other, Specify___________________________

5. If No, why? 1=production risks, 2 = price risks, 3 = financial risks, 4 = any other, specify__________________

SECTION B: LAND OWNERSHIP AND VEGETABLE PRODUCTION

6. What is the total land size owned during the last cropping season? (acres____________)

Season	**Plot in acres (cultivated)**	**Tenure of plot (**1=purchased, 2= Rent/leased, 3=inherited 4=gift 5=other, specific (___________)	**Gender of plot owner:** (1=Male 2=Female 3=Both)	**Proportion of land under spider plant** 1=25%, 2=50% 3=75%, 4=100%	**Proportion of land under chili:** 1=25%, 2=50% 3=75%, 4=100%	**Do you Intercrop chili/spider plant with other crops?** 1= Yes 0=No	**If YES, what crops:** 1 = kales 2 = soybeans 3 = tomatoes 4 = cowpeas 5 = Maize 6=other, specify (__________)	**Spider plant yield Quantity:** (Kg)	**Chili yield Quantity:** (Kg)
Long rains									

Short rains									

INPUT USE

7. SEEDS

Crop	**Variety grown:** 0=local 1=improved 2=both	**Quantity of seeds used (kg)**	**Mode of acquisition:** 1=bought 0= non-bought	**If bought where is the source:** 1=agro-vets 2=seed company 3=open air market 4=Neighbour/other farmers 5=other, specify	**Mode of payment for the seed:** 1=cash 2=credit 3=both	**If non-bought:** 1=Own saved 2=farmers to farmers exchange 3=gift from family/neighbor 4=Other, specify	**If bought:** How much did you pay per (Kg)	**Constraints faced in accessing seeds:** 1= poor availability of seeds, 2=high prices of seed 3=presence of counterfeit seeds 4=poor quality seeds 5=other, specify
Chili								
Spider plant								

8. Did you use fertilizer during the last cropping season ? **1. Yes** **0. No** if **NO** skip to question 12

9. Fertilizer

Crop	Type of fertilizer used: (1=conventional 2=manure 3=both)	Quantity of fertilizer used(kg)	Mode of acquisition: 1=bought 0= non-bought	If bought where is the source: 1=agro-vets 2=trader 3=open air market	If bought, What is the cost per kg (Ksh)	Mode of payment for the fertilizer: 1=cash 2=credit 3=subsidy 4=Other , specify	If non-bought: 1=own saved 2=farmers to farmers exchange 3=gift from family/neighbour 4=Other, specify	Constraints faced in accessing fertilizer 1= poor availability of fertilizer, 2=high prices of fertilizer 3=Lack of credit to buy fertilizer 4=other, specify___________
Chili								
Spider plant								

10. Reasons for not using fertilizer? (1= expensive, 2= have fertile soils, 3= lack of accessibility, 4 = burns crops, 5. Other, specify________________________)

11. Other input costs in the last one year

Crop	Cost Ploughing (Ksh)	Cost of Planting (Ksh)	Cost of weeding (Ksh)	Cost of harvesting (Ksh)	Cost of post-harvest management (Ksh)
Chili					
Spider plant					

12. Risks affecting vegetable production

Risk factor	**Did you encounter this risk factor in the last 5 planting seasons (**1=yes, 0=No**)**	**If yes how many times did it occur in the last 5 seasons**	**Did you put in place any strategies to prevent the risk factor before it happens (**1=Yes, 0=No**)**	**If YES What risk adaptation strategy did you put in place before risk occurrence:** 1=change crop varieties 2=early planting 3=crop diversification 4=Savings 5= change planting sites 6= increased seed rate 7=more of off-farm employment 8=None 9=other, specify	**What proportion of vegetable yield did you lose due to this risk factors (**1=25%, 2=50%, 3=75%, 4=100**)**
Drought					
Too much rain/floods					
Crop pests/diseases					
Hail storms					
Theft of assets/crops					
Spoilage of crops					

SECTION C
MARKETING

13. Did you sell vegetable after the last cropping season ? (1=Yes, 0=No) ____.

Type of market **(MAIN)**	Quantity of vegetable sold in during last season	Unit	Price per Unit	Period to payment after selling, weeks (zero if immediately)	Do you have a contract with the buyer 1= Yes 2=No	If **YES** what are the terms of this contract: 1= Pay immediately 2= pay after some duration 3=advance of inputs + cash 4= Other, specify (_________)	Transport costs	Cess tax
Farm gate								
Institutional markets (schools, hospitals)								
County government market								
Brokers /middlemen								
Village market								
Other, Specify								

14. For contract farmers,

a). Who sets the price? 1=Buyer, 2=Seller, 3=Both agree________

b). How is produce delivery done? 1=Farmer delivers, 2=Buyer picks from the firm, 3=Group delivery, 4=Other, Specify______

c). What are the rules governing contracts? ____

d). What are the challenges experienced with contract farming? 1=Very high standards, 2=Low prices, 3=Violation of terms by the buyer, 4=low education, 5=lack of information, 6=Climate change, 7=Inadequate production resources, 8Other, specify___________

e). Are contracts effective? 1=Agree, 2=Strongly agree, 3=Disagree, 4=Strongly disagree, 5=Not sure_______

15. a) Did you get market information before you decided to sell the crop? (1=Yes, 0 = No)________

b) If ***yes, what was*** your **MAIN** source of information? (1= farmer coop/groups, 2=neighbor farmers, 3=seed traders/ agrovets, 4=research centre,

5=extension provider, 6=radio/TV, 7=mobile phone, 8=other, specify)__________

16. Have you ever failed to sell vegetable due to lack of buyers? (1=Yes, 0=No)________

17. Have you ever failed to sell vegetable due to poor prices? (1=Yes, 0=No)___________

18. Distance to the nearest MAIN MARKET CENTRE from residence in (KM)_______

19. Average transport cost to and from the nearest main market per person_________

SECTION D: INSTITUTIONAL SUPPORT SERVICES

20. **Social capital and credit access**

Have you been a member of any development group since 2014? (1= Yes, 0= No) ____ if **YES** please fill the details in the table below: If **NO** skip to **Q.21**

Type of group	Member to group(1=Yes, 0=No)	If yes duration of membership	What is the most **(ONE)** important group function: 1=produce marketing 2=input access 3=savings and credit 4=farmer trainings 5=transport services 6.Agricultural production 7=other, specify	Role in the group: 1=official 0=ordinary member	Are you still a member now: 1=Yes, 0=No	If **NO,** reasons for leaving group: 1=group was not profitable 2=poor mgt and corrupt officials 3=unable to pay annual subscription fee 4=Group ceased to exit 5.=Other, specify
Women group						
SACCO/credit group						
Farmer coops/input supply						
Producer and marketing groups						
Youth group						

21. If you are **NOT** a member of any development group/organization, why not? (1=Not available, 2=time wasting, 3=Doesn't want to be a member, 4=corruption in the group, 5=other, specify____)

22. Most buyers can be trusted

(1=strongly disagree, 2=Disagree, 3=Neutral, 4=agree, 5=strongly agree)

EXTENSION SERVICES

23. Did you access extension services during the last cropping season? (1=Yes, 0=No) if **YES** fill details in the table below

Source (MULTIPLE)	Did you receive extension service from this source:? (1= Yes, 0=No)	Frequency over the last 12 months	What kind of information did you receive from this source:?**MAIN** 1=pests and diseases, 2=markets and prices, 3=government initiatives, 4= Good agricultural practices, 5= other, specify(____________)	Was this information timely (1= Yes, 0=No)	Was this information helpful/relevant in your agricultural activities (1= Yes, 0=No)	What would you want improved in the extension services from these providers?
Extension officer (govt)						
Researchers						
Contracting company						
Farmer to farmer						
Farm Demonstrations						
Print media (magazines)						
Tv/radio						
Out grower (seed companies)						

24. Credit services

Have you ever applied for credit over the last two years? (1=Yes, 0=No)__________ If**NO** skip to **Q. 25**

Source of Credit **MAIN**	Did you get it. (1=Yes, 0=No)	**If YES,** how was it received? 1=as a group, 2=Individual	**IF YES** what proportion of the credit applied for did you get: 1=1/4, 2=1/2, 3=3/4, 4=all	**Main** use of credit: 1=farm inputs 2=school fees 3=food 4=land 5=livestock 6=offset a problem one had 7=other, specify__________	**Did you use ALL of this credit for the intended purpose:?** 1= Yes 0=No	**If NO, how else did you use this credit:** 1=farm inputs 2=school fees 3=food 4=land 5=livestock 6=offset a problem one had 7=Farm implements/equipment 8=non -farm business/trade 9=buy livestock 10=other, specify__________	**If NO,** why did you not get the requested amount(**MAIN**): 1=high default rate 2=lacked guarantors 3=didn't adhere to all requirements 4=lacked collateral 5=couldn't access lender 6=Age limit 7=don't know 8=Other(specify)	Have you started repaying this loan? (1=Yes, 0=No)	If **YES,** what proportion have you repaid: 1=1/4, 2=1/2, 3=3/4, 4=all
Farmer group/cooperative									
Merry go Round									
Bank									
Sacco									
Relative									
Neighbour									
Friends									
Other (specify)									

25. If you did not apply for credit what was the **main** reason? (1=high interests rate, 2=lacked collateral, 3=too much paper work, 4=borrowing is risky, 5=expected to be rejected so I dint try it, 6=fear loans, 7= I don't need it 8. Other. Specify__________________________)

SECTION E: VALUE-CHAIN GOVERNANCE

26. (a) To what extent do you agree with the following statement**? (1=agree, 2=strongly agree, 3=disagree, 4=strongly disagree,5=Not sure)**

Transaction complexity	The contracting firms/buyers exchange considerable information with us (e.g. product requirements)	
	The contracting firm/buyer require more than the contractual agreement to award us business	
Ability to codify	Technology is the same across neighboring farms	
	We are well conversant with the contracting firm's/buyers technical standards	
Supply base capabilities	We are able to timely deliver complete products that meet market requirements with minimum input from the buyers.	
	The buyers do not spend more time monitoring us to fulfil our commitments.	

b) Vegetable Value chain management

Value-chain stage	Who coordinates this stage? 1=Farmer 2=Farmer groups 3=Buyer/firm 4=Government 5=Other Specify	What rules apply in coordination of this stage?	What are the challenges in this stage?
Input supply			
Production			
Transportation			
Value addition			
Assembling			
Marketing			

SECTION F: LIVELIHOODS

27. Household Asset Ownership

ASSET NAME	DO YOU HAVE THIS ASSET (1=Yes 0=No)	NUMBER CURRENTLY OWNED	CURRENT VALUE (KSHS)
1.Ox-plough			
2.Ox-cart			
3.Radio			
4. Television			
5. Mobile phone			
6. Wheelbarrow			
7.Mortocycle			
8. Pick-up			
9.Machete			
10.Hoe			
11. Car/pickup			
12Tractor			
13Slasher			
14Spraypump			
15.Shovels			

Income

28. (a) How much do you earn on-farm per cropping season?**____**(Kshs)

AMOUNT(Ksh)	Tick
500-1000	
1001-1500	
1501-2000	
2001-3000	
3001-5000	
5001-7000	
7001-10,000	
10,001-20,000	
20,001-30,000	
Above 30,000	

b) How much do you earn off-farm per cropping season? ____(Kshs)

Savings

29. How much have you been saving from vegetable production per season on average? ________________________________(Kshs)

Amount	**Tick**
0-1000	
1001-1500	
1501-2000	
2001-3000	
3001-5000	
5001-7000	
7001-10,000	
10,001-20,000	
20,001-30,000	
Above 30,000	

SECTION G: SOCIO-DEMOGRAPHICS

30. How many times has any of the household members sort medical attention in the last one month?__________

31. Education level of children

Child's, Sex 1=Male, 0=Female	**Education level, 0=None , 1=Primary, 2=Secondary, 3=Tertiary**

32. Respondent's MAIN occupation? (1=farmer, 2=civil servant, 3=student, 4=teacher, 5=trader, 6=tailor, 7=boda boda, 8=casual laborer (Juakali), 9=other, specify___________________)

33. Farmer's age in years. __________

34. Farmer's Sex , 1=Male, 0=Female

35. How many people live and depend on the household for food on a daily basis? __________

36. What is the total number of the household members______________?

37. Number of years of formal schooling for respondent ______________

THANK YOU FOR YOUR TIME

Appendix 2: VIF for probit model

Variable	VIF	1/VIF
Distance to market	1.06	0.939
Farming experience	1.12	0.890
Age of the farmer	1.53	0.652
Land size	1.2	0.831
Household size	1.23	0.810
Gender	1.25	0.800
Membership to group	1.45	0.691
Access to extension services	1.34	0.744
Access to credit	1.26	0.791
Household type	1.28	0.779
County	1.11	0.899
Off-farm income	1.08	0.928
Mean VIF	1.24	

Appendix 3: VIF for OLS

Variable	VIF	1/VIF
Farming experience	1.11	0.904
Age	1.55	0.645
Land size	1.21	0.828
Household size	1.24	0.809
Gender	1.26	0.795
Membership to group	1.43	0.699
Access to extension services	1.35	0.740
Access to credit	1.27	0.789
Household type	1.4	0.715
Gender of plot owner	1.17	0.852
County	1.12	0.895
Income	1.08	0.927
Mean VIF	1.26	

Appendix 4: Partial and Semi-partial correlations for income with independent variables

Variable	Partial Correlation	Semi-partial Correlation	Partial	Semi-partial	Significance
Variable	Corr.	Corr.	Corr.^2	Corr.^2	Value
A3_CONTRA~D	0.498	0.484	0.248	0.234	0.000
lnpoolmkt~t	0.059	0.050	0.004	0.003	0.318
lnpoolland	0.056	0.047	0.003	0.002	0.343
lnpoolage	-0.088	-0.074	0.008	0.006	0.135
lnpoolHHs~e	0.061	0.052	0.004	0.003	0.299
lnpoolexp	0.088	0.074	0.008	0.006	0.137
lnpoolsch~l	0.032	0.027	0.001	0.001	0.582
D20_DEV_G~P	0.027	0.023	0.001	0.001	0.644
D23_EXTEN~S	0.005	0.004	0.000	0.000	0.930
D24_CREDIT	-0.046	-0.039	0.002	0.002	0.434

Appendix 5: Stochastic frontier instruction file

Code	Interpretation
1	1 = Error components model, 2 = TE effects model
lww-dta.txt	data file name
lww-out.txt	output file name
1	1 = production function, 2 = cost function
y	logged dependent variable (y/n)
(173,127)	number of cross sections
1	number of time periods
(173, 127)	number of observations in total
4	number of regressor variables (Xs)
y/n	mu (y/n) [or delta0 (y/n) if using TE effects model]
y/n	delta (y/n) [or number of TE effects regressors (Zs)]
n	starting values specified (y/n)

Appendix 6: Spider plants and chili Shazam codes

CHILI

```
*1. READ DATA AND ESTIMATED PARAMETERS OF GROUP STOCHASTIC
FRONTIERS
sample 1 254
genr one = 1
dim group 254 t 254 y 254 famlab 254 hirlab 254 Lnseed 254 Lnplot 254
```

```
read (hhp.txt) group t y        famlab hirlab   Lnseed Lnplot/ beg=1 end=70 list
read (hhn.txt) group t y        famlab hirlab   Lnseed Lnplot/ beg=71 end=127 list
read (hht.txt) group t y        famlab hirlab   Lnseed Lnplot/ beg=128 end=254 list
sample 1 254
print group t y famlab hirlab   Lnseed Lnplot
matrix x = one|famlab|hirlab|Lnseed|Lnplot
print x

dim x1 70 5 x2 57 5 x3 127 5
copy x x1 / frows = 1;70 trows = 1;70
copy x x2 / frows = 71;127 trows = 1;57
copy x x3 / frows = 128;254 trows = 1;154
dim fem 5 mal 5 joi 5
read (phhh.txt) fem mal joi / beg=1 end=5 list
matrix s = fem|mal|joi
print s

sample 1 5
dim s1 5 s2 5 s3 5
copy s s1 / fcols = 1;1 tcols = 1;1
copy s s2 / fcols = 2;2 tcols = 1;1
copy s s3 / fcols = 3;3 tcols = 1;1


*2. CONSTRUCT DATA MATRICES AND ESTIMATE METAFRONTIER
matrix g1 = x1*s1
matrix g2 = x2*s2
matrix g3 = x3*s3
print g1
print g2
print g3
matrix b = -(g1'|g2'|g3')'
print b
stat x / means = xbar
matrix c = (-xbar'|xbar')'
matrix A = (-x|x)
print A
print C
?lp c A b /iter = 6000 primal = bstar
print bstar
*3. USE METAFRONTIER ESTIMATES TO OBTAIN TECHNOLOGY GAP RATIOS
dim meta 5
read (pppc.txt) meta / beg=1 end=5 list
sample 1 5
matrix starb = meta
print starb
matrix g1star = x1*starb
matrix g2star = x2*starb
matrix g3star = x3*starb
```

```
print g1star
print g2star
print g3star
matrix dev1 = g1star-g1
matrix dev2 = g2star-g2
matrix dev3 = g3star-g3
print dev1
print dev2
print dev3
matrix tgr1 = exp(g1)/exp(g1star)
matrix tgr2 = exp(g2)/exp(g2star)
matrix tgr3 = exp(g3)/exp(g3star)
sample 1 70
stat tgr1
print group tgr1
sample 1 57
print group tgr2
stat tgr2
sample 1 127
print group tgr3
stat tgr3
```

SPIDER

```
*1. READ DATA AND ESTIMATED PARAMETERS OF GROUP STOCHASTIC
FRONTIERS
sample 1 346
genr one = 1
dim group 346 t 346 y 346 famlab 346 hirlab 346 Lnseed 346 Lnplot 346
read (spt.txt) group t yfamlab hirlab   Lnseed Lnplot/ beg=1 end=79 list
read (snc.txt) group t y    famlab hirlab   Lnseed Lnplot/ beg=80 end=173 list
read (spo.txt) group t y    famlab hirlab   Lnseed Lnplot/ beg=174 end=346 list
sample 1 346
print group t y famlab hirlab   Lnseed Lnplot

matrix x = one|famlab|hirlab|Lnseed|Lnplot
print x

dim x1 79 5 x2 94 5 x3 173 5
copy x x1 / frows = 1;79 trows = 1;79
copy x x2 / frows = 80;173 trows = 1;94
copy x x3 / frows = 174;346 trows = 1;173
dim fem 5 mal 5 joi 5
read (tpspi.txt) fem mal joi / beg=1 end=5 list
matrix s = fem|mal|joi
print s

sample 1 5
dim s1 5 s2 5 s3 5
```

```
copy s s1 / fcols = 1;1 tcols = 1;1
copy s s2 / fcols = 2;2 tcols = 1;1
copy s s3 / fcols = 3;3 tcols = 1;1

*2. CONSTRUCT DATA MATRICES AND ESTIMATE METAFRONTIER
matrix g1 = x1*s1
matrix g2 = x2*s2
matrix g3 = x3*s3
print g1
print g2
print g3
matrix b = -(g1'|g2'|g3')'
print b
stat x / means = xbar
matrix c = (-xbar'|xbar')'
matrix A = (-x|x)
print A
print C
?lp c A b /iter = 6000 primal = bstar
print bstar
*3. USE METAFRONTIER ESTIMATES TO OBTAIN TECHNOLOGY GAP RATIOS
dim meta 5
read (tspmeta.txt) meta / beg=1 end=5 list
sample 1 5
matrix starb = meta
print starb
matrix g1star = x1*starb
matrix g2star = x2*starb
matrix g3star = x3*starb
print g1star
print g2star
print g3star
matrix dev1 = g1star-g1
matrix dev2 = g2star-g2
matrix dev3 = g3star-g3
print dev1
print dev2
print dev3
matrix tgr1 = exp(g1)/exp(g1star)
matrix tgr2 = exp(g2)/exp(g2star)
matrix tgr3 = exp(g3)/exp(g3star)
sample 1 79
stat tgr1
print group tgr1
sample 1 94
print group tgr2
stat tgr2
sample 1 173
print group tgr3
```