DETERMINANTS OF AGRICULTURAL COMMERCIALIZATION AND ITS IMPACTS ON WELFARE AMONG SMALLHOLDER FARMERS IN KENYA

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Economics at the School of Economics, University of Nairobi

2015

DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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DEDICATION

To my late dad, Simon Muricho Musee for instilling the culture of hard work in me. May his soul rest in peace.

ACKNOWLEDGEMENT

My greatest gratitude goes to my two University supervisors, Prof. Damiano M. Kulundu and Dr. Fredrick O. Sule for their intellectual input in this work. Despite their busy schedules, they always had time for me and made sure that I did the right thing expected from me. Am also grateful to Dr. Bekele Shiferaw for his motivation and financial support through CIMMYT that enabled me start my PhD program. This CIMMYT support is also credited to Dr. Olaf Erenstein and Dr. Dil Rahut, the CIMMYT Socioeconomics Program Director and Manager, respectively. Dr. Menale Kassie of CIMMYT on the other hand deserves a lot of credit for morally and technically supporting me all through my PhD program. I can't forget Caroline Mbogo and Humphrey Keah, both of ICRAF Library for availing to me promptly all the journal papers and other reference materials that I required. My PhD coursework classmates Alice Muthoni, Tabitha Mwangi, Jemima Moraa, Laura Barasa and Esther Kariuki played a critical role for cheering me on when coursework seemed so hard to go through successfully. John M. Njoroge, my fellow PhD student, is also acknowledged for encouraging and morally supporting me from proposal writing stage all through until I finalized my thesis.

Last, but not least, my immediate family members. My wife Gentrix Nekesa Mukholi for her exceptional patience and wit in dealing with my occasional temperamental moods especially during coursework. She is the true laugh and love of my life. My three children Gertrude Nanjala Muricho, Grace Nafula Muricho and Geoffrey Wekesa Muricho deserve my acknowledgement for patiently sharing their reading room with their dad in the evenings and during the weekends. Also, my parents especially my late dad Simon Muricho Musee who stood firm and insisted that I have to complete my PhD studies at the time I contemplated dropping out during coursework. My three mothers Mary Nekesa Muricho, Gladys Nakhatama Muricho and Juliana Nasimiyu Muricho are acknowledged for being there and giving me the motherly love I needed during my PhD studies, especially after dad passed away.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACIAR: Australian Center for International Agricultural Research

APNs: Agricultural Production Networks/groups

ASDS: Agricultural Sector Development Strategy

CA: Conservation Agriculture

CIMMYT: International Maize and Wheat Improvement Center

CRE: Correlated Random Effects

DHM: Double Hurdle Model

EAGC: East African Grain Council

ERS: Economic Recovery Strategy

ESR: Endogenous Switching Regression

FAO: Food and Agricultural Organization of the United Nations

GDP: Gross Domestic Product

GPS: Generalized Propensity Score

HCI: Household Commercialization Index

IEA: Institute of Economic Affairs

IFAD: International Fund for Agricultural Development

IFPRI: International Food Policy Research Institute

MSU: Michigan State University

PSM: Propensity Score Matching

SAIPs: Sustainable Agricultural Intensification Practices

SAPs: Structural Adjustment Programmes

SRA: Strategy to Revitalize Agriculture

SSA: Sub-Saharan Africa

TLU: Tropical Livestock Units

UNCTAD: United Nations Conference on Trade and Development

ABSTRACT

Rampant poverty and food insecurity among rural farming households in developing countries have been linked to poor performance of the agricultural sector. In Kenya, for example, statistics show that rural households are mainly dependent on agriculture, are the poorest and most food insecure in the country. Majority of these households are smallholder farmers and account for about 75% of the total agricultural output and 70% of marketed agricultural produce in the country. However, empirical evidence shows that agricultural output market participation is very skewed in the sense that about 20% of smallholder households account for over two thirds of the marketed volumes. Reasons for this limited and skewed commercialization are not clear. Similarly, there is limited empirical evidence to demonstrate the impact of agricultural commercialization on smallholder welfare.

Using two year panel data collected from randomly selected households in five districts in Kenya, this study investigated the determinants of household agricultural commercialization decision and intensity using the double hurdle model based on a comprehensive household commercialization index constructed from the value of all crops produced on the farm. On the other hand, impacts of agricultural commercialization on smallholder welfare (food security and poverty) were estimated using the endogenous switching regressions. Both the double hurdle and endogenous switching regression models were estimated using a fixed and random effects hybrid framework called correlated random effects.

The results showed that bigger farm size and more soil fertility affected household commercialization positively. Similarly, access to farm input credit, contacts with extension staff and membership to rural agricultural production networks positively determined agricultural commercialization. Mobile phone ownership, ownership of local means of transport like bicycles, wheelbarrows etc. and transport cost to main markets (proxy measure for household remoteness) affected smallholder commercialization significantly. Ownership of mobile phone and local transport means affected smallholder commercialization positively while transport costs to the main market (household remoteness) was negatively related to commercialization. On the other hand, results from impact assessment showed that agricultural commercialization significantly reduces food insecurity and poverty among commercialized and non-commercialized households.

Therefore, having demonstrated empirically the positive impacts of agricultural commercialization on smallholder farmers' welfare, the study recommends policy interventions that could help stimulate and enhance agricultural commercialization. These policy interventions include controlling the continuous subdivision of agricultural land into smaller uneconomical units. However, such policy intervention should consider availing alternative sources of livelihoods for majority of the rural poor who will be rendered landless. On the other hand, another viable option could be public and private interventions that would make fertilizer more accessible and affordable to smallholder farmers. Beside fertilizer, policies that promote adoption of other soil management practices that enhance soil fertility are encouraged e.g. conservation agriculture and sustainable agricultural intensification practices. Also, policies that can improve smallholder access to affordable agricultural input credit are likely to induce more smallholder agricultural commercialization that could result into reduced food insecurity and poverty.

CHAPTER ONE: INTRODUCTION

1.1 Background

Food insecurity and poverty are characteristic features of rural households in most developing countries. Past empirical studies have linked these problems to poor performance of the agricultural sector (World Bank, 2008; Schneider and Gugerty, 2010). This is because agriculture is the mainstay of most rural economies in these countries. The importance of this sector is exemplified by the recognition that governments of these countries have given to the sector. In Kenya, the importance of the agricultural sector and its need for transformation dates back to pre-colonial period under the famous Swynnerton Plan of 1954 whose ideals spilt into the post-independence era. In fact, the first decade after independence (1963 – 1973) witnessed a robust economic performance that is usually associated with the implementation of economic policies outlined in the Sessional Paper No. 10 of 1965 that was based on African socialism and its application to planning in Kenya (Republic of Kenya, 1965). The main thrust of this sessional paper was to promote rapid economic growth by encouraging of both smallholder and large scale farming. This strategy had positive results that translated into average annual economic growth rate of about 6.5% for the entire period though slowed down during global oil crisis of 1973.

In the 1960s agricultural sector grew by about 6% up from about 2% in the 1950s but slowed down to just about 4% in the 1980s (IEA, 2000). The period following the 1973 international oil crisis saw the country encounter one of its worst balance of payment (BoP) deficits. These economic problems intensified in the decade 1976 – 1986 which culminated into drawing up of the Sessional Paper No. 1 of 1986 based on economic management for renewed growth (Republic of Kenya, 1986). This policy document set to renew economic recovery and growth through market liberalization. It set out institutional and structural reforms that were in line with Structural Adjustment Programmes (SAPs) supported by the Bretton Wood institutions, that is the World Bank and the International Monetary Fund. Under SAPs, the government was expected to withdraw from actively participating in the marketing of agricultural products and inputs through state funded parastatal. The private sector on the other hand was expected to come and fill up this void left by the government withdrawal. However, due to poor marketing institutions and infrastructure leading to high transaction costs and coordination failure, the private sector did not fill this void. In fact, most studies that evaluated the impacts of these SAPs reported mixed results (Rono, 2002).

By the end of the 1990s, the Kenyan economy was performing very poorly reaching its worst growth of negative 0.2% in the year 2000. In response to this unimpressive economic growth rate, the new government that came to power in 2002 launched the Economic Recovery Strategy (ERS) in the year 2003 as a five year economic blueprint (Republic of Kenya, 2004). The ERS identified agriculture as the leading productive sector for eradicating poverty and achieving food security in the country. Under ERS, the government established a programme called Strategy for Revitalizing Agriculture (SRA) with the sole purpose of transforming Kenya's agricultural sector from subsistence production to a profitable, commercially oriented economic activity. By the year 2007, food insecurity had been reduced from 48.5% in 2003 to 36.5%, while poverty had been reduced from 56% in 2003 to 46% (Republic of Kenya, 2010).

With the impressive results from ERS, the government developed a long term development blueprint dubbed Kenya Vision 2030 that was launched in the year 2008 (Republic of Kenya, 2007). Vision 2030 aimed at transforming Kenya into a newly industrialized middle income country. The vision was anchored on three pillars i.e. economic, social and political. Consistent with its predecessor ERS, the Vision 2030 also identified agriculture as the key sector to deliver a 10% annual economic growth rate envisaged in its economic pillar. To achieve this growth, Agricultural Sector Development Strategy (ASDS) programme was initiated with the aim of transforming agriculture from subsistence to *farming–as–a–business* approach by promoting an agribusiness-oriented culture, transparent markets, efficient use of inputs and agricultural credit. Other programmes that were geared toward promoting smallholder agricultural commercialization in Kenya included *Kilimo Plus* and *Kilimo Biashara* under the Ministry of Agriculture. These later initiatives are aimed at promoting the culture of farming-as-business among smallholder farmers by availing credit and other inputs plus easing output market access constraints.

However, the success of this kind of development approach in different countries of sub-Saharan Africa (SSA) has been varied. For example, available statistics show that despite the explosion of supermarkets as niche retail outlets of farm produce in urban centers, it is only in South Africa that smallholder farmers account for about 55% of the farm produce marketed through this outlet. In other countries in the region, like Kenya, smallholder farmers account just for about 10% of the farm produce marketed through the supermarkets (Kirsten *et al.*, 2012). There is, therefore, the need to thoroughly investigate what drives this agricultural transformation and what measures should be

taken in this transformation process to ensure that benefits arising therein are maximized and are all inclusive.

The foregoing historical assessment of the Kenyan economy points to the fact that the potential of agricultural growth for poverty alleviation and food security has not been realized fully. This has led to persistently high levels of poverty and food insecurity in the country. About 47% of the total population lives below the poverty line while 46% are food insecure (Table 1). Similarly about 34% of the urban population is poor compared to almost 50% of the rural population. In terms of food insecurity, available statistics show that while 40% of the urban population is food insecure about 47% of the rural population is food insecure (Table 1). In fact, per capita annual average growth in total food production in Kenya declined by 0.6% between 1990 – 2004 (World Bank, 2008).

These disappointing statistics have been attributed to rapid population growth and declining agricultural productivity. Overall agricultural productivity in Kenya declined by an average of 0.1% per year over the same period (Bluffstone and Kohlin, 2011). However, policy makers have recognized the importance of increased smallholder market participation (commercialization) in improving agricultural productivity and thereby tackling national poverty and food insecurity (Republic of Kenya, 2010). This recognition is justified on the basis that the Kenyan economy is heavily dependent on the agricultural sector which contributes about 25% of Gross Domestic Product (GDP) and accounts for over 75% of the national employment (Republic of Kenya, 2005) – a clear indication of low labour productivity in the country's agricultural sector.

Table 1. Poverty indicators and levels in Kenya in 2005

Level	Poverty measure	Headcount (%)	Number of poor (million)	Poverty gap (%)
National	Overall	46.6	16.6	16.6
	Food	45.8	16.3	na
	Severe	19.5	6.9	na
Urban	Overall	34.4	2.5	11.7
	Food	40.4	2.9	13
	Severe	8.3	0.6	2.5
Rural	Overall	49.7	14.1	17.8
	Food	47.2	13.4	16.2
	Severe	22.3	6.3	6.9

Source: World Bank (2009)
Note: na stands for not available

However, commercialization as a concept is multi-dimensional and no one definition has been able to capture all its facets. The definitions differ in focus and breadth, which has also influenced its measurement. It is more than whether or not a cash crop is present in a production system (von Braun *et al.*, 1994). Sometimes a proportion of the so called traditional food crops are sold while on the other hand, some proportions of the so called traditional cash crops are retained for home consumption. Similarly, agricultural commercialization is more than marketing agricultural outputs because commercialization can also occur on the input side with use of purchased inputs in agricultural production (von Braun *et al.*, 1994).

On the other hand, Pingali and Rosegrant (1995) and Pingali (1997) defined agricultural commercialization as "when household decisions on product choice and input use are made based on the principles of profit maximization". Therefore, commercialization takes place when households purposively target markets in their production decisions rather than being simply related to the amount they are likely to sell as a result of surplus production. In other words, this means that commercialization occurs when production is in response to signals from the market and on the basis of comparative advantage whereas subsistence production is on the basis of production feasibility and subsistence requirements with only surplus product sold after meeting own consumption needs.

Gebremedhin and Jaleta (2010) broadened the definition of agricultural commercialization by asserting that it is a combination of both market orientation and market participation. Market orientation in this context is defined as agricultural production decision based on market signals while on the other hand, market participation is simply the produce offered for sale and use of purchased inputs. From this approach, market orientation seems to be more inclined toward profit maximization while market participation appears to aim at utility maximization. Therefore, commercialization is a combination of market oriented production and the actual amount bought from or offered to the market for sale. However, most agricultural commercialization literature makes little distinction between market orientation and market participation.

A close analysis of the various definitions tends to suggest that, generally, agricultural commercialization[1] is the integration of farmers into input and output markets, a line of thought followed in this study. This study therefore follows the definition by Gebremedhin and Jaleta, (2010) i.e. produce offered for sale and use of purchased inputs in the production process. However, the later component of this definition (use of purchased inputs) is beyond the scope of this study due to first and foremost, data limitations and secondly as illustrated by Pingali (1997), commercialization on the input side is likely to proceed in tandem with the degree of participation in output markets. Based on this adopted definition, a more comprehensive household commercialization index (HCI) that incorporates all crop enterprises on the farm was developed. This approach is an improvement on past empirical studies that focused on the output side of one or a few selected crop enterprises. Yet smallholder producers typically produce quite a number of crops in any given production season which they consume and/or sell surpluses for cash. Therefore, the comprehensive HCI that was developed gives a more accurate picture of smallholder agricultural output commercialization thereby enabling a more in-depth understanding of agricultural transformation process than before.

Similarly, on the impact of agricultural commercialization on household welfare, there is also no consensus on the definition of the term "welfare". However, according to the World Bank (2000), there are three aspects of welfare i.e. poverty, inequality and vulnerability. The current study focuses on poverty which is defined as whether households or individuals have enough resources or abilities to meet their needs (Coudouel *et al.,* 2002; Haughton and Khandker, 2009; World Bank 2009). These needs range from consumption, education, health, assets etc. (Coudouel *et al.,* 2002). Although this poverty concept has numerous measures and analytical tools, this study focused on food security and total household expenditure needed to meet household food and non-food needs annually. Those who have enough resources to meet their food needs are usually referred to as food secure. On the other hand, those with resources to meet both food and non-food needs are non-poor households (not in poverty class) and the converse is also true. Therefore, the concept of welfare is multi-dimensional and flexible when used and whenever it is introduced in a study, then it is necessary to carefully establish the explicit or implied definition (Maxwell, 1996).

[1] In this study, agricultural commercialization and household commercialization are used interchangeably and they refer to household participation in crop output market/s as sellers

The most widely negotiated definition of food security given by the Food and Agricultural Organization (FAO) during the World Food Summit of 1996 was that food security exists "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" (FAO, 1996). This widely used definition of food security involves availability, access to sufficient and nutritious food for an active and healthy life. The State of Food Insecurity 2001 redefined food security as a situation that exists when all people at all times can have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002). In this later definition, the word "food preferences" has been added which essentially implies that people with equal access to food, but different food preferences, could exhibit different levels of food security. Therefore, a useful working definition provided by FAO (2003) states that "food security exists when people at all times have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life". To capture this subjective food security aspect of preferences in the definition, a subjective assessment of household food security by the respondent was adopted, where by the respondent was asked to give personal assessment of the household's food security in the last 12 months preceding the survey visit. This subjective measure of food security is consistent with the empirical work of Mallick and Rafi (2010) and Kassie *et al.,* (2014b).

On the other hand, quantitative and more objective monetary measures of poverty have been used widely in literature. Most poverty analysts have argued that, provided the consumption data obtained from a household survey is detailed enough, then using consumption as an indicator of poverty measurement is better than income for two main reasons as outlined by Coudouel *et al.,* (2002). First, consumption is a better outcome indicator than income because it is more closely related to a person's wellbeing (welfare) in the sense defined above i.e. having enough to meet current basic needs. Consumption expenditures reflect not only goods and services that a household can command based on its current income, but also its ability to access credit markets or savings at times of low or even negative incomes due to seasonal variation, harvest failure or other circumstances that can cause income to fluctuate widely. On the other hand, income will only show ability but not actual access. Secondly, consumption may be a better measure of wellbeing than income especially in rural agrarian economies where incomes fluctuate during the year according to

the harvest cycle. Besides, it is easier for a respondent to unconsciously reveal his total income through expenditure compared to income which many will have high tendencies to cheat.

It is therefore on the basis of these advantages that this study uses the annual per capita household expenditure on food and non-food items including the value of own production that was consumed on the farm as a proxy measure of household poverty. For easier comparison across households of different sizes and even composition, the per capita expenditure was based on household size defined by adult equivalent. It is also important to note that, despite the mentioned advantages, this does not mean that measuring consumption expenditure does not have its own challenges. However, it may be more reliable if the module to capture consumption data in the questionnaire is well designed.

1.2 Problem statement

Commercialization of smallholder agricultural producers through increased participation in output markets has been promoted as one of the best strategy to address low agricultural productivity that has led to high levels of poverty and food insecurity among rural farming households in developing countries (Thurlow *et al.,* 2007; Jaleta *et al.,* 2009; Olwande and Mathenge, 2011; Wickramasinghe and Weinberger 2013). Even the market liberalization policy agendas that were widely promoted in sub-Saharan Africa (SSA) in the 1980s and 1990s under structural adjustment programmes (SAPs) were broadly aimed at stimulating and enhancing agricultural commercialization. Though these liberalization policies were aimed at opening up new market-led opportunities for economic growth, their results were mixed in most countries. Even to date, many smallholder producers continue to engage in subsistence agriculture and thus unable to benefit from commercialization opportunities presented by the liberalized markets (Rono 2002; Boughton *et. al.,* 2007; Barrett, 2008; Shiferaw *et al.,* 2008; Siziba *et. al.,* 2011; Olwande and Mathenge 2011; Wollverton *et al.,* 2014).

Similarly, for decades, domestic agricultural markets in developing countries like Kenya were heavily protected against low priced imports and even sometimes governments have been supporting producer output prices through parastatals (Todaro, 1989; Barrett, 2008; Reyes *et al.,* 2012). These policy instruments were aimed at protecting the welfare of the producer and the country at large. However, following the international food crisis of 2006 and 2008, international

food prices doubled with poor households in developing countries being worst hit. Though these prices have come down since mid-2008, they are still higher than the period before the surge and projections indicate that they are likely to remain so for the next decade (IFAD, 2010). To date, much of the production response to these higher food prices has come from rich countries (IFAD, 2010). Empirical literature to understand the limited output market participation in post food-price crisis era is still very thin if any.

Several studies were conducted in Kenya to understand reasons behind limited agricultural market participation in post liberalization era (Alene *et al.,* 2008; Barrett, 2008; Omiti *et. al.,* 2009; Olwande and Mathenge 2011). Most of them were based on output market participation of one or just a few selected crops, yet smallholder commercialization involves all crops grown on the farm including the non-traditional cash crops (Pingali and Rosegrant 1995; Gebremedhin and Jaleta, 2010).

Another motivation for use of aggregate value of all crops is that this approach allows the use all information available, including data on households that sell other crops other than main staples like maize or main cash crops like sugar cane and coffee. Moreover, because of substitution among crops, some of the exogenous variables are likely to increase sales of a specific crop at the expense of other crops (Bahta and Bauer, 2012). Although single crop supply is more elastic than aggregate output supply, aggregate supply is what matters to policy makers (Binswanger, 1990).

Similarly past empirical studies did not explicitly estimate the impact of agricultural output market participation on the welfare of smallholder producers. This was the case despite doubts raised by the government on the impacts of commercializing smallholder production. However, with recent advances in impact analysis methods that extensively take care of the counterfactual problem (de Janvry *et al.,* 2011), this study goes beyond identification of determinants of agricultural output market participation. It used the recently developed methodological tools to estimate the impact of market participation on food security and poverty among the sampled rural farm households.

1.3 Research questions

The current study estimated smallholder farmers' product supply function (output market participation) that helped to answer the following questions:-

i) What are the determinants of smallholder output market supply?

ii) What is the impact of output market participation on smallholder food security?

iii) What is the impact of output market participation on smallholder poverty status?

iv) Which specific policy interventions are needed to reduce or eradicate rural food insecurity and poverty?

1.4 Study objectives

The general objective of the study was to shade more light on how poverty and food insecurity problems among rural farming households can be addressed through a market-led approach. To achieve this general objective, the study pursued the following specific objectives:-

(i) Analyze the determinants of smallholder household agricultural output market participation decision and intensity;

(ii) Analyze the impact of household agricultural output market participation on smallholder households' food security;

(iii) Analyze the impact of household agricultural output market participation on smallholder households' poverty status;

(iv) Based on the results draw policy implications.

1.5 Significance of the study

The significance of this study is two-fold i.e. addresses the serious problems of rural food insecurity and poverty and also adds a new strand of agricultural commercialization literature to the existing one. The study generates knowledge on how the national and county governments in Kenya can stimulate and enhance smallholder agricultural commercialization. Increased smallholder agricultural commercialization will significantly address the rampant rural food insecurity and poverty. Secondly, the study contributes to smallholder agricultural commercialization literature in several ways. While most past empirical studies considered only one or a few selected crops to study smallholder agricultural commercialization, the current study is based on a comprehensive household commercialization index developed by considering all crop enterprises on the farm. Also, most of the past empirical studies were based on cross sectional data or even where panel data was used then OLS or pooled regression models were used to assess the impact of agricultural commercialization on household welfare. However, in this study, more innovative analytical models that have previously been common in labour economics and agricultural technology adoption and impact studies are used. The double hurdle model for determinants of agricultural

commercialization and the endogenous switching regression models for impact assessment in correlated random effects frame are used here. To the best of our knowledge, this could be the premier study not only in Kenya but eastern and southern Africa that has used panel data to construct a comprehensive household commercialization index to study both the determinants and impacts of agricultural commercialization on household welfare at ago.

1.6 Structure of the thesis

This thesis has seven chapters. Chapter one is the introduction of the thesis that sets out the background information of the study and the problem statement. Also, the chapter outlines the research questions and objectives of the thesis before highlighting the significance of the study. The overall literature review for the study is covered in chapter two and it starts with theoretical literature and then empirical. This chapter ends with a section on the summary of the reviewed theoretical and empirical literature. On the other hand, chapter three is devoted to a broad overview of the methods and data used in the whole study. This chapter starts with an elaborate overview of the theoretical model before building the empirical ones. The last section of chapter three is devoted to the data used in the study. Chapter four presents a full paper on the determinants of agricultural commercialization among smallholder farmers in Kenya. Overall introduction of the chapter is given and then this is followed by the methods before results and discussions of the determinants of agricultural commercialization are given. The summary and conclusions based on the results is given before policy implications of these results are outlines. Chapter five is devoted to the impacts of agricultural commercialization on household food security probability. This chapter is presented in the same format as chapter four i.e. a brief introduction is given before methods are outline. Results and discussions of the impacts of agricultural commercialization on household food security are presented before summary and main conclusions of these results are outlined. Lastly, the chapter gives policy implications of these results. On the other hand, chapter six is on the impact of agricultural commercialization on household poverty. This chapter, like its two preceding chapters starts by giving the introduction before following up with the methods and then the results and discussions. After results and discussion, the chapter outlines the summary and conclusions before finishing off with policy implications. Finally, overall study summary, conclusions and policy implications that cuts across all the preceding six chapters is given in chapter seven.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In order to put this study in its right context, relevant theoretical and past empirical literatures on agricultural market participation and its impact on welfare are reviewed in this chapter. The first section presents the theoretical literature in whose context the study is set. A theoretical foundation of agricultural commercialization that encompasses output market participation is given. Thereafter, impacts of agricultural commercialization are discussed from a theoretical perspective. The second section of this chapter outlines past empirical studies in this area of agricultural commercialization. These past empirical studies are critically analyzed with the aim of identifying research gaps upon which the current study is anchored. Finally, a summary of both the theoretical and empirical literature is presented in the third section of this chapter.

2.2 Theoretical literature

2.2.1 Theoretical foundation of agricultural commercialization

Majority of developing countries' population live in rural areas and mainly dependents on subsistent agriculture as a source of livelihood. Transformation of the agricultural sector through commercialization has been seen as the most viable way to address the pervasive high levels of rural poverty and food insecurity. This view dates back to theoretical work of Johnston and Mellor (1961) that closely analyzed the role of agriculture in economic development in the context of William Arthur Lewis' Dual Economy growth model. Johnston and Mellor (1961) argued that increased agricultural productivity (especially agricultural labour productivity) is necessary in order to free rural labour that is needed in the industrial sector. Increased agricultural productivity is also necessary to enlarge the size of the market for industrial outputs because rural farming households often constitute the bulk of the market for a wide range of consumer goods produced by the industrial sector. This increased productivity can be achieved through commercialization where households specialize in production of goods for which they have comparative advantage (Johnston and Mellor, 1961).

Later on, other theorists synthesized agricultural commercialization as a sequence of a transformation process going through three stages that can be seen in the lens of Rostow's theoretical model of economic development stages (Wharton 1963; Timmer 1988; Todaro 1989; Pingali and Rosegrant 1995; Pingali 1997). These authors identified three stages of agricultural

transformation – from a low productivity traditional agriculture to a high productivity commercial sector. The first and most primitive is the low-productivity, purely subsistence peasant farming (Todaro, 1989) characterized by use of mainly non-traded and household generated inputs with the main production objective being food self-sufficiency (Pingali and Rosegrant, 1995). The second stage is what Todaro (1989) called "diversified" or "mixed" family agriculture, where part of the crop is grown for self-consumption and part of it is sold. This second stage is what Pingali and Rosegrant called semi-subsistence production that employed both traded and non-traded farm inputs with focus to production for both household consumption and surpluses for the market (similar to transition stage of Wharton, 1963). Finally, the third stage was identified as that representing the "modern" farm, exclusively engaged in high productivity, "specialized" agriculture geared to the commercial market – what can qualify as commercial agriculture (Todaro 1989) or a fully commercialized agricultural system where inputs are mainly bought and profit maximization is the main objective (Pingali and Rosegrant 1995; Pingali 1997). Therefore, these theoretical works suggest that rural economic growth and development policies should focus more on moving the agricultural sector rapidly from first stage through the second stage and ultimately to third stage.

However, it is important to note that Pingali *et al.,* (2005) have cautioned that although agricultural commercialization is theoretically believed to emphasize specialization, it is not just restricted to production of the so called "cash crops". Production of marketable surplus of staple food crops is usually the most common initial form of commercialization among smallholder peasant farmers (Jaleta *et al.,* 2009). Due to pervasive market failures in most developing countries, commercialization can only offer the possibility of some level of diversification into non-staple cash crops but not total specialization. Therefore, smallholder farmers can commercialize either in main staple crops and/or cash crops depending on their agro-ecological and market circumstances. However, this does not preclude the theoretical argument that these farmers will tend to be more specialized in the long run. It therefore follows that in modeling agricultural commercialization in developing countries with pervasive market failures, the most appropriate model to adopt is the non-separable household utility maximization (Yotopoulos and Lau 1974; Ellis, 1993; Vance and Goeghegan 2004). This non-separable household utility maximization follows the standard consumer theory with a caveat that there exists imperfect market information (de Janvry *et.al.,* 1991).

2.2.2 Impacts of agricultural commercialization

Theoretical literature categorizes impacts of agricultural commercialization into three orders i.e. first, second and third order impacts. The first order impacts are immediate household direct effects on income and employment while on the other hand health and nutrition are second order effects. These second order effects are mainly dependent on the level of income through the existing level of commercialization. Lastly, the third order impacts are macro-economic and environmental impacts that are usually beyond the household level. These impacts can be positive or negative though positive impacts generally outweigh the adverse consequences.

According to proponents of agricultural commercialization, this process will stimulate increased agricultural productivity that is essential for poverty eradication and ensure food security (Johnston and Mellor, 1961; Wharton, 1970; Timmer 1988, von Braun *et al.*, 1994; von Braun, 1995; Pingali and Rosegrant 1995; Pingali 1997; Bruntrup and Heihues 2002). Increased agricultural productivity leads to increased incomes that motivate households to enter the exchange economy and become even more commercialized. Other arguments for commercialization have been that it increases diversity of commodities in the market and specialization at both regional and farm levels (Timmer 1997; Kurosaki 2003). Increased specialization is bound to stimulate trade and present households with the opportunity to produce according to their comparative advantage and thereby enabling them to enjoy welfare gains associated with trade. This is based on the underlying premise is that markets will allow households to increase their incomes by producing what gives them the highest returns to their resources and then use the cash income from markets to buy household consumption items, rather than be limited to producing all the various goods that they need for own consumption (Timmer 1997; Pingali 1997).

Commercial agriculture will also necessitate the link between the input and the output side of markets. Increased use of purchased modern production inputs is assumed to lead to increased production beyond subsistence needs thus creating surpluses for the markets. Govereh *et al.,* (1999) argue that benefits arising from agricultural commercialization can happen both at household level and regional level through spill-over effects. At household level, they argued that commercialized production can ease the credit constraint that smallholder farmers usually face. This is because with continued contacts with buyers, trust can be developed and credit advances can be made. They also argued that commercialization especially through cash cropping under contracts can enhance

training or ease access to extension information from the buyer. Finally, at macro level, they noted that commercialization will create markets for both inputs and outputs thus attracting investors in rural areas to provide these goods and services that smallholder farmers and traders need e.g. banking, agrovet dealers, transporters etc. It should also be remembered that agricultural commercialization can also spur private and public investment in infrastructure and human capital development that eventually improves productivity.

On the other hand, theoretical arguments against agricultural commercialization contend that it contributes to poverty and food insecurity (Pingali and Rosegrant, 1995; Pingali 1997; Strasberg *et al.,* 1999). They argue that commercializing smallholder agriculture entails loss of capacity to produce food and loss of food productivity on the basis that farmers will drop food crop production in favour of purely cash crop production. This will in turn expose households to increased risks usually associated with market price fluctuations that are normally of little concern in subsistence production settings. In addition, it is argued that commercialized farmers face increased risks associated with yield fluctuation when production becomes more specialized thereby loosing advantages associated with production diversification. Given the risky economic environment under which smallholder farmers in developing countries operate, maintenance of own food supplies can therefore be economically first best strategy. In this context, commercializing smallholder production is likely to negatively affect food crop production and general household welfare due to lack of reliable and efficient food markets (Strasberg *et al.,* 1999). This school of thought also argues that commercial agriculture can lead to overuse of fertilizers, pesticides and land degradation too due to increased production intensification thereby affecting the environment negatively.

However, the theory that agricultural commercialization is not pro-poor has been countered by von Braun (1995) and Govereh *et al.,* (1999). They argued that the perception that agricultural commercialization in developing countries undermines food security is "overly simplistic" and based on "if" statements. Example of such "if" statements include:- if food crops are replaced with non-food crops, and if markets are not working well; if landless farm labourers are replaced with highly mechanized and less labour intensive production systems (von Braun, 1995). Therefore, according to these authors, anti-agricultural commercialization does account for the potential synergies that exist between cash cropping and food crop production intensification. While cash crops are likely to compete with food crops for land, the relationship with other factors of

production like labour, working capital and even crop management is largely complementary. As such, von Braun (1995) concludes that many adverse effects of commercialization are not because of the inherent nature of commercialization, but instead, it is because of bad policies. The answer to these bad policies is policy reforms and not reversal or deceleration of technological advancement and commercialization (von Braun, 1995). Therefore, there is urgent need to identify and address risks and market failures that limit agricultural commercialization instead of conceding that these risks and market failures as inherent and unalterable features in developing countries context that necessitate a food-first production orientation (Strasberg *et. al.,* 1999).

Overall, von Braun *et al.*, (1994) developed a comprehensive theoretical framework of determinants of agricultural commercialization and how this process is linked to agricultural commercialization and household welfare (Figure 1). In this theoretical conceptual framework, it can be seen that the welfare impacts of agricultural commercialization is mediated through a complex intra-household relationships. Food insecurity can be achieved if a household or an individual is capable of acquiring more food or better quality food or both through the growth of income (reduced poverty). The implication of this is that commercialization welfare benefits will be achieved if markets are working and there are no intra-household conflicts.

However, in a practical real world situation, particularly in developing countries like Kenya, there are pervasive market failures and therefore it is important in any analysis to separate the exogenous variables that determine commercialization from the endogenous variables that tend to affect the impact of agricultural commercialization process on household welfare (food security and poverty). The theoretical conceptual framework that separates these two groups of factors (exogenous and endogenous) is as shown in Figure1. A close look at Figure 1 shows that some of the exogenous factors may have more immediate effects on farmers' decision to commercialize whereas others have long term effects. These exogenous factors are what Zhou *et al.*, (2013) called drivers or triggers of smallholder commercialization. These are demand drivers for agricultural products, farming technologies and enabling environment for efficient or increased household commitment to commercial activities. On the other hand, endogenous factors that facilitate the impact of commercialization relate to intra-household decision making process (von Braun, 1995). Since household members may have different preferences in resource allocation (for example between

food and non-food needs), commercialization may affect the welfare of various household members differently.

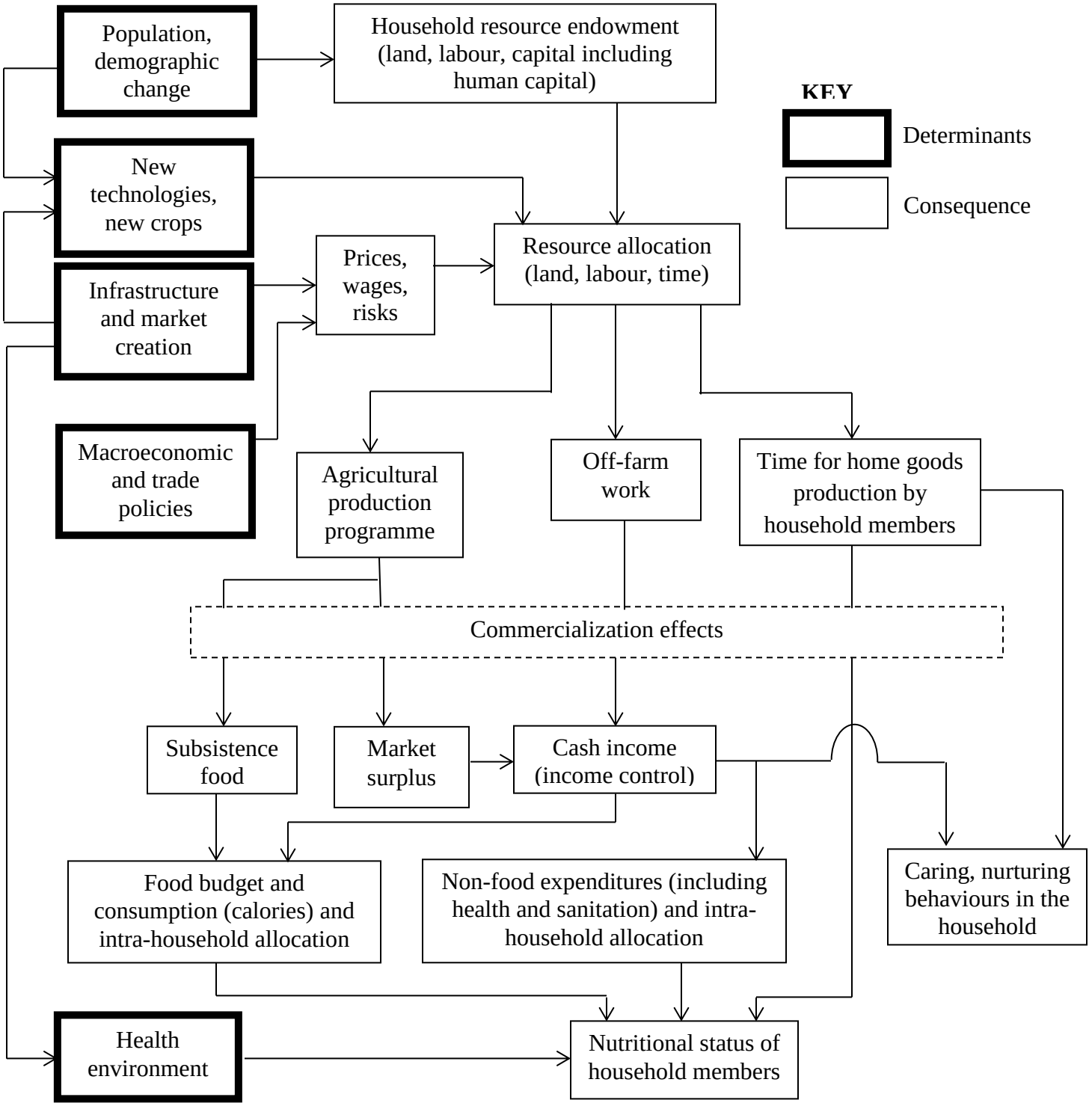

Figure 1. Household level agricultural commercialization determinants and outcomes
Source: von Braun *et al.,* (1994) as derived from von Braun *et al.,* (1991)

2.3 Empirical literature

Following agricultural commercialization theoretical work, a series of empirical studies were conducted to test the arguments advanced in theory. Kennedy and Cogill (1987) empirically measured the effects of agricultural commercialization on income and nutrition in Kenya using mainly descriptive statistics and OLS models. They used descriptive statistics to compare income and calorie intake between commercialized households (those contracted by sugar millers to grow sugarcane purely for commercial purposes) and non-commercialized household (not growing sugarcane). This static analysis was supported by OLS estimations of the determinants of total household incomes and total calorie intake with one of the explanatory variables in both models being income from sugar cane. Their results showed that more commercialized farmers (sugar cane growers) had higher household incomes which translated into higher levels of non-food expenditures. They did not however detect any significant differences in nutritional outcomes (calorie intake). This was contrary to the then government position that agricultural commercialization undermined food security (Republic of Kenya, 1981).

Later on in the 1990s after the implementation of SAPs in most SSA countries, Goetz (1992) analyzed agricultural households' binary decision to participate in markets of coarse grain as either sellers or buyers followed by the continuous decision of how much of the coarse grain they sold or bought conditional on having decided to participate in the market. This study was based on household data collected from Senegal. Goetz (1992) applied a selectivity model which endogenously switched households into alternative market participation regimes. This endogenous switching model was preferred because it corrected for the bias caused by the unobserved variables. It was found that access to market information (a proxy for fixed transaction costs) significantly affected the decision to participate in coarse grain markets while access to cereal processing technology (proxy for proportional transaction costs) influenced the amount of grain to be marketed conditional on participation. The analytical framework used in this study (endogenously switching selectivity model) ingeniously corrected for bias caused by exclusion of unobservable variables affecting both discrete and continuous market participation decisions. Also this framework, unlike the tobit type models, plausibly assumed that factors affecting the discrete decision (whether to participate in the market or not) might not necessarily be the same as those that affect the continuous decision (amount sold). However, the study in Senegal was silent on the impacts of market participation on household welfare and therefore no empirical basis to argue for or against

promotion of market participation. Similarly, this study could have been more informative if it could have considered all the crops grown on the farm instead of only considering coarse grain.

On the other hand, results from a comparative analysis of impacts of agricultural commercialization on health and nutrition of smallholder farm households across several countries in Asia, Latin America and Africa (including Kenya) by von Braun (1995) demonstrated that agricultural commercialization process had a significant positive effect on the wellbeing of rural smallholder farmers. Using descriptive statistics and fitting an OLS model to analyze the determinants of per capita income and the nutritional status of children in sampled households, von Braun (1995) incorporated share of cash crop income in total household income as an explanatory variable in the model. The econometric results showed that increased agricultural commercialization resulted into higher per capita incomes that reduced household poverty significantly. Except for Kenya, the rest of the study countries (Guatemala, Philippines, Rwanda, Malawi and Gambia) exhibited increased nutritional status of commercialized households compared to those not commercialized. In the Kenyan case where there was limited improvement in child nutrition, this was attributed to factors like insecure land tenure, gender biases, market failures and policy biases against smallholder producers. However, this study did not empirically analyze the determinants of commercialization but instead concentrated on the impact of agricultural commercialization on household welfare. Also, the impact analysis framework adopted in this study was less rigorous i.e. used pooled data and assumed that commercialized and non-commercialized households had same characteristics with the only difference being agricultural output market participation (commercialization). This assumption is likely to be untrue because of the problem of households self-selecting themselves into commercialized and non-commercialized groups due to their unobserved characteristics.

Empirical work on agricultural commercialization continued throughout the 1990s and the first decade of the 21st century, mainly justified on the grounds that there was still dismal participation of smallholder farmers in agricultural markets despite liberalizing markets under SAPs. Govereh *et al.,* (1999) and Strasberg *et al.,* (1999) analyzed the effect of agricultural commercialization (output market participation) on household use of fertilizer and food productivity in selected countries of eastern and southern Africa region. Govereh *et al.,* (1999) undertook a comparative study across Kenya, Mozambique and Zimbabwe while Strasberg *et al.,* (1999) concentrated only on Kenya. To test the effect of commercialization econometrically, the two studies developed a HCI based on all

crops grown on the farm (see Eqn. 3.15) and used this index as one of the explanatory variables in a tobit and instrumental variable (IV) estimation frameworks to study determinants of use of purchased inputs (fertilizer) and food crop productivity, respectively. They justified the use of tobit in the fertilizer equation because about 44% of the households applied no fertilizer and thus the distribution of this variable was censored. On the other hand, IV model was used in the crop productivity equation on the basis that fertilizer and use of hybrid maize seed were used as explanatory variables yet they were endogenous to the determination of crop productivity.

These studies (Govereh *et al.,* 1999 and Strasberg *et al.,* 1999) showed consistent results indicating that agricultural commercialization positively and significantly affected use of fertilizer and productivity of food crops and thus overall farm income in all the three countries. However, though substantial efforts were made in computing a more comprehensive commercialization index by considering all crop enterprises found on the farm, the studies did not investigate the determinants of household commercialization that could have shade more light on how more households could be facilitated to commercialize and reap the benefits arising therein. Also, these results should be interpreted with caution because the econometric estimations are based on pooled data and therefore did not tackle the counterfactual problem that is usually associated with pooled regression analyses in impact assessment analyses.

Building on the earlier work of Govereh *et al.,* (1999) and Strasberg *et al.,* (1999), Govereh and Jayne (2003) presented an elaborate case of synergies between cash cropping and food crop productivity using the case of cotton in Zimbabwe. An OLS model was used to analyze the determinants of commercialization where by the dependent variable in this case was the value of cotton (main cash crop) produced on the farm expressed as a ratio to the total value of all crops produced on the farm in that given year. On the impact assessment, a two-stage least squares instrumental variable estimation method was adopted. This later estimation involved the per hectare value of food crops produced on the farm as the dependent variable and a host of explanatory variables including the commercialization variable instrumented from the OLS estimation. The results indicated that households that engaged intensively in cash crop production (cotton) obtained higher grain yields of main staples than otherwise. Interestingly, at regional level, they found evidence of commercialization schemes having spill-over effects induced by second order benefits in terms of investments in a given area that ended up providing benefits to all farmers regardless of

their commercialization positions. Such investments included financial service providers (banks and microfinance), grain and other merchandize traders setting up their operations in those locations and even improvement in infrastructure (roads, telecommunication etc.) by public and private investors. Again, while this study made tremendous improvement on econometric modeling compared to preceding ones reviewed herein, the use of pooled data and counterfactual issues were not addressed adequately and therefore results not fully informative. On the other hand, the OLS framework used to analyze determinants of agricultural commercialization was not able to separate the factors that affect the dichotomous decision to or not to commercialize from the continuous decision of how much to commercialize on condition of having decided to commercialize. Also, estimating household commercialization level by use of one main cash crop might not be conclusive because some portions of food crops are also sold for cash income.

Limited commercialization among rural farm households has also been hypothesized to be as a result of market failures resulting from inherent high transaction costs in the markets. A number of empirical studies have explored this transaction costs hypothesis and its impact on market participation (Key *et al.,* 2000; Bellamere and Barrett 2006; Alene *et al.,* 2008; Omiti *et al.,* 2009). Key *et al.,* (2000) used household level data collected from maize (corn) farmers in Mexico to advance the conceptual framework that had been built by Goetz (1992). They identified the role of transaction costs (fixed and proportional) on market participation (commercialization). In this study, an endogenous switching regression was used to analyze the determinants of households' position in three different maize market regimes i.e. selling regime, autarkic regime and buying regime. Their results showed that both fixed and proportional transaction costs significantly determine the binary decision of commercializing or not commercializing. However, intensity of commercialization (amount sold) was only determined by proportional transaction costs conditional to market participation.

On the other hand, Bellamere and Barrett (2006) used a two stage econometric model to test whether rural households in northern Kenya and southern Ethiopia make livestock market participation decision and volume to sale decision simultaneously or sequentially. They developed ordered probit to test the market participation decision and ordered tobit model for the volume (market participation intensity) decision. In the ordered probit model, households were put into three market participation regimes just like Key *et al.,* (2000) i.e. net sellers, autarkic and net

buyers. In the ordered tobit model, determinants of market participation intensity (volume involved) conditional on participating in the market was analyzed using the tobit framework which the authors called "ordered tobit model" because they used ordered probit in the first stage. The results from this study indicated that prices positively and significantly determined the continuous market participation intensity decision. On the other hand, fixed transaction costs were found to negatively and significantly affect both the binary decision and the intensity of market participation. They also found that market participation was highly correlated with increased non-livestock assets and land implying a negative linear relationship with poverty. However, while this study was very innovative in analyzing the determinants of market participation in the livestock sector, it did not explicitly assess the impact of such market participation on household welfare.

Alene *et al.,* (2008) on the other hand analyzed the effect of transaction costs on market participation using a selectivity model. They applied a two stage decision making model as done previously by Bellamere and Barrett (2006). This latter study expanded the scope to include participation in both product and factor markets using the maize sub-sector in Kenya. They estimated and decomposed maize output supply and input demand functions, the responses of these two functions to changes in transactions costs and price and non-price factors and finally the impact of these transaction costs on market entry decisions and market participation intensity. In the maize output supply model, they first estimated a probit model from which the inverse mills ratio (IMR) was generated. The IMR was used later as an explanatory variable in the second stage of estimating the determinants of market participation intensity thereby correcting for the sample selection bias because non-market participants were not included in the second estimation. The results from this study corroborated earlier findings by Bellamere and Barrett (2006) in the livestock sector by showing that transactions costs negatively and significantly affected the discrete market participation decision. Output price did not have any effect on output market participation decision but instead affected market participation intensity positively and significantly. On top of this, this later study also found out that group marketing was an emerging institutional innovation to mitigate the costs of accessing markets. While this study analyzed determinants of market participation adequately by controlling for sample section in the second stage of estimation, it could have been more informative if it had considered all the crop enterprises on the farm. The study also did not address explicitly the impacts of market participation on smallholder welfare, particularly on poverty and food insecurity.

Moving further with the investigation of the effect of transaction costs on smallholder farmers' commercialization, Omiti *et al.,* (2009) analyzed factors that influenced market participation intensity in rural and peri-urban areas in Kenya. In this study, a truncated regression specification was adopted by excluding households that did not participated in the market i.e. the lower bound of the truncation. Their results showed that transaction costs significantly affected market participation intensity in a negative way. They also concluded that infrastructure development was a necessary but not sufficient condition for market participation, instead, simultaneous efforts to improve market integration through institutional reforms like group marketing could bring down transactions costs considerably and enhance market participation – similar conclusion like in Alene *et al.,* (2008). However, the HCI developed here were based on single commodities thus just partial and not a fully reflection of overall household commercialization status since other crop enterprises on the farm were not considered. Besides, Omiti *et al.,* (2009) did not analyze the determinants of the binary decision of households to participate or not to participate in the market. The study was also silent on investigating the impacts of market participation on household welfare.

The adduced evidence from empirical literature on the impact of transaction costs on agricultural commercialization shows that reducing these transaction costs could unlock the limited market participation by smallholder farmers. However, Rios *et al.,* (2009) developed on what had been done previously by Govereh *et al.,* (1999) and Govereh and Jayne (2003) on the synergies between commercialization and crop productivity by investigating the direction of causality between market participation and productivity. This later empirical work arrived at contradictory conclusion about transaction costs in Tanzania, Vietnam and Guatemala. They used two-stage instrumental variable framework because market participation is endogenous. Debatably, while most pioneer studies found that market access factors like road infrastructure were crucial for market participation decision, results from Rios *et al.,* (2009) indicated that households with high productivity tended to participate in agricultural markets regardless of market access factors. In contrast, better market access was not found to significantly lead to high productivity. Therefore, this means that investments in market access infrastructure like roads provide minimal improvements in agricultural productivity. However, the study did not address the issue of impact of this market participation and productivity improvements on household welfare.

Using household level panel data, Mathenge *et al.,* (2010) analyzed the determinants of market participation and the implication of this market participation on welfare of the poor and marginalized households in Kenya. They used the Double Hurdle model proposed by Craigg (1971). They found out that market participation was dominated by 20% of the households, who sold over two thirds of the marketed volume for various crops. Their results also showed that a high proportion of households who exited poverty sold some of their crop production, and similarly, a high proportion of those who exited poverty sold a high proportion of their crop production. Though this study made significant contribution in understanding the determinants and impacts of household commercialization, it did not explicitly analyze the impact of commercialization on household welfare. Like earlier studies before it, it also used pooled data that is unlikely to unmask some determinants and impacts of commercialization due to individual household heterogeneity and unobserved characteristics of the sampled households.

2.4 Overview of the literature review

The reviewed theoretical literature is grounded in economic development theories of William Arthur Lewis' Dual Economy growth model and Rostow's stages of economic development model. The former model fairly describes the current dualistic nature of the Kenyan economy represented by rural economy that is largely agricultural compared to urban economy that is more industrial and service oriented. The interdependency of these two economies in terms forward and of backward linkages is well captured in dual economy model. On the other hand, Rostow's economic development model puts agricultural sector into three transformative stages of traditional (purely subsistence), semi traditional/modern (semi-subsistence) and the ultimate modern and fully commercialized sector. Analyzing the Kenyan economy in the context of Rostow's economic development model shows that the country is in the second stage i.e. semi-subsistence where majority of smallholder agricultural producers produce for both home consumption and surpluses are marketed for cash. The producers use both purchased and household produced inputs in varying proportions in their production activities.

However, it should be noted that smallholder farmers are a mixed lot and they tend to be spread in all the three theoretical stages with majority being in the second stage. This is in appreciation of the fact that these three agricultural transformation stages seen in the lens of Rostow's development stage theory are only indicative because some late comers (households) might skip some of the

stages. Concerted efforts are therefore needed to move the agricultural sector from the current second stage of semi-subsistence to fully commercialized modern sector as postulated in the theoretical model rather than curtailing this important process on the basis that it could be counter-productive due to pervasive market failures. Such transformation is bound to increase productivity and incomes thereby positively addressing rural poverty and food insecurity as argued by proponents of agricultural commercialization.

On the other hand, the reviewed empirical literature shows that determinants and impacts of agricultural commercialization have been analyzed using different approaches in Kenya and beyond. While majority of the studies used a partial HCI that was based on one or just a few selected crop enterprises on the farm, only Govereh *et al.,* (1999) and Strasberg *et al.,* (1999) used a more comprehensive HCI based on all crop enterprises on the farm. However, even these two studies that used a comprehensive HCI only analyzed the impact of agricultural commercialization but not the determinants of agricultural commercialization. In fact, to the best of our knowledge, no study of agricultural commercialization in Kenya has empirically analyzed determinants and impacts of agricultural commercialization using a comprehensive HCI. Similarly, the analytical frameworks used in reviewed empirical studies are varied. However, it is important to note that though majority of these studies used two step selectivity models (Goetz, 1992; Alene et al., 2008; Bellamere and Barrett, 2006; Mathenge *at al.,* 2010; Bahta and Bauer, 2012), other studies were based only on the continuous decision of market participation intensity modeled using the tobit model (Omiti *et al.,* 2009; Macharia *et al.,* 2014).

Overall, the statistical models used to empirically study determinants of market participation decision (discrete and continuous) were very elaborate except that they did not use a more comprehensive HCI. However, it is important to note that the models that have been used in the reviewed literature to analyze the impacts of agricultural commercialization on household welfare have not been rigorous like what has been witnessed in impact assessment studies of agricultural technologies like improved seed, fertilizer, sustainable intensification practices (Mwabu *et al.,* 2006; Wu *et al.,* 2010; Becerril and Abulai, 2010; Kassie *et al.,* 2014a; Shiferaw *et al.,* 2014). Therefore there is need to study agricultural commercialization in Kenya using a more comprehensive farm level index and assess its impacts on household welfare using more recent and

robust impact assessment methodologies as it has been applied in other research areas like technology adoption and labour economics.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents both the theoretical and empirical methodologies that were adopted in this study. The chapter starts by describing the theoretical model on which the empirical models are built. Thereafter, an overview of the empirical models used in the study is briefly put forward together with their overall estimation strategy. Also, the measurement of the main dependent variable for objective one of this study, which is also the treatment variable in objective two and objective three (i.e. household commercialization index), is described. The last section of this chapter describes the data used in the study.

3.2 Theoretical model

A typical farm household in a developing country like Kenya produces a range of goods that can be used either for home consumption and/or sold. Similarly, the production process on the farm uses purchased inputs (labour and non-labour) from the markets and/or own produced on the farm. Therefore, a farm household always faces an optimization problem based on benefits and costs arising from participating in both input and output markets. However, market failures are so pervasive in developing countries (Ellis, 1993) leading to what is now referred to as non-separability modeling of rural household behavior (Yotopoulos and Lau 1974). A non-separable household model is when the production decision is affected by consumption decision and vice versa. Theoretically, under perfect markets (no market failures), it does not matter whether a household is both a producer and/or a consumer because it will optimize its problem through a two-step recessive separable process i.e. maximize its profits as a producer and use the generated production income to maximize its utility as a consumer (Lofgren and Robinson, 1999). By contrast, a separable model is when the household behaves a strict profit maximizing producer. Therefore, modeling household optimization problem under pervasive market failures is commonly done by non-separable household models with utility rather than profit maximization as the objective function (Vance and Goeghegan, 2004; Mather *et al.,* 2011).

Following standard microeconomic consumer theory, a rational economic agent (household) is assumed to maximize utility (U) by choosing levels of goods and services produced (Q_i), consumed (C_i), bought (B_i), sold (S_i) and inputs used (K_i) subject to income constraint, resource constraint and production technology constraint (Key *et al.,* 2000; Azam *et al.,* 2012). That is, using K_i inputs

(labour and non-labour), the household can produce output (Q_i) which it can either sell (S_i) or consume (C_i). Sales enter into the utility function through revenue generated from sales (P_iQ_i), the sum of which is used to purchase other goods represented by B_i. Therefore, assuming no transaction costs, the neo-classical subjective utility maximization equilibrium for commercializing (market participating) household will then be given in the following constrained optimization framework:-

$$Max\ U(C_i, Z^c) \quad (3.1)$$

Subject to:-

i) Income constraint

$$A + \sum_{i=1}^{N} P_i^m S_i \geq \sum_{i=1}^{N} P_i^m B_i \quad (3.2)$$

ii) Resource constraint

$$Q_i + E_i + B_i \geq K_i + C_i + S_i \quad (3.3)$$

iii) Production technology constraint

$$G(Q_i, K_i, Z^q) = 0 \quad (3.4)$$

iv) Non-negativity constraint:

$$C_i, Q_i, S_i, B_i, K_i \geq 0 \quad (3.5)$$

Where:

P_i^m = Market price

E_i = Total endowment of good *i*

A = Exogenous transfers and other incomes

Z^c = Household characteristics

Z^q = Production technology characteristics

The income constraint (Eqn. 3.2) implies that the sum of all exogenous income and total value of sales must be greater or equal to all household purchases. On the other hand, the resource constraint (Eqn. 3.3) states that consumed and sold quantities plus what was used in production cannot be more than production, endowment and purchased quantity of each good (Azam *et al.*, 2012). Finally, the production technology constraint (Eqn. 3.4) relates all inputs with outputs and it is assumed to be a well behaved production function that is continuously differentiable.

However, in real life, the above assumption of no transaction costs does not hold, especially in developing countries with pervasive market failures. Therefore, relaxing this assumption means that fixed and proportional transaction costs have to be considered in this optimization problem. Fixed transaction costs (τ_i^{fs}) corresponds to costs incurred by market participating households in selling outputs regardless of the quantities involved in the transaction/s while proportional transaction costs (τ_i^{ps}) are costs dependent on volumes involved in the transaction/s. Similarly, in case of purchases, fixed transaction costs (τ_i^{fb}) corresponds to costs incurred by market participating households in buying outputs regardless of the quantities involved in the transaction/s while proportional transaction costs (τ_i^{pb}) are costs dependent on volumes involved in the transaction/s. Therefore, with transaction costs, Eqn. 3.2 (income constraint) is transformed into the following Eqn. 3.6:-

$$A + \sum_{i=1}^{N}\left[S_i(P_i^m - \delta_i\tau_i^{ps}) - \delta_i\tau_i^{fs}\right] \geq \sum_{i=1}^{N}\left[B_i\left(P_i^m + \gamma_i\tau_i^{pb}\right) + \gamma_i\tau_i^{fb}\right] - - - - - \quad (3.6)$$

From Eqn. 3.6 above, δ_i = 1 if the household is a seller in the market and 0 if otherwise. On the other hand, γ_i = 1 if the household is a buyer in the market and 0 if otherwise. This Eqn. 3.6 implies that by factoring in transaction costs in selling, the price received by market participating household will be the market price (P_i^m) reduced by the amount of proportional transaction costs (τ_i^{ps}) because the household has to incur this amount for each unit of output it sells as a proportional cost. In addition, selling of each of the output *i* will cost τ_i^{fs} to the household regardless of the volumes involved. Inversely, when buying goods from the market, the household pays an additional proportional transaction cost (τ_i^{pb}) besides the market price (P_i^m) for each unit purchased. In this later case, the household also incurs fixed transaction cost (τ_i^{fb}) regardless of the amounts purchased.

From the above constrained optimization problem with transaction costs, the following Lagrangian function (Eqn. 3.7) can be set up from which the first order conditions (FOCs) can be derived to yield the reduced form of output and input market participation conditional on participation (Goetz, 1992; Key *et al.*, 2000).

$$L = U(C_i, Z^c) + \lambda\left\{A + \sum_{i=1}^{N}\left[S_i\left(P_i^m - \delta_i\tau_i^{ps}\right) - \delta_i\tau_i^{fs}\right] - \sum_{i=1}^{N}\left[B_i\left(P_i^m - \gamma_i\tau_i^{pb}\right) - \gamma_i\tau_i^{fb}\right]\right\}$$
$$+ \sum_{i=1}^{N}\mu_i(E_i + Q_i + B_i - K_i - C_i - S_i) + \Phi G(Q_i, K_i, Z^q) - - - - - - (3.7)$$

Where λ, μ and $\Phi$are the Lagrange multipliers associated with income constraint, resource balance and technology constraints respectively.

Given that the fixed transaction costs create discontinuities in the Lagrangian, the optimal solution cannot be found by simply solving for first order conditions. However, Key *et al.*, (2000) and Azam *et al.* (2012) have shown how the solution can be derived by solving first for the optimal solution conditional on market participation regime, and thereafter choosing the market participation regime that leads to the highest utility. On the basis of this, the decision to participate in the market and market participation intensity conditional on being already in the market can be represented by the following Eqn. 3.8 and Eqn. 3.9 respectively:-

$$Q_{si} = \left(P_i^m, \tau_i^{fs}, \tau_i^{ps}, Z^q, Z^c, E_i, A\right) - - - - - - - - - - - - - - - - (3.8)$$
$$Q_s = \left(P_i^m - \tau_i^{ps}, Z^q\right) - (3.9)$$

Eqn. 3.8 implies that the binary decision to commercialize or not to commercialize is affected by both fixed and proportional transaction costs while the intensity of commercialization is only affected by the proportional transaction costs as depicted in Eqn. 3.9. That is, once fixed costs of commercialization are covered, fixed costs do not affect the commercialization intensity (amount sold). These Eqn. 3.8 and Eqn. 3.9 technically mean that fixed transaction costs can be used to identify the market participation equation (Azam *et al.*, 2012).

3.3 Empirical models

Following the utility maximization consumer theory discussed in section 3.2, empirical models are developed so as to achieve the study objectives. This section also highlights briefly these empirical models before outlining the overall estimation technique used in the three empirical models. Lastly, the definition and measurement of the key dependent variable (impact treatment variable i.e. agricultural commercialization) is outlined.

3.3.1 Empirical models of determinants and impacts of agricultural commercialization

This study adopted the two-tier double hurdle model as proposed by Craig (1971) in order to achieve its first objective as stated in section 1.4. The model assumes that the household binary decision to commercialize and the continuous decision of how intensively it should commercialize on condition that it has decided to commercialize are determined by different process (factors). Detailed structural formulations of this empirical model are as outlined in section 4.2.

On the other hand, the empirical challenge in impact assessment using observational cross-section or short panel data is establishing a suitable counterfactual against which the impact can be measured due to self-selection problem. Several econometric methods have been developed to address this problem and they include propensity score matching (PSM) in a binary treatment framework, generalized propensity score (GPS) matching in a continuous treatment framework; instrumental variable (IV) approaches and switching regressions. PSM, GPS and IV approaches have inherent limitations that switching regressions overcome as discussed in section 5.2 and section 6.2. Therefore, this study adopts the two-step switching regression frameworks. These switching regressions models estimates two separate treatment outcome equations (for example in this case, one for commercialized and another for non-commercialized) along with the selection equation. This approach reduces the selection bias by controlling for both observed and unobserved heterogeneity despite its distributional (tri-variate normal distribution) and exclusion restriction assumptions (Kassie, *et al.*, 2014a). Again, detailed structural formulation of these two-step switching regression models as adopted for assessing the impact of agricultural commercialization on household food security and poverty are as discussed in section 5.2 and section 6.2, respectively.

3.3.2 Estimation strategies of the empirical models

This study is based on two wave balanced panel data that offers an analytical advantage of controlling for unobserved time invariant individual households characteristics. Therefore, a correlated random effects (CRE) approach is employed using the *Mundlak–Chamberlain* device (Mundlak, 1978; Chamberlain 1982) to estimate all the empirical models in this study. Traditionally, these unobserved heterogeneities have been estimated using the fixed effects (FE) and random effects (RE) models. However, these traditional approaches of panel data have some inherent weakness. On one hand, the RE models assumes no correlation between the unobserved heterogeneities and the observed explanatory variables in the model. If this RE assumption holds,

then across-sectional analysis employing OLS estimation would also consistently estimate the model parameters (Wooldridge, 2010). On the other hand, while FE approach looks attractive because it assumes arbitrary correlation between the unobserved heterogeneity and observed explanatory variables, its biggest weakness is that the transformation it uses to eliminate this correlation also removes completely the time invariant observed explanatory variables from the model as these are differenced out in the estimation process. This becomes very problematic in cases where a researcher intends to investigate the effects of the time invariant explanatory variables. Similarly, using FE for double hurdle model is problematic as the FE probit approach has been shown to be inconsistent (Wooldridge, 2010) while the FE truncated normal model has also been shown to be biased when the panel waves are less than 5 (Greene, 2011; Wooldridge, 2010). CRE approach preserves the advantages of FE approach while at the same time enabling the inclusion of time invariant explanatory variables in the analysis and thus adopted in this study.

Therefore, CRE approach allows for the correlation between unobserved heterogeneity (Γ_i) and the vector of explanatory variables across all time periods (X_{it}). Following Wooldridge (2010) and Cameron and Trivedi (2009), in this CRE framework, the assumption is that there is a linear relationship between the unobserved time varying individual heterogeneity and the observed explanatory variables that can be modeled as follows:-

$$\Gamma_i = \varphi + \bar{X}_\iota \lambda + a_i \quad ---------- \quad (3.10)$$

Where:-

φ is a scalar

$\bar{X}$ is the averages of time varying explanatory variables

λ is a vector of coefficients to be estimated

a_i is the error term assumed to have zero mean conditional on the entire history of the covariates (X_{i1}, X_{i2}, ------, X_{iT}) i.e. a_i is uncorellated with X_{it} for all t and therefore X_i

The reduced form of the model in which φ is absorbed into the intercept term and $\bar{X}_\iota$ are added to the set of explanatory variables including time invariant variables is estimated as follows:-

$$Y_{it} = a_t^* + X_{it}\beta + \bar{X}_\iota \lambda + Z_i \gamma + a_i + \varepsilon_{it} \quad ---------- \quad (3.11)$$

Where:

Y_{it} is the outcome variable

Z_i is a vector of time invariant explanatory variables

Following Schunck (2013) and Burke and Jayne (2014), β are estimated parameters in the model that are interpreted as "within-household" or "within-cluster" effect. It is important to note that these "within-household" estimates are similar to the FE estimates i.e. these coefficients are the effect of a given time varying variable's effect of deviation from its overall average or "permanent" level (Burke and Jayne 2014). Therefore, logically, these coefficients can be interpreted as the effect of a deviation within a household. On the other hand, λ and γ are estimated model parameters that are interpreted as "between-household" or "between-cluster" effects (Burke and Jayne 2014). These variables are constant for each household across the panel period and therefore they only represent "between-household" effect. This means that the time varying covariates (X_{it}) can be decomposed into "within" and "between" cluster or household effects. Detailed derivation and interpretation of "within" and "between" estimates are given in Schunck (2013) and Burke and Jayne (2014).

3.3.3 Measurement of agricultural commercialization

Due to different definitions of agricultural commercialization in literature, different yardsticks have been developed to measure it. The most widely adopted measurements of agricultural commercialization are the three household level indices developed by von Braun *et al.*, (1994), that is, output and input side commercialization; rural economy commercialization; and degree of a household integration into the cash economy. For each type of commercialization, the authors formulated indices that can be used to measure the extent of household commercialization. First, the household commercialization index (HCI) measured the proportion of the value of agricultural output sold in the market and purchased inputs to the total value of agricultural production (Eqn. 3.12 and Eqn. 3.13). The two indices basically measured household participation in output and input markets respectively. The focus of this study is agricultural commercialization measured by the proportion of the value of agricultural output sold in the market to total value of agricultural production (Eqn. 3.12). On the other hand, commercialization of rural economy was measured as the ratio of the value of goods and services acquired through market transactions to total household income. Finally, the degree of household integration into cash economy was measured as the ratio of the value of goods and services acquired by cash transaction to the total household income.

$$HCI_O = \frac{Total\ Value\ of\ Agricultural\ Sales\ in\ the\ Market}{Total\ Agricultural\ Production\ Value} - - - - - - - - - - (3.12)$$

$$HCI_I = \frac{Total\ Value\ of\ inputs\ acquired\ from\ the\ Market}{Total\ Agricultural\ Production\ Value} - - - - - - - - - - (3.13)$$

3.4 Data source

This study is based on two-year panel data collected from rural farming households in western and eastern parts of Kenya. The data collection exercise was conducted by International Maize and Wheat Improvement Center (CIMMYT) and its partners in Kenya with financial support from the Australian Center for International Agricultural Research (ACIAR). The first wave of data collection was conducted in year 2011 while the second wave in year 2013. A total of 613 households were surveyed in wave one while 535 were successfully resurveyed in wave two – an attrition rate of about 13%.

The surveyed smallholder farming households were from Bungoma and Siaya districts of western Kenya and Embu, Meru South and Imenti South districts of eastern Kenya. A semi-structured questionnaire was used to capture key information for profiling targeted farming communities. The questionnaire captured data on various aspects including socioeconomic profiles of the households, household social capital and other village networks and household specific transaction costs variables. Information on household ownership of farm implement and other assets was also collected. The questionnaire had specific modules to capture data on household crop and livestock production and marketing, access to information and other farm production institutions and annual household expenditure data on food and non-food items among others. It is also important to note that annual data on other sources of income apart from agriculture was captured in the questionnaire. Finally, it is important to note that the questionnaire had a module that was designed to capture the respondents' subjective assessment of household food security status in the last 12 months preceding the survey. For detailed information on all the data collected during these two survey visits, see Appendix 3. This study is based 914 observations of balanced panel data drawn from 457 households.

CHAPTER FOUR: DETERMINANTS OF SMALLHOLDER AGRICULTURAL COMMERCIALIZATION IN KENYA

4. 1 Introduction

Majority of the population in developing countries live in rural areas and are mainly dependent on subsistent agriculture to earn their livelihoods. Transformation of the agricultural sector through commercialization is seen as the most viable way to address the pervasive high levels of rural poverty and food insecurity. However, despite decades of promotion of agricultural market led development strategies like commercialization, very few smallholder farmers in SSA participate in commodity markets as sellers (Siziba *et al.,* 2011). Yet consensus among researchers and development practioners has been that agricultural sectors in developing countries need to transform from the low productivity semi-subsistence farming to highly commercialized production systems. Therefore, the potential of commercialization as an engine of rapid agricultural growth and pathway out of abject poverty especially for the poorest of the poor in rural areas of developing countries still remains elusive.

In Kenya, for example, more than three quarters of the population live in rural areas mainly practicing subsistence farming. These rural areas also harbor the poorest of the poor and the most food insecure in the country (World Bank, 2009). Available statistics show that of the 46% of the total national population that is classified as poor (Republic of Kenya, 2010), about 82% of these poor live in rural areas (Manda, 2007). Similarly, while about 46% of the national population is food insecure, about 47% of the rural population is poor compared to 40% of the urban population (World Bank, 2009). Majority of these rural people are smallholder farmers producing on farms averaging less than 3 hectares and account for about 75% of the total agricultural output and 70% of the marketed agricultural produce (Republic of Kenya, 2010). Though they account for 70% of the marketed agricultural produce, empirical evidence shows that the markets are highly concentrated and majority of these smallholders are just subsistent (Olwande and Mathenge, 2011; Woolverton *et al.,* 2014). According to Olwande and Mathenge (2011), about 20% of smallholder farmers account for over two thirds of the marketed agricultural volumes in Kenya. Yet agricultural growth brought about by market participation (commercialization) should be useful in reducing rural poverty and food insecurity for all with as many smallholder producers benefiting from it as possible. Therefore, improvement of smallholder producers through an all-inclusive commercialization approach could

be one single most important pathway out of poverty and general improvement in welfare of the rural poor (Mather *et al.*, 2011; Olwande and Mathenge, 2011; Kirstein *et al.*, 2012).

However, reasons for these worryingly high levels of subsistence orientation especially among smallholders are not yet clear. Majority of past studies that sought to understand this limited commercialization among smallholder farmers were in response to mixed results of structural adjustment programmes (SAPs) that were meant to provide market led opportunities for rapid economic growth and development though they failed to do so (Rono, 2002). Most of these studies were based on partial commercialization measures i.e. they were based on a household commercialization index (HCI) that was built using either a single crop or a few selected crops (Alene *et al.,* 2008; Omiti *et al.,* 2009; Mathenge *et al.,* 2011; Macharia *et al.,* 2014). The use of partial household commercialization index persisted despite the fact that smallholder farmers in developing countries like Kenya usually have a portfolio of crop enterprises on their farms in every season. They also sell other crops, other than main staples like maize or main cash crops like sugar cane, tea and coffee. Though the use of a single crop based HCI could be attractive given the fact that single crop supply is more elastic than aggregate output supply, arguably, this study pursued the line of thought that aggregate supply is what ultimately matters to policy makers as noted by Binswanger (1990).

Besides, there have been limited empirical studies to understand the reasons behind limited smallholder agricultural market participation despite the high international food prices that have been experienced since the international food crisis of 2006 and 2008. According to IFAD (2010), much of the increased market participation in post international food crisis has been from developed countries despite the fact that developing countries used to heavily protect their local producers against the so called cheap imports prior to the crisis era. This limited market participation by farmers from developing countries in post international food crisis era affirms the argument by Barret (2008) that just "getting the prices right" is not adequate to elicit positive supply response. This means that there are other confounding factors apart from price that inhibit or drive smallholder agricultural commercialization.

Therefore, this study empirically investigates factors that drive smallholder agricultural commercialization in Kenya using a more comprehensive farm level HCI with the aim of answering

the following three specific questions:- a) what are the determinants of smallholder farmers' binary decision to commercialize (participate in crop markets as sellers); b) what factors determine smallholders commercialization intensity (the proportion of the value of crop produced that is marketed) and; c) what are the viable policy interventions to enhance the overall smallholder agricultural commercialization. The findings from this study are useful in informing policy for appropriate interventions that can stimulate and enhance an all-inclusive smallholder agricultural productivity and development growth mediated through the commercialization process.

4.2 Methods

An aggregated (comprehensive) household output market supply function of all crops produced on the farm is estimated in order to analyze the determinants of agricultural commercialization (output market participation). The study follows the definition of agricultural commercialization by von Braun *et al.,* (1994) and therefore the HCI is computed as follows:-

$$HCI_O = \frac{Total\ value\ of\ all\ crops\ \ sold\ in\ the\ market\ from\ own\ production}{Total\ value\ of\ all\ crops\ produced\ on\ the\ farm} - - - -(4.1)$$

Therefore, HCI is a ratio ranging from zero for non-commercialized to one for the fully commercialized households. The crop output market supply function based on Eqn. 4.1 above was estimated econometrically using the two step (two-tier) double hurdle model (Craig, 1971). The motivation for use of the double hurdle model is the fact that in econometric modeling of determinants of market participation, the concern is usually the fact that not all households participate in the market i.e. there is non-trivial portion of observations located at zero sales. This kind of distribution in the data can create problems for standard OLS regression estimations (Wooldridge 2010). To circumvent these problems, past studies modeled market participation decisions as a two-step decision making process involving first the binary decision to participate or not to participate in the market and then followed by intensity of participation conditional on having decided to participate (Goetz, 1992; Mathenge *et al.,* 2010; Mather *et al.,* 2011; Reyes, 2012). These studies either used tobit models, Heckman sample selection models or double hurdle models (Boughton *et al.,* 2007; Alene *et al.,* 2008; Omiti *et al.,* 2009; Mathenge *et al.,* 2010; Mather *et al.,* 2011; Reyes *et al.,* 2012).

The tobit model proposed first by Tobin (1958) describes the relationship between non-negative dependent variable and a set of independent explanatory variables. The weaknesses of the tobit model in this kind of analysis is the assumption that a given set of explanatory variables have the same effects on both the probability of market participation and intensity of market participation (Wooldridge, 2010). This assumption also means that the partial effect of a given explanatory variable on the binary decision and the continuous decision is of the same sign. The model also assumes that zero traded volumes for non-market participating households are due to rational choice of the households (corner solution), though it may be due to a market entry barrier as noted by Komarek (2010). Another limitation of the tobit model is that it is only estimated when the dependent variable is above or below some cut off level (censored from left or right), hence it could underestimate the intercept and overestimate the slope (Sigei *et al.,* 2014).

However, the Heckman sample selection and double hurdle are two-step models that relax these tobit assumptions by allowing different mechanisms to determine the discrete probability of participation and the intensity of participation. In these two-step models (Heckman and Double Hurdle), the first step involves estimation of a probit model while the second step can take different functional distributions (lognormal or truncated normal). In the Heckman sample selection models developed by Heckman (1979), a probit analysis is employed first to estimate the probability of participation (selection model) and then compute the inverse mills ratio (IMR) from the estimated probit regression. The computed IMR is used thereafter in the second step with other explanatory variables to explain the variation in the continuous (non-zero) outcome variable. These Heckman sample selection models correct for the fact that non-market participating group is not a random sub-sample of the population but one that self-selected itself into non-participating group due to both observed and unobserved covariates. In other words, as indicated by Wooldridge (2010), this self-selection bias is viewed as an omitted variable in the selected sample which is corrected by including IMR in the second step estimation.

On the other hand, the two step double hurdle model nests the tobit model and therefore allows to test the restrictions implied in the tobit hypothesis (Wooldridge, 2010; Mather *et al.,* 2011). Also, unlike the Heckman sample selection models where households that do not sell output or buy inputs are treated as missing observations in the second step (Goetz, 1992), the double hurdle model treats such households as corner solutions (modeled as a tobit). The rationale for a corner solution model

is that non-market participating households are treated as valid and rational economic choices to be explained in the model and not a reflection of missing data (Reyes *et al.*, 2012).

Therefore based on consumer theory and following Key *et al.*, (2000) and Azam *et al.*, (2012) on how to derive an optimal solution from a non-separable household utility maximization theoretical model discussed in section 3.2, the double hurdle model that was used in this study was as follows:-

First stage:-

$$H_{it}^{*} = X_{1it}\beta_1 + \varepsilon_{1it} \qquad \varepsilon_{1it} \sim N(0, \sigma^2) \quad ---------- (4.2)$$

$$H_{it} = \begin{cases} 1 \; if \; H_{it}^{*} > 0 \\ 0 \; if \; H_{it}^{*} \leq 0 \end{cases} \quad ---------- (4.3)$$

Second stage:-

$$Y_{it}^{*} = X_{2it}\beta_2 + \varepsilon_{2it} \qquad \varepsilon_{2it} \sim N(0, \sigma^2) \quad ---------- (4.4)$$

$$Y_{it} = \begin{cases} 1 \; if \; Y_{it}^{*} > 0 \\ 0 \; if \; Y_{it}^{*} \leq 0 \end{cases} \quad ---------- (4.5)$$

Where:

Subscripts *it* = i^{th} household during period *t*

H_{it}^{*}= Latent (unobservable) discrete decision of whether to or not to participate in the market

H_{it} = Observable discrete decision of whether to or not to participate in the market

Y_{it}^{*} = Latent (unobserved) variable of market participation intensity status (desired HCI)

Y_{it} = Observed market participation intensity (actual observed HCI)

β_1, β_2 = Parameters to be estimated

ε_{1it}, ε_{2i} = Error terms E(ε_{1it}, ε_{2it}) = 0

X_{1it}, X_{2it} = Vectors of exogenous explanatory variables that need not to be same variables

Since Y_{it} can be zero for the non-participants, then the DHM can be modeled as follows:

$$Y_{it} = \begin{cases} X_{1it}\beta_1 + \varepsilon_{1it} \; if \; \min(X_{1it}\beta_1 + \varepsilon_{1it};\; X_{2it}\beta_2 + \varepsilon_{2i}) > 0 \\ 0 \qquad\qquad Otherwise \end{cases} ------ (4.6)$$

$$\begin{pmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \end{pmatrix} \sim N(0, \sum), \sum = \begin{pmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma \end{pmatrix} ---------- (4.7)$$

Letting ψ(X, Y, ρ) denote the CDF of a bivariate normal with correlation ρ, the log-likelihood function for the double hurdle model is given as:-

$$Log\ (L) = \sum_{Y_{it}=0} \left[log\left\{1 - \phi\left(X_{2i}\beta_2, \frac{X_{1i}\beta_1}{\sigma}, \rho\right)\right\}\right] + \sum_{Y_{it}>0} \left(log\left[\phi\left\{ \frac{X_{2i}\beta_2 + \frac{\rho}{\sigma}(Y_i - X_{1i}\beta_1)}{\sqrt{1-\rho^2}} \right\}\right] - \log[\sigma] + log\left\{ \phi\left(\frac{Y_i - X_{1i}\beta_1}{\sigma}\right)\right\}\right) - - - (4.8)$$

Therefore, the DHM can be reduced to the tobit model by setting $X_{2it}\beta_2 = 0$ and taking the limit $X_{2it}\beta_2 \to \infty$

4.2.1 Variable definition and measurements

Dependent variable: For the first stage of the estimation (probit model shown in Eqn. 4.9), the dependent variable (H_{it}) was binary (Table 2). If $H_{it} = 1$, then household *i* participated in the market at time *t* while if $H_{it} = 0$, then household *i* did not participate in the market at time *t*.

$$P(H_{it} = 1) = P(Y_{it} > 0) = X_{1it}\beta_{1it} + \eta_{it} \quad (Binary\ market\ participation\ decision) - -(4.9)$$

On the other hand, for the second stage estimation of the determinants of market participation intensity, the dependent variable (Y_{it} as shown in Eqn. 4.10) was a household commercialization index (HCI_{it}) which is a ratio ranging between 0 and 1 developed on the basis of Eqn. 4.1. In this case, $HCI_{it} = 0$ indicates non-commercialized household *i* at time *t* while $HCI_{it} = 1$ means that the household *i* was fully commercialized at time *t* i.e. it sold all its crop production.

$$Y_{it} = X_{2it}\beta_{2it} + \eta_{2it} \qquad (Market\ participation\ intensity) - - - - - - - - - - -(4.10)$$

Independent variables: Based on theory and past empirical studies (Goetz, 1992; Key *et al.*, 2000; Heltberg and Tarp, 2002; Barrett, 2008; Alene *et al.*, 2008; Omiti *et al.*, 2009; Martusceli 2012), factors that influence household market participation (binary decision and continuous intensity) were grouped into four categories:- i) demographic characteristics; ii) physical and financial asset endowments; iii) social capital; and iv) transaction costs as shown in Table 2. The demographic characteristics included in the model as explanatory variables were human capital in terms of family size (adult equivalent)[2] and dependency ratio[3]. Adult equivalent was preferred over absolute

[2] Was computed following Muyanga *et al.*, (2006)

numbers because the former allows comparison of households that have same number of members but of different composition in terms of age and sex (White and Masset, 2003). Other demographic characteristics were sex, age and education of the household head. On the other hand, physical and financial asset endowments such as livestock and non-livestock assets like owned land were included in the model. Also, soil fertility score of all operated plots weighted by plot size, total annual household non-farm income, access to agricultural input credit and household contacts with extension staff were included in the model as household's physical and financial assets. Social capital indicator variables considered in the model were household membership to agricultural production networks/groups (APNs), number of dependable relatives living within the same village and household's trust in grain traders. Lastly, following Goetz (1992) and Key *et al.*, (2000), both fixed and proportional transaction costs were included in the model. Fixed transaction costs were proxied by mobile phone ownership while proportional transaction costs were proxied by transport costs from the farm to the nearest main market and ownership of any of the common local transportation means (bicycle, ox-cart and wheelbarrow). Transport costs to the nearest main market assessed the impact of farming household's remoteness on its agricultural commercialization. Regional fixed effects on agricultural commercialization were also assessed by the inclusion of regional dummy as one of the explanatory variables. The detailed definition, measurement and priori expectations of these variables are as shown in Table 2.

To construct the *Mundlak-Chamberlain* devise, the panel average variables of selected time varying variables were computed based on the two panel periods. These panel average variables were added in the first hurdle and second hurdle models as additional explanatory variables. Specifically, on one hand, for demographic variables, panel averages were computed for age of the household head, household size and dependence ratio. It was assumed that given the short time difference between the first and second wave data collection (about two years), it was unlikely that gender and education level of the household head could have changed significantly if any. On the other hand, time average variables were computed for all physical and financial asset variables included in the model because they were assumed to have changed reasonably across the two panel periods. However, social capital variables were assumed to change slowly over time and they were not

[3] Following Mathenge *et al.*, (2010), A household's dependency ratio was calculated as follows:

$$Dependency\ ratio = \frac{(Number\ of\ household\ members\ under\ 15\ years\ old)+(Number\ of\ household\ members\ over\ 64\ years\ old)}{Number\ of\ household\ members\ aged\ between\ 15\ \ to\ 64\ years}$$

expected to have changed significantly within two years. Only one transaction cost was considered to have changed significantly across the two periods i.e. ownership of mobile phone and therefore its time average was computed as part of the *Mundlak-Chamberlain* devise. Otherwise, the change in transport costs and ownership of common local means of transport were not expected to have changed significantly within the two years. Lastly, the regional dummy was fixed across the two panels for each household and therefore it was not averaged.

Table 2. Definition of variables in Double Hurdle Model

Variable definition	Variable measurement	Expected sign of participation	
		Step 1: Participation decision	Step 2: Participation intensity
Dependent variables:			
Output market participation	Binary (1=Participating; 0=Otherwise)	√	na
Output market participation intensity	Continuous (ratio between 1 & 0)	na	√
Independent Variables:			
a) Demographic characteristics:			
Gender of the household head	Binary (1=Male; 0=Otherwise)	+	+
Age of the household head	Continuous (years)	+	+
Education of the household head	Continuous (years)	+	+
Household size	Continuous (adult equivalent)	+/-	+/-
Dependency ratio	Continuous (ratio >=0)	+/-	+/-
b) Physical & financial assets:			
Livestock owned	Continuous - Natural log (Tropical Livestock Units i.e. TLU)	+	+
Per capita own farm size	Continuous (ha/adult equivalent)	+	+
Per capita own farm size squared	Continuous (ha/adult equivalent)	+	+
Mean soil fertility of cultivated plots	Continuous (Fertility mean score)	+	+
Total annual non-farm income	Continuous - Natural log (KSh)	+/-	+/-
Access to credit to buy inputs	Binary (1=Yes; 0=Otherwise)	+	+
Contacts with the extension	Binary (1=Yes; 0=Otherwise)	+	+
c) Social capital:			
Membership to agricultural production group (APN)	Binary (1=Yes; 0=Otherwise)	+	+
Number of dependable relatives in	Continuous (absolute numbers)	+	+

village			
Trust grain traders	Binary (1=Yes; 0=Otherwise)	+	+
d) Transaction costs:			
Mobile phone ownership	Binary (1=Yes; 0=Otherwise)	+	+
Transport cost to main market	Continuous – Natural log (KSh/person/trip)	-	-
Ownership of transportation means	Binary (1=Yes; 0=Otherwise)	+	+
Regional dummy	Binary (1=Eastern; 0=Western)	+/-	+/-

Source: Author's compilation
Note: na stands for not applicable

4.2.2 Estimation strategy for the double hurdle model (DHM)

Fitting a two-step (two-tier) double hurdle model by way of estimating first step (tier 1) and second step (tier 2) separately is tedious and interpreting the results arising therein is complicated. In this study, the two-tier double hurdle model was estimated using the maximum likelihood estimator whose standard errors are robust to autocorrelation (Burke, 2009). Post estimation analysis included the computation of the probability of a household participating in the output market or not participating given the observable covariates. Similarly, conditional and unconditional expected values of the second stage (tier 2) were computed following Burke (2009). Lastly, since the coefficients of the DHM indicates the direction of influence of the independent variables and not the magnitude of the effect on the dependent variable like the ones observed under OLS, average partial effects of each of the independent variable was computed to represent the marginal effect of the independent variable on the dependent variable.

Given that this study is using a two wave panel data, a correlated random effects (CRE) approach is employed using the *Mundlak–Chamberlain* Device (Mundlak, 1978; Chamberlain 1982). One major advantage of panel data is its ability to control for time invariant unobserved heterogeneity. Traditionally, these unobserved heterogeneities have been estimated using the fixed effects (FE) and random effects (RE) models. However, these traditional approaches of panel data have some inherent weakness. On one hand, the RE models assumes no correlation between the unobserved heterogeneities and the observed explanatory variables in the model. If this RE assumption holds, then a cross-sectional analysis employing OLS estimation would also consistently estimate the model parameters (Wooldridge, 2010). On the other hand, while FE approach looks attractive as it assumes arbitrary correlation between the unobserved heterogeneity and observed explanatory variables, it does not include the time invariant observed explanatory variables. Therefore, CRE

approach that preserves the advantages of FE approach while at the same time enabling the inclusion of time invariant explanatory variables in the analysis (Wooldridge, 2010) is more attractive and it is adopted in this study.

The explanatory variables in the first and second stage of the double hurdle model can be the same or different (Mather *et al.* 2011; Mottaleb *et al.,* 2015). Theoretically, according to Cameroon and Trivedi (2009), the same regressors can appear in both parts of the model though this assumption can be relaxed if there is priori information to believe that there are obvious exclusion restrictions. In the current study, no such priori information was available and therefore same regressors are used in both parts of the model. This approach of having same explanatory variables in the first and second stage is consistent with empirical studies of Gao *et al.* (1995), Mather *et al.,* (2011), Wu *et al.,* (2014) and Mottaleb *et al.,* (2015).

4.3 Results and discussion

This section presents the estimation results on the determinants of agricultural commercialization among the surveyed farmers using the DHM that simultaneously estimates the binary decision to commercialize and commercialization intensity conditional on having decided to commercialize. First, descriptive statistics of the variables used in this model are presented and they are disaggregated by household commercialization regime (i.e. commercialized and non-commercialized households). Thereafter, the DHM econometric results are presented and discussed.

4.3.1 Descriptive statistics

The descriptive statistics of the variables used in DHM are presented in Table 3. About 75% of the surveyed households were commercialized i.e. sold at least some of the crop output they had produced on their farms. This means that about a quarter of the sampled households were practicing pure subsistence farming. Reasons for this non-trivial proportion of households engaging in subsistence farming are not clear. For the commercialized households, the average commercialization intensity was 37%, that is, commercialized households were selling on average about 37% of the value of all crops they produced. Therefore, even the commercialized households are consuming more than 60% of the value of crops that they produce. This low commercialization intensity among the commercialized households also need to be investigated further. A clear understanding of why a significant proportion of farmers are involved in subsistence farming and

reasons for limited commercialization intensity will help in designing interventions that can stimulate and enhance smallholder commercialization.

Majority of the surveyed households were male headed (84%) though commercialized households had a significantly higher proportion of male household heads (86%) compared to non-commercialized households (79%). While causality cannot be implied from these descriptive results, these gender differences might result from male headed households having better market access compared to their female counterparts. Average education level of household heads also followed a similar pattern like gender i.e. commercialized households had on average, significantly more years of formal education (8.0) compared to those heading the non-commercialized households (6.7). More educated household heads being commercialized might imply that education level could be one of the drivers of smallholder agricultural commercialization.

It is also important to note that asset ownership plays a key role in enabling households to commercialize as noted by Bellemare and Barrett (2006). Theoretically, productive assets like the amount of land owned, fertility of land and livestock ownership are critical in agricultural commercialization process. Descriptive statistics showed that the average per capita own farm size among the surveyed households was about 0.24 ha. Commercialized households had a significantly bigger average farm size of about 0.25 ha compared to non-commercialized ones who owned about 0.18 (Table 3). Since land is a primary factor in agricultural production, these descriptive results means that those households with bigger farms might be having a higher probability of commercialization compared to those with small farms. More detailed regression analysis that follows this descriptive analysis will be more conclusive on the impact of farm size on agricultural commercialization.

Descriptive statistics of weighted average soil fertility scores for operated plots showed that commercialized households had on average significantly more fertile plots than non-commercialized households (Table 3). Similarly, a significantly higher proportion of commercialized households accessed agricultural input credit (17%) compared to the non-commercialized households (5%). These statistics could mean that there is a high positive correlation between soil fertility and access to credit with commercialization probability and/or intensity.

Table 3. Descriptive statistics of the Double Hurdle Model

Variable label	Commercialized (N=681)		Non-commercialized (N=233)		Total (N=914)		Difference
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Proportion of commercialized households	1.0000	0.0000	0.0000	0.0000	0.7451	0.4361	1.0000
Proportion of value of crop produced sold	0.3690	0.2461	0.0000	0.0000	0.2749	0.2664	0.3690***
Demographic characteristics:							
Household head sex	0.8561	0.3513	0.7897	0.4084	0.8392	0.3676	0.0664**
Household head age	50.4787	13.2821	51.5236	14.9854	50.7451	13.7355	-1.0449
Household head education	7.9716	3.7410	6.8670	3.8757	7.6900	3.8043	1.1047***
Household size	4.9024	2.1937	5.5433	2.4678	5.0658	2.2825	-0.6409***
Dependency ratio	0.9108	0.7747	1.0166	0.9093	0.9377	0.8119	-0.1059*
Physical and financial assets:							
Tropical livestock units (TLU)	1.6877	1.9248	1.5260	1.6682	1.6465	1.8632	0.1617
Per capita owned farm size	0.2527	0.2248	0.1844	0.2238	0.2353	0.2264	0.0683***
Per capita owned farm size squared	0.1143	0.2399	0.0839	0.3760	0.1066	0.2810	0.0305
Soil fertility score	2.1456	0.5540	1.9644	0.7464	2.0994	0.6135	0.1812***
Total annual non-farm income (1000 KSh)	97.0434	212.4168	99.6298	227.8099	97.7027	216.3209	-2.5864
Had contacts with extension staff	0.4963	0.5004	0.4936	0.5010	0.4956	0.5003	0.0028
Household got agricultural credit	0.1689	0.3749	0.0515	0.2215	0.1389	0.3461	0.1174***
Social capital:							
Membership to APNs	0.5653	0.4961	0.3562	0.4799	0.5120	0.5001	0.2091***
Number of dependable relatives in village	6.3612	10.6046	4.8798	10.6954	5.9836	10.6416	1.4814*
Trust in grain traders	0.7401	0.4389	0.7296	0.4451	0.7374	0.4403	0.0105
Transaction costs:							
Owns mobile phone	0.8869	0.3169	0.6824	0.4665	0.8348	0.3716	0.2045***
Transport cost to main market	48.1278	34.6282	54.7082	35.4104	49.8053	34.9279	6.5804**
Own local transport means	0.6711	0.4702	0.6052	0.4899	0.6543	0.4759	0.0659*
Regional dummy	0.5844	0.4932	0.2318	0.4229	0.4945	0.5002	0.3527***

Significance: *** at 1%; ** at 5%; * at 10%

Source: Author's computations

In developing countries like Kenya with pervasive factor and product market failures, social capital is very important in facilitating market access as shown by Shiferaw *et al.*, (2011). About 51% households belonged to some agricultural production networks/groups (APNs). These APNs included crop production and marketing groups, seed production groups, input access/marketing groups and farmer research groups. A significantly higher proportion of commercialized households belonged to these groups than non-commercialized households (Table 3). Therefore, there could be a positive correlation between APN membership and agricultural commercialization among smallholder farms.

Theoretically and empirically, transaction costs (fixed and proportional) influence the ability of the household to commercialize. Results from the descriptive statistics showed statistically significant differences in all transaction costs related variables between commercialized and non-commercialized households (Table 3). Ownership of variables that reduce transaction costs e.g. mobile phone was significantly higher among commercialized households compared to non-commercialized ones. However, remoteness of the household as proxied by transport costs (increases transaction costs) was higher among non-commercialized households compared to commercialized (Table 3). Therefore, transaction costs could be very important in determining agricultural commercialization as demonstrated by Gotz (1992) and Key *et al.* (2000).

4.3.2 Econometric results

Following Lin and Schmidt (1984), it is important first to test whether the DHM is preferred over the tobit specification using the log likelihood ratio (LR) statistic. In this study, the LR test statistic was -196.077 and it was significant at 1% (Table 5). Therefore, this test statistic showed that the DHM was strongly preferred to tobit model. Also, the correlation coefficient between ε_{1i} in Eqn. 4.2 (selection model) and ε_{2i} in Eqn. 4.4 (commercialization intensity model) as measured by the sigma constant shown in Table 5 is relatively high (0.2460) and statistically significant at 1%. This later statistic is a clear indication of strong dependence between the two tiers i.e. Eqn. 4.2 and Eqn. 4.4, thus reinforcing the superiority of DHM approach over the tobit model (Wu *et al.*, 2014). On the other hand, a joint test on the variables used to construct the Mundlak-Chamberlain device (time averaged variables) returned a chi-square test statistic, that is, $\chi^2_{(22)}$ of 49.30 that was statistically significant at 1% thus strongly rejecting the null hypothesis that these time averaged variables were jointly equal to zero (Wooldridge 2010). The implication of this test for the Mundlak-Chamberlain device variables shows that the unobserved

heterogeneity is significantly correlated with the observed explanatory variables in the model (Burke and Jayne, 2014). Therefore, one could have quickly opted for the FE instead of the RE though FE approach could have meant that time invariant explanatory variables are excluded in the model. However, CRE model is a hybrid framework that preserves the advantages of FE approach while allowing the inclusion of time invariant variables.

To check further the fitness of the DHM, probabilities of observing a household commercializing, as well as conditional and unconditional expected intensity of commercialization (value of the crops sold as a proportion of the value of all crops produced on the farm) were computed and results presented in Table 4. The overall probability of a household commercializing among the sampled households was estimated to be about 75%. This probability of commercialization compares very well with the results derived from descriptive statistics presented in Table 4 and thus showing that the econometric model does indeed predict commercialization rather precisely (Smed and Anderson, 2012). On the other hand, the unconditional commercialization intensity was about 28% while the conditional commercialization intensity was 34% (Table 4). The conditional commercialization intensity shows the proportion of the value of all crops produced on the farm that is sold by commercialized households. The unconditional commercialization intensity on the other hand represents the proportion of the value of all crops produced that was sold across all sampled households regardless of household commercialization status.

Table 4. Probability of commercialization decision and commercialization intensity (N=914)

Variable	Mean	Std. Dev.
Probability of commercializing	0.7455	0.2200
Probability of not commercializing	0.2545	0.2200
Conditional commercialization intensity	0.3427	0.1408
Unconditional commercialization intensity	0.2755	0.1671

Source: Author's computations

Since the dependent variable in the first hurdle of the DHM was binary, the coefficients of the explanatory variables just indicated the direction of the relationship and not their marginal effects/contribution on the dependent variable. Therefore, further post-estimation analyses were carried out to compute the average partial effects (APE) of the explanatory variables. These APE were computed at three levels i.e. on the probability of agricultural commercialization (selection model), on the expected value of commercialization intensity conditional on the household

having commercialized, and on unconditional expected value of commercialization intensity (overall average commercialization intensity in the sample regardless of household commercialization status). However, as cautioned by Burke (2009), the standard deviation of the predicted partial effects should not be used as standard errors (SE) for drawing inference on the APE. For that matter, standard errors used to draw inferences on the APE were computed using the delta method[4] (Burke, 2009; Wu *et al.,* 2014). The computed average partial effects (APE) are presented in Table 6. The first column of Table 6 (Tier 1) presents the APE on the probability of a household commercializing while the second column (Tier 2a) presents the conditional expected values of commercialization intensity. On the other hand, the third column (Tier 2b) presents the APE on the unconditional expected values of commercialization intensity.

The econometric results of the DHM generated from the CRE framework are presented in Table 5. Following Burke and Jayne (2014) and Schunck (2013), the *Mundlak-Chamberlain* device variables (level 2 variables) and other time invariant variables in the model are interpreted as "between-household" effects. On the other hand, the level 1 variables in the model (the equivalent of *Mundlak-Chamberlain* device variables that are not panel averaged) represent the "within-household" effects. The "between-household" analysis highlights the effect of differences in endowment between households while "within-household" analysis captures the effect of endowments within a given household over time.

The "within-household" effect results show that while age of the household head had no effect on the household binary decision to commercialize, it had a positive and significant effect on household's intensity of agricultural commercialization (Table 5). This means that as the household head grows older, the household tends to sell more and more of its crop produce. The average partial effects results presented in Table 6 showed that one year increase in age of the household head is likely to increase commercialization intensity by about 1% both on conditional and unconditional on the household having decided to commercialize. The finding could be related to the possibility that as the household head grows older, opportunities to derive cash income from other off-farm and non-farm sources dwindles and therefore selling of crop produce becomes the only alternative. This finding could hold especially in smallholder rural agrarian economies like the ones from which this data was derived – where non-farm and off-farm income sources are very few and probably highly competitive.

[4] For details on APE and standard error computation after *craggit* command, see Burke (2009).

On the other hand, the "between-household" results (*Mundlak-Charmerlain* device) showed that age of the household head was neutral on the decision to commercialize agricultural activities on the farm but had a negative and significant effect on the commercialization intensity contrary to the "within-household" effect. This means that holding all else constant, a household that is younger is likely to be more intensively commercialized compared to a similar household that is older. Average partial effect results showed that a one year younger household head was likely to be 1% more intensively commercialized conditional and unconditional to agricultural commercialization decision (Table 6). The negative relationship could be explained by the fact that as farmers grow old, there is increased risk aversion and decreased long term investment in the farm. Young farmers are therefore less risk averse and are more willing to try new highly productive agricultural technologies like improved seed and fertilizer which makes them produce surpluses for the markets. A younger farmer, compared to an older farmer is also likely to venture into high return but equally high risk cash crops to earn extra money.

The analysis of the effect of household head education level on agricultural commercialization was evaluated only from a "between-household" effect point of view because it was assumed that there could be no significant change in this variable within the two year panel period. Education of the household head was found to have a positive and significant "between-household" effect on household decision to commercialize agricultural activities (Table 5). A household whose household head had one more year of formal education was about 1% more likely to commercialize its crop production activities compared to a similar household with one year less of formal education (Table 6). This positive and significant relationship could be associated with what Gebremedhin and Jaleta (2010) and Mottaleb *et al.*, (2015) called better skills and better access to information that enables these household heads to process information accurately. This accurate information processing is likely to make households participate in crop output market in a more profitable way than otherwise.

The "within-household" analysis of determinants of agricultural commercialization also showed that household size in terms of adult equivalents was positively related to the decision and intensity of agricultural commercialization. However, this positive effect was only statistically significant on the commercialization intensity (Table 5). A one unit increase in household size was likely to increase commercialization intensity by 2% each on conditional and unconditional of agricultural commercialization decision (Table 6). This finding could be attributed to the

possibility that as the household size increases in a given household, holding other factors constant, there will be increased demand for cash to buy foods that are not produced on own farm and other non-food items like clothing, education, health care etc. Given that these are farming households, pressure will be on the household to sell more or diversify more into cash crops in order to raise the much needed cash income.

However, the "between-household" effect results showed a negative and significant effect of household size on agricultural commercialization intensity (Table 5). A household with one more adult equivalent was likely to be less intensively commercialized by about 3% compared to a similar household with one less adult equivalent (Table 6). This finding could be informed by the fact that a bigger household is likely to sell less because most of its agricultural production could be targeted at producing food for home consumption. This livelihood strategy is understandable because the surveyed households are agrarian with limited off-farm opportunities to provide alternatives.

Physical and financial assets variables were also included in the model. The inclusion of these variables was driven by the theory of asset traps advanced by Carter and Barrett (2006) who argue that lack of assets may preclude many smallholder farmers from being able to produce a surplus necessary for participating in output markets as sellers. All the physical and financial asset variables included in the model were found to significantly affect agricultural commercialization decision and intensity either from the "within-household" and/or "between-household" analysis (Table 5). The "within-household" analysis showed a positive and significant relationship between the amount of livestock owned (measured by tropical livestock units i.e. TLU) and the probability of household commercialization (Table 5). Increasing the number of livestock units owned by a household by about 100%, is likely to increase the probability of commercialization by about 0.4% (Table 6). This positive relationship could be associated with the possibility of households selling off some of their livestock to buy food or buy crop productivity enhancing inputs like improved seed and/or fertilizer that enable them to produce surpluses for sell in the markets.

Further, "within-household" analysis of physical and financial asset endowments showed that per capita total own farm size was positively and significantly related to commercialization decision and intensity (Table 5). This meant that households whose per capita owned farm sizes

increased over time were likely to be commercialized and also more intensively commercialized compared to those whose per capita own farm sizes reduced. An increase in per capita farm size by 1 ha was likely to increase the probability of a household commercializing by about 93% and increase the conditional commercialization intensity by about 60% and unconditional commercialization intensity by about 61% (Table 6). The implication of this finding is that households with a bigger farm size are likely to diversify their production into cash crops like sugar cane in Bungoma district or tea and coffee in the eastern Kenya districts of Embu, Meru South and Imenti South. Also, households with bigger farm sizes have a higher probability of producing more food crops beyond their subsistence consumption levels thus selling the surpluses. In fact, according to IFPRI work by Chapoto *et al.,* (2013) and Jayne and Muyanga (2012), most of the agricultural production increases in Africa has been as a result of area expansion and not productivity growth. Empirical work in south Asia by Sharma *et al.,* (2012) also found out that one of the major constraints faced by smallholder farmers in responding to market driven commercialization opportunities in the region included small and fragmentation of land holdings.

To assess if there was an indefinite linear relationship between farm size and commercialization, extended investigation of the "within-household" effect of farm size on agricultural commercialization was conducted using the squared per capita own farm size variable. This latter investigation showed that there was a non-linear relationship between farm size and household commercialization (Table 5). The finding showed that while there was a positive relationship between farm size and commercialization probability and intensity within the household, there is a point beyond which an increase in farm size will result into a reduction in commercialization probability and intensity – probably a point of diminishing marginal returns to farm size. Households with larger farm sizes beyond the threshold level were probably likely to be inefficient in their production systems and even probably lease or rent out their land to those that are more efficient and commercially oriented.

Table 5. Double Hurdle Regression Results

Variable label	Tier 1: Commercialization decision		Tier 2: Commercialization intensity	
	Coef.	Std. Err.	Coef.	Std. Err.
Demographic characteristics:				
Household head sex	-0.0903	0.1530	0.0470	0.0376
Household head age	0.0089	0.0145	0.0073**	0.0034
Household head education	0.0342**	0.0157	0.0022	0.0040
Household size	0.0265	0.0510	0.0292*	0.0180
Dependence ratio	-0.0539	0.1131	-0.0440	0.0274
Physical and financial assets:				
Owned livestock size	0.0147**	0.0071	-0.0001	0.0017
Per capita owned land	3.8204***	1.3622	0.8998**	0.3621
Per capita owned land squared	-1.7225**	0.6916	-0.4707*	0.2453
Soil fertility score	-0.1511	0.1184	-0.0258	0.0310
Annual non-farm income	-0.0093*	0.0050	-0.0002	0.0009
Got agricultural input credit	0.0569	0.2585	0.0782*	0.0422
Contacts with extension	0.2137	0.1450	-0.0515	0.0329
Social capital:				
Membership to APNs	0.5515***	0.1109	0.2726***	0.0274
Dependable relatives in village	0.0010	0.0054	0.0024***	0.0008
Trust grain traders	0.1804	0.1147	0.0215	0.0272
Transaction costs:				
Own mobile phone	0.8913***	0.2031	-0.0360	0.0703
Transport costs to nearest main market	-0.0156*	0.0085	-0.0006	0.0016
Own transport means	0.1327	0.1166	0.0653**	0.0277
Regional dummy	0.9400***	0.1305	0.1338***	0.0299
Mundlak-Chamberlain device:				
Household head age	-0.0116	0.0153	-0.0100***	0.0034
Household size	-0.0342	0.0609	-0.0424**	0.0195
Dependence ratio	0.1346	0.1396	0.0357	0.0326
Owned livestock size	-0.0063	0.0106	0.0019	0.0024
Per capita owned land	-1.6208	1.4541	-0.6515*	0.3794
Per capita owned land squared	0.3784	0.7751	0.2720	0.2564
Soil fertility score	0.4152**	0.1668	0.0729*	0.0394
Annual non-farm income	0.0078	0.0062	-0.0007	0.0012
Got agricultural input credit	0.7084**	0.3305	0.0947	0.0622
Contacts with extension	-0.1432	0.2114	0.0757*	0.0466
Own mobile phone	-0.2894	0.2799	0.0018	0.0729
Constant	-1.7167	0.4307	-0.0117	0.1146
sigma_cons			0.2460***	0.0107

Significance level: *** at 1%; ** at 5%; * at 10%

Model description:

Number of obs = 916 Wald chi2(30)=194.690 Prob > chi2=0.000 Log pseudolikelihood= -196.077

Source: Author's computations

However, it is worthy to note that the "between-household" analysis showed a negative and significant effect of per capita farm size on agricultural commercialization intensity (Table 5). A household with a bigger farm size was found to be less intensively commercialized compared to the counterpart that had smaller farm size. A difference of 1 ha in per capita farm size between households that resembles in all aspects was likely to lead to about 43% and 68% conditional and unconditional reduction in commercialization intensity, respectively, for the one that has a higher per capita farm size (Table 6). This finding is very insightful though inconclusive as this could need further investigations beyond the scope of the current study to ascertain the minimum and the maximum farm size that could be needed for beneficial smallholder commercialization. However, this finding could also be pointing to the fact that households with smaller farms are likely to be venturing into high value crops like horticulture which they sell to buy other foods and non-food items.

Land productivity is also very critical in driving agricultural commercialization. Soil fertility has been cited in literature as one of the main contributors to low agricultural productivity in these developing countries (Tittonell *et al.,* 2008). The use of modern soil fertility enhancing inputs in most cases is limited and this could explain partly why the green revolution witnessed mainly in Asia was not realized in SSA (Christiaensen and Demery, 2007). In this study, the effect of soil fertility on household probability and intensity of agricultural commercialization was evaluated using the average weighted soil fertility score of all plots operated by the household. The econometric results showed that there was no significant "within-household" effect of average weighted soil fertility score on agricultural commercialization (Table 5). However, there was a positive and significant "between-household" effect of soil fertility score on agricultural commercialization (Table 5). A household with a unit more in weighted soil fertility score was found to be 10% more likely to be commercialized than a similar household that had one unit lower in soil fertility score (Table 6). Similarly, a household with one unit more in weighted soil fertility score was likely to be 5% and 13% more intensively commercialized conditional and unconditional to having commercialized, respectively, than one that has one unit less of weighted soil fertility score (Table 6). This means that households with relatively higher proportions of their operated plots that were more fertile were likely to engage either in commercial crops like sugarcane, tea and coffee or they were likely to produce some surpluses above their subsistence needs and thus sell some in the markets for cash income.

Another physical and financial asset variable that significantly affected household commercialization was total annual household income from non-farm activities. This variable had a negative and significant "within-household" effect on commercialization decision (Table 5). An increase in total annual household income from non-farm activities by one thousand units (KSh. 1000) was found to reduce the probability of household commercialization by about 2% (Table 6). The implication of this finding is that as non-farm income increases over time, a household is likely to be less commercialized compared to a similar household whose non-farm income reduces over time. This is because increased non-farm income reduces the household's incentive to commercialize its agricultural activities probably due to the fact that it has alternative sources of cash income. The contrary is true for a household with less non-farm income who has to sell part of its production to raise cash income needed for other household purchases and payments. Similar empirical findings have been documented by Kan *et al.,* (2006) in their study of farm output, non-farm income and commercialization in rural Georgia. However, there was no significant "between-household" effect of annual non-farm income on agricultural commercialization (Table 5).

Credit access has been considered as a factor of productivity improvement in literature (Jaleta *et al.,* 2009, Keita, 2012). It is argued that increased productivity will translate into increased probability of selling some of the surplus production by the farmers. In this study, access to credit to buy agricultural inputs (seed, fertilizer, herbicides/pesticides) was found to affect positively and significantly the "within-household" commercialization intensity (Table 5). As a household accesses credit, its commercialization intensity is likely to increase by about 5% both conditional and unconditional to commercialization decision (Table 6). On the other hand, the "between-household" analysis showed that access to credit had a positive and significant effect on household decision to commercialize. A household that accessed credit had about 17% more chances of commercializing compared to a similar household that had not accessed agricultural input credit (Table 6). These "within-household" and "between-household" findings could have been informed by the fact that those who accessed agricultural credit are households with less off-farm income and therefore had to sell some of their crop production however small it could have been, to raise the needed cash income. Similar findings of the effect of credit on household agricultural commercialization have been documented in empirical work of Keita (2012) in Mali.

This means that access to credit for agricultural inputs translates into increased production that will eventually generate surplus for the market.

The econometric analysis went further and assessed the impact of extension contacts on household commercialization process. While the results showed no significant effect of this variable on "within-household" analysis, the "between-household" analysis showed that a household that had contacts with extension staff was likely to be more intensively commercialized than a similar household that had no contacts with extension staff (Table 5). With extension staff contacts, a household was likely to be 5% and 6% more intensively commercialized conditional and unconditional on having commercialized, respectively, than a similar household without extension contacts (Table 6). This finding could be attributed to the possibility that households that have contacts with extension are likely to adopt improved agricultural technologies that enable them to produce above their subsistence needs. Also, extension staff could be a source of better market information that enables households to commercialize more intensively.

Transaction costs are also important in determining the success of market transactions whether in formal or informal markets. When transaction costs are so high, markets may fail completely thereby denying potential buyers and sellers in that market the benefits arising from trade. One way to reduce these transaction costs especially in developing countries like Kenya where there are pervasive market failures is use of social capital. In this study, the impact of social capital on household commercialization was analyzed using household membership to agricultural production networks/groups (APNs), number of dependable relatives to the household that lived in the same village and household's trust in grain traders. These social capital variables were assumed to change very slowly over time and were considered time invariant especially in a short time panel of two years in this study. Therefore, interpretations of their results are based on "between-household" effects only.

Table 6. Average partial Effects (APE) of DHM explanatory variables

Variable label	Tier 1: Market participation decision (N=914)		Tier 2a: Conditional commercialization intensity (N=681)		Tier 2b: Unconditional commercialization intensity (N=914)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Demographic characteristics:						
Household head sex	-0.0220	0.0113	0.0314	0.0094	0.0035	0.0234
Household head age	0.0022	0.0011	0.0049**	0.0015	0.0056***	0.0010
Household head education	0.0083***	0.0043	0.0014	0.0004	0.0086***	0.0040
Household size	0.0065	0.0033	0.0195**	0.0059	0.0204**	0.0049
Dependence ratio	-0.0131	0.0067	-0.0294*	0.0088	-0.0338**	0.0063
Physical and financial assets:						
Owned livestock size	0.0036**	0.0018	0.0000	0.0000	0.0032***	0.0019
Per capita owned land	0.9304***	0.4786	0.6006***	0.1808	1.2890***	0.3076
Per capita owned land squared	-0.4195***	0.2158	-0.3142***	0.0946	-0.6135***	0.1281
Soil fertility score	-0.0368*	0.0189	-0.0172	0.0052	-0.0461**	0.0140
Annual non-farm income	-0.0023***	0.0012	-0.0002	0.0000	-0.0022***	0.0012
Got agricultural input credit	0.0139	0.0071	0.0522*	0.0157	0.0515*	0.0145
Contacts with extension	0.0520***	0.0268	-0.0344*	0.0103	0.0214	0.0403
Social capital:						
Membership to APNs	0.1343***	0.0691	0.1819***	0.0548	0.2571***	0.0346
Dependable relatives in village	0.0002	0.0001	0.0016**	0.0005	0.0014**	0.0005
Trust grain traders	0.0439***	0.0226	0.0143	0.0043	0.0504***	0.0186
Transaction costs:						
Own mobile phone	0.2170***	0.1116	-0.0240	0.0072	0.1783***	0.1243
Transport to nearest main market	-0.0038***	0.0020	-0.0004	0.0001	-0.0037***	0.0019
Own transport means	0.0323*	0.0166	0.0436**	0.0131	0.0617***	0.0083
Regional dummy	0.2289***	0.1178	0.0893***	0.0269	0.2736***	0.0925
Mundlak-Chamberlain device:						
Household head age	-0.0028	0.0014	-0.0067***	0.0020	-0.0075***	0.0015
Household size	-0.0083	0.0043	-0.0283**	0.0085	-0.0286**	0.0075
Dependence ratio	0.0328	0.0169	0.0238	0.0072	0.0474**	0.0102
Owned livestock size	-0.0015	0.0008	0.0013	0.0004	-0.0005	0.0013
Per capita owned land	-0.3947*	0.2030	-0.4348**	0.1309	-0.6811***	0.0996
Per capita owned land squared	0.0922	0.0474	0.1816*	0.0547	0.2187**	0.0364
Soil fertility score	0.1011***	0.0520	0.0487**	0.0147	0.1277***	0.0381
Annual non-farm income	0.0019**	0.0010	-0.0005	0.0001	0.0014*	0.0012
Got agricultural input credit	0.1725***	0.0887	0.0632	0.0190	0.2031***	0.0710
Contacts with extension	-0.0349	0.0179	0.0505*	0.0152	0.0062	0.0374
Own mobile phone	-0.0705*	0.0363	0.0012	0.0004	-0.0628	0.0380

Significance level: *** at 1%; ** at 5%; * at 10%

Source: Author's computations

The econometric results also showed that membership to APNs had a positive and significant "between-household" effect on both the probability and intensity of household commercialization (Table 5). Households that were members to these APNs had 13% more chances of commercializing compared to similar households that were not members (Table 6). Similarly conditional and unconditional commercialization intensity was found to increase by about 18% and 26%, respectively, among households that were members to these APNs (Table 6). Hence this finding is in line with those of Shiferaw *et al.,* (2008) who have also shown a positive relationship between membership to APNs and household participation in dry land grain markets in Kenya. Also, Akinlade *et. al.,* (2013) found the same influence of membership to farmer organizations on commercialization of urban farming in Nigeria. However, these two previous empirical studies were based on cross-sectional data and partial HCI.

While there was no significant "between-household" effect of the number of dependable relatives living in the same village with the household on the decision to commercialize, there was a positive and significant "between-household" effect on household's commercialization intensity (Table 5). A household with an additional dependable relative living in the same village was likely to be 0.2% and 0.1% more intensively commercialized conditional and unconditional to having commercialized, respectively, compared to a similar household that had one less dependable relative living in the same village (Table 6). This could imply that more dependable relatives may act as insurance against risk and probably as a source of credit for agricultural inputs. More dependable relatives could also provide additional farm labour that enables the household to produce surplus for the market.

Ownership of transaction costs reducing assets is likely to impact on both the decision to commercialize and commercialization intensity. In this study, the "within-household" effect of ownership of mobile phone, one of the transaction costs reducing asset, was found to affect commercialization decision positively and significantly (Table 5). Owning a mobile phone increased household commercialization probability by about 22% (Table 6). There was no significant "between-household" effect of mobile phone ownership on agricultural commercialization. The positive and significant "within-household" effect could be attributed to the fact that a mobile phone is used to gather market information. Gathering market information is a fixed cost and therefore has a direct effect on the decision to commercialize and not the

intensity of commercialization that is likely to be influenced by proportional (variable) transaction costs. Similar findings of fixed transactions costs have empirically been demonstrated by Goetz (1992) and Key *et al.,* (2000) in Senegal and Mexico, respectively, when they found out that fixed costs only affected the binary decision and not the continuous decision.

This study also assessed the "between-household" impact of market access (remoteness) in terms of transport costs to the main market on agricultural commercialization of the household. Majority of the past studies used distance to market as a proxy variable for this kind of analysis (Key *et al.,* 2000, Komarek 2010, Mather *et al.,* 2011, Keita 2014, Akinlade *et al.,* 2013). These past studies consistently found a negative effect of distance on the probability and intensity of market participation (commercialization). However, distance could hide many factors affecting market access (remoteness) especially land topography and quality of the road to those markets and many more – a limitation well acknowledged by Mather *et al.,* (2011). As such, in this study, average transport cost using the most common means of transport to the main market was used to measure market access or remoteness. This average cost of transport to the main market was found to have a negative and significant "between-household" effect on the binary decision to commercialize agricultural production (Table 5). A household that incurred higher transport costs to the main market was less likely to commercialize its agricultural activities compared to a similar household that incurred less transport costs to the main market. An increase in the transport cost to the main market by one hundred units (Ksh. 100) reduced the probability of the household commercializing by about 32% (Table 6). However, while this cost of transport to the main market was theoretically expected to significantly affect commercialization intensity negatively given that it was a proxy variable for proportional (variable) transaction costs, it did not significantly affect the intensity of agricultural commercialization – probably because most of the farm produce sold by smallholders is usually bought by traders at farm gate thus farmers, in most cases, do not incur proportional transaction costs but instead this cost is borne by traders (Shiferaw *et al.,* 2008).

Another transaction costs variable considered in this analysis was ownership of commonly used local transport means. The "between-household" results indicated that a household that owned any of these assets was likely to be more intensively commercialized than a similar household without these transport means (Table 5). A household owning any of these transportation means

was about 4% and 6% more intensively commercialized conditional and unconditional to commercialization decision, respectively, than its counterpart without any of these transportation means. This finding could be attributed to the fact that households with these means of transport could be using them to transport their crop produce to the market thus reducing per unit transportation costs (variable or proportional costs).

Lastly, the "between-household" econometric analysis also showed that households in eastern Kenya districts of Embu, Meru South and Imenti South were more likely to be commercialized than their western Kenya counterparts in Bungoma and Siaya districts (Table 5). Eastern Kenya households were also more intensively commercialized than the western Kenya ones. A household in eastern Kenya was about 23% more likely to be commercialized compared to a household in western Kenya (Table 6). On the other hand, households in eastern Kenya had about 9% higher conditional commercialization intensity than their western Kenya counterparts and similarly, eastern Kenya households had about 27% higher unconditional commercialization intensity than those from western Kenya. These differences in commercialization across the surveyed regions could be associated with the presence of cash crops and agro-industries in these areas. Whereas major cash crops like tea and/or coffee are commonly grown by smallholder farmers in all the three surveyed eastern Kenya districts, only Bungoma district in western Kenya has a main cash crop, sugar cane. Siaya district in western Kenya has no major cash crop and no agro-industry since the cotton sector collapsed in the country. This finding points to the fact that agro-industrialization and cash cropping could be one of the key approaches that could transform smallholder farmers from subsistence to commercial orientation.

4.4 Summary and conclusions

Smallholder agricultural transformation through commercialization process has been promoted as a key avenue to address widespread rural food insecurity and poverty in most developing countries like Kenya. However, to date, a non-trivial proportion of smallholder farmers still practice pure subsistence production. Reasons for this limited market participation are not yet clear. Past studies that investigated this limited commercialization among smallholder producers were mainly based on partial household commercialization index that focused on one main crop or just a few selected crops thereby not giving a full picture of agricultural sector commercialization. However, a comprehensive index based on all crop enterprises is more

informative especially for policy intervention intended to stimulate and/or enhance agricultural commercialization among smallholders.

This study builds on past literature in this area of agricultural commercialization by investigating the determinants of agricultural commercialization in Kenya using panel data and a more comprehensive commercialization index that was based on all crop enterprises on the farm. By fitting a double hurdle model proposed by Craig (1971) in a correlated random effects framework, factors that condition smallholder agricultural commercialization decision and commercialization intensity are identified. Policy variables that were identified as significant in determining agricultural commercialization included physical and financial assets, social capital and transaction cost variables. The key physical and financial asset policy variables that were significant in explaining commercialization included farm size, soil fertility, credit access and contacts with extension. Households with bigger farm sizes, more fertile soils, accessed agricultural input credit and were in contact with extension staff were likely to be commercialized compared to those that did not. In terms of social capital, households that belonged to agricultural production networks (groups) were not only likely to commercialize but were also more intensively commercialized compared to those who were not members. Lastly, the key transaction cost variables were mobile phone ownership and transport costs to the nearest main market. Smallholder farmers who owned mobile phones were likely to be commercialized while those households that were in more remote areas (had higher transport costs to the nearest main market) were unlikely to be commercialized.

4.5 Policy implications

To stimulate and enhance agricultural commercialization among smallholder farmers in Kenya, policy interventions are needed to ensure that rural farming households have reasonably more agricultural land. These policies could include legal framework to control the continuous sub-division of agricultural land into smaller units that are uneconomical. This legislative framework has been proposed in the *Minimum and Maximum Land Holding Acreage Bill of 2015* that is before the National Assembly. However, it is important to note that such policy options may be controversial both politically and economically. Politically, it might be unpopular as it goes against the cultural norms of most ethnic communities in the country where land is passed over to the next generation through mandatory sub-division. Economically, such policy interventions

without alternative sources of livelihoods for the majority of the rural poor who depend on their small pieces of land to earn income might render them destitute. Non-legislation interventions could include putting up infrastructure in non-utilized arable lands so that populations can move from the currently densely populated areas to these new agricultural frontiers. This is not farfetched given the fact that Jayne and Muyanga (2012) have shown that about 40% of Kenya's rural population resides on just 5% of its arable land.

Secondly, since the empirical evidence adduced in this study has shown that soil fertility is critical in enabling households to commercialize their farm enterprises, policy interventions that could help farmers improve the soil fertility of their plots are needed. Such policies could include but not limited to government intervention to create an enabling environment that will make fertilizer more accessible to smallholder farmers. The government could also conduct a national soil survey to establish specific soil nutrient needs in different agro-ecological zones of the country. This could inform recommendations for appropriate fertilizers to farmers located in different parts of the country. Also, equally important in addressing soil fertility problem could be promotion of adoption of soil and land management practices that enhances soil fertility e.g. conservation agriculture and sustainable agricultural intensification practices like cereal-legume rotations.

On credit access, public policies that can improve smallholder farmers' access to business development services such as rural micro-finance are encouraged. These business development institutions that targets agricultural inputs e.g. the warehousing credit system could ease credit constraint and make a significant contribution to smallholder commercialization. Public warehousing credit system in eastern Africa has developed slowly especially in the grain sector due to poor policy environment and the political sensitivity of most grains that act as main staples (UNCTAD, 2009). However, East African Grain Council (EAGC) has managed to establish a few certified credit warehouses in Kenya and this need to be scaled out.

CHAPTER FIVE: IMPACT OF AGRICULTURAL COMMERCIALIZATION ON FOOD SECURITY AMONG SMALLHOLDER FARMERS IN KENYA

5.1 Introduction

Global economic and demographic changes in terms of rising incomes and increasing urbanization, respectively, have provided smallholder farmers in developing countries with immense opportunity to commercialize their agricultural activities. This opportunity has further been fueled by recent trends in increasing demand for non-staple western dietary habits of the growing urban population, rising household incomes, foreign investment in food markets, emergence of supermarkets and vertical integration of agricultural production and retail activities (Sharma *et al.,* 2012). In light of these changes, many sub-Saharan Africa (SSA) countries like Kenya have identified agricultural commercialization as one of the crucial pillars of their economic growth and development agenda (Republic of Kenya, 2004; Republic of Kenya, 2007; Republic of Kenya, 2010). This commercialization process is intended to reduce substantially the rampant food insecurity and poverty among rural smallholder farmers who mainly depend on agriculture to earn their livelihood. Food security is of particular importance to rural households because existing empirical evidence shows that about 47% and 50% of the national and rural populations in Kenya, respectively, are food insecure compared to 40% of the urban population (World Bank, 2009). These disappointing statistics have been attributed to rapid population growth and declining agricultural productivity. To address the declining agricultural productivity problem, agricultural commercialization has been promoted for many years in the country. However, to date, empirical evidence to show that agricultural commercialization process can indeed reduce or eradicate rural food insecurity is minimal. This lack of evidence exists despite earlier government position that agricultural commercialization could undermine national food security (Republic of Kenya, 1981).

The theoretical premise for smallholder commercialization has been that markets provide increased incomes to participating households who in turn are able to enhance their overall consumption than it could have been under subsistence orientation (Pingali, 1997; Timmer 1997). On the other hand, arguments against smallholder agricultural commercialization content that commercialization compromises food security as farmers will divert most of their production resources toward pure cash cropping at the expense of food crops (Strasberg *et al.,* 1999). This

latter argument by antagonists of agricultural commercialization has been refuted by protagonists who argue that the perception that agricultural commercialization in developing countries undermines food security is "overly simplistic" and based on "if statements" like – if food crops are replaced with non-food cash crops, and if markets are not working well (von Braun, 1995). These two competing schools of thought on smallholder agricultural commercialization ignited a number of empirical studies in developing countries (von Braun 1995; Govereh *et al.,* 1999; Strasberg *et al.,* 1999; Govereh and Jayne, 2003; Rios *et al.,* 2009).

While past empirical works on this subject were informative and cannot be wished away, they were either based on a single crop or just a few selected crops. This kind of analysis is bound to give partial and inconclusive information on the impact of agricultural commercialization compared to a study that is based on a comprehensive commercialization index constructed from all crop enterprises on the farm. Also, most of the past empirical studies that documented the impact of agricultural commercialization on household welfare were based on cross sectional data that is limited in generating information on intra and inter household differences as it could have been with panel data. Another important weakness observed in past empirical studies was that they were based on pooled regression models to analyze the impact of agricultural commercialization on household welfare. Pooled regression models assumes that sampled households are similar in all aspects except that some are treated (commercialized) and others not (non-commercialized) with the difference in the outcome variable (welfare indicator like food security) being solely attributed to the treatment effect. This latter assumption might not be right if the treated and untreated households have systematic differences that could be correlated with the outcome variable.

Similarly, just like there has been no unanimous agreement on the impact of agricultural commercialization on household food security outcome, there has been no unanimous agreement on the definition of agricultural commercialization. Some authors have argued that agricultural commercialization is not just about cash crops because even food crops are sometimes sold and the vice versa (von Braun *et al.,* 1994). Agricultural commercialization is also not limited to the product market only but can also occur on the factor market (von Braun *et al.,* 1994). Other theorists of agricultural commercialization have defined this concept as when households purposively target markets in their production decisions (Pingali and Rosegrant (1995); Pingali

1997). On the other hand, Gebremedhin and Jaleta (2010) defined agricultural commercialization as a combination of both market orientation (agricultural production decision based on market signals) and market participation (produce offered for sale and use of purchased inputs). This current study follows the definition by Gebremedhin and Jaleta, (2010), that is, produce offered for sale and use of purchased inputs in the production process though the later component of this definition (use of purchased inputs) is beyond the scope of this study due to data limitations. Based on this adopted definition, a more comprehensive household commercialization index (HCI) that incorporates all crop enterprises on the farm is developed and used in this study.

On the other hand, there is also no consensus on the definition of food security. However, this study focuses on food security whose widely used working definition as provided by FAO (2003) states that "food security exists when people at all times have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life". To capture this subjective food security aspect of "preferred food" in the definition, a subjective assessment of household food security is needed.

Therefore, the objective of this study is to empirically analyze the impact of agricultural commercialization on household food security. Unlike past empirical studies that were based on one or just a few selected main crop enterprises on the farm, we use a more comprehensive household commercialization index based on all crop enterprises found on the farm. More innovative analytical frame is also adopted, that is, the study fits an endogenous switching regression model on panel data in a correlated random effects framework. This correlated random effects approach computes fixed effects estimators while at the same time allowing time invariant variables to be used as explanatory variables (Wooldridge, 2010). The rest of the chapter is organized as follows:- Section 5.2 presents the methods used in this chapter in order to effectively address the objectives of this study. The results of the analysis are presented in section 5.3 starting with descriptive statistics of the variables used in the regression analysis disaggregated by the food security regime of the household and then the econometric regression results. Section 5.3 delves into the treatment effects of agricultural commercialization on household food security probability while section 5.4 presents the summary and conclusions of the chapter. Lastly, section 5.5 gives the policy implications of this study's results.

5.2 Methods

Estimating the impact of agricultural commercialization on household food security outcome using non-experimental data is challenging because of lack of the counterfactual, that is, it is not possible to observe the food security outcome of a household that commercialized had it not commercialized and the vice versa. In experimental studies, this problem can be addressed by randomly enabling the treated households to be commercialized and the untreated group of households to be in the control status (non-commercialized). This random assigning of households to the treated and untreated groups ensure that the food security probability outcome observed among the commercialized (treated) and non-commercialized (untreated or control) households are statistically true representative of what would have been in cases of with and without commercialization. However, commercialization among the sampled households in this current study is not a randomly assigned treatment but rather households selected themselves into these two treatment regimes (commercialized and non-commercialized). This self-selection into treatment regimes means that there could be systematic differences between these two groups of households that make them fall in their respective treatment regimes.

Therefore, evaluating the impact of agricultural commercialization on household food security by estimating a single outcome equation with a dummy variable of commercialization as one of the explanatory variable in a pooled regression might yield biased estimates. This is because such an estimation approach assumes that commercialization decision is exogenously determined while in real sense it is potentially endogenous. Household agricultural commercialization decision is not random but instead based on individual household's observed and unobserved characteristics. As such, commercialized households may be systematically different from non-commercialized households. This means that it might be inappropriate to use a pooled regression with a common slope coefficient for both commercialized and non-commercialized households because this approach assumes that there is no interaction between commercialization decision dummy variable and other explanatory variables (covariates). Essentially, the pooled regression assumes that commercialization decision affects only the intercept of the food security model i.e. it is an intercept shifter irrespective of the values taken by other explanatory variables that determine food security among the surveyed households.

However, if explanatory variables have different effects on household food security outcome of commercialized and non-commercialized households, then separate food security outcome functions for each group of households need to be specified. This approach accounts for endogeneity because commercialization decision is potentially endogeneous to the household. Therefore, the use of an endogenous switching regression (ESR) model that accounts for both endogeneity and sample selection is more appealing. Also, ERS allows interactions between commercialization decision and other explanatory variables in the household food security outcome function. The ESR model captures such interactions by estimating two separate equations (one for commercialized and another for non-commercialized households) along with the selection equation.

Following the consumer theory and non-separable household utility maximization theoretical model discussed in section 3.2 of this thesis, the impact of agricultural commercialization on household food security can be modelled using the random utility formulation in a non-separable farm household model. This no-separable household model approach is based on the fact that household's production and consumption decisions are not made independently/separately. Therefore, the first-step of the two-step ESR involves modeling household's binary decision to commercialize (participate in crop output market as a seller) using the probit model that can structurally be represented as shown in Eqn. 5.1.

$$H_{it} = f(DC_{it}; PF_{it}; SC_{it}; TC_{it}) - - - - - - - - - - - - (5.1)$$

Where:

Subscript *i* and *t* indexes household and time, respectively

H = Binary indicator of commercialization i.e. 1 if commercialized and 0 if otherwise

DC = Demographic characteristics of the households

PF = Physical and financial endowments of the households

SC = Social capital proxies of the household

TC = Transaction costs variables of the household

The food security outcome functions conditional on commercialization decision are written in an endogenous switching regression regime model as follows:-

Regime 1: $Y_{Pit} = \beta_P X_{Pit} + \varepsilon_{Pit}$: If $H_{it} = 1 - (5.2a)$

Regime 2: $Y_{Nit} = \beta_N X_{Nit} + \varepsilon_{Nit}$: If $H_{it} = 0 - (5.2b)$

Where:

Y_{Pit} = Outcome indicator variables of agricultural commercialization (food security) for commercialized households

Y_{Nit} = Outcome indicator variables of agricultural commercialization (food security) for non–commercialized households

X_{Pit} = Observed vectors of covariates determining agricultural commercialization outcome i.e. food security probability for commercialized households

X_{Nit} = Observed vectors of covariates determining agricultural commercialization outcome i.e. food security probability for non–commercialized households

β_P and β_N = Vectors of parameters to be estimated

ε_{pit} and ε_{Nit} = Normally distributed error terms with zero mean and constant variance

For ESR model to be identified, it is important for the explanatory variables in the selection model (Eqn. 5.1) to contain a selection instrument in addition to those automatically generated by the non-linearity of the selection model of commercialization (Kassie *et al.,* 2014a; Shiferaw *et al.,* 2014). These instrument variables should affect directly endogenous selection variable (commercialization i.e. market participation) but not the outcome variables (food security). In this study, all the transaction costs outlined in Eqn. 5.1 were instrument candidates subject to verification to ascertain their suitability as valid instruments. The choice of transaction costs as instrument variables was informed by a combination of economic theory and findings of past empirical studies. Theoretically, it was hypothesized that transaction costs affect agricultural commercialization more directly and only affects household food security indirectly through agricultural commercialization. On the other hand, empirical studies for example in Senegal and Mexico by Goetz (1992) and Key *et al.,* (2000), respectively, have demonstrated that transaction costs affect agricultural commercialization significantly.

Therefore, Eqn. 5.2a and Eqn. 5.2b are used to estimate the average counterfactual food security probability distribution i.e. what could have been the food security probability outcome of the commercialized households had they not commercialized and the vice versa. Following the wage decomposition literature pioneered by Oaxaca (1973), this analytical framework is also used to decompose the food security probability gap between commercialized and non-commercialized

households. The observed food security gap is decomposed into the portion that is caused by differences in the amount of resources held by the two groups of households (quantity or level effect) and that component due to differences in the resource use efficiency (efficiency or return effect). The actual expected food security probability outcomes for commercialized and non-commercialized households are computed using Eqn. 5.3a and Eqn. 5.3b, respectively. On the other hand, the counterfactual expected food security outcome probability outcomes are estimated using Eqn. 5.4a and Eqn. 5.4b for commercialized and non-commercialized households, respectively.

Actual scenarios (observed from the sample data):

Commercialized: $E(Y_{Pit} \backslash H = 1; X) = \beta_P X_{Pit} + \gamma_{P\varepsilon}\lambda_{Pit} - - - - - - - - - - - - - - (5.3a)$

Non-commercialized: $E(Y_{Nit} \backslash H = 0; X) = \beta_N X_{Nit} + \gamma_{N\varepsilon}\lambda_{Nit} - - - - - - - - - - - (5.3b)$

Counterfactual scenarios:

Commercialized if they didn't commercialize: $E(Y_{Pit} \backslash H = 0; X) = \beta_P X_{Nit} + \gamma_{P\varepsilon}\lambda_{Nit} - - (5.4a)$

Non-commercialized if they commercialized: $E(Y_{Nit} \backslash H = 1; X) = \beta_N X_{Pit} + \gamma_{N\varepsilon}\lambda_{Pit} - - (5.4b)$

Applying these conditional expectations and using agricultural commercialization as the treatment variable, decomposition of the observed food security gap between commercialized and non-commercialized households (Eqn. 5.3a less Eqn. 5.3b) is computed as shown in Table 7. The difference in food security probability outcome of commercialized households emanating from their differences in efficiency of use of their currently held resources compared to the efficiency of non-commercialized households is obtained by subtracting Eqn. 5.4a from Eqn. 5.3a. Similarly, the difference in food security probability outcome of non-commercialized households emanating from their differences in efficiency of use of their currently held resources compared to the efficiency of commercialized households is obtained by subtracting Eqn. 5.3b from Eqn. 5.4a (Table 7). On the other hand, the difference in food security probability outcome of commercialized households as a result of their differences in the amount of resources held compared to the amount of resources held by non-commercialized households, holding efficiency constant, is obtained by subtracting Eqn. 5.3b from Eqn. 5.4a. Finally, the difference in food security probability outcome of non-commercialized households originating from their differences in the amount of resources held by commercialized household, holding their resource use efficiency constant, is obtained by subtracting Eqn. 5.4b from Eqn. 5.3a (Table 7).

Table 7. Conditional expectations, returns effects and level effects

Household type	Market participating households' response to characteristics	Non-market participating households' response to characteristics	Returns effects (difference caused by difference in resource use efficiency)
Commercialized households	(5.3a) $E(Y_{Pi}/H=1)$	(5.4a) $E(Y_{Ni}/H=1)$	(5.3a) – (5.4a)
Non-commercialized households	(5.4b) $E(Y_{Pi}/H=0)$	(5.3b) $E(Y_{Ni}/H=0)$	(5.4b) – (5.3b)
Level effect (difference caused by differences in resource quantities)	LE_N = (5.3a) – (5.4b)	LE_P = (5.4a) – (5.3b)	(5.3a) – (5.3b)

Source: Author's compilations

5.2.1 Variable definition and measurement

Dependent variable: In the first-step of the two-step ESR, determinants of agricultural commercialization based on Eqn. 5.1 is estimated using a probit model. On the other hand, the second step of the ESR is based on Eqn. 5.2a and Eqn. 5.2b where like in the first step, the dependent variable in both equations (household food security probability) is binary. In the questionnaire that was used to collect data for this study, household respondents were asked to consider all their food sources (own food production + food purchases + help from different sources etc.) and then self-assess their food security status in the last twelve months before the interview. Their responses included – food shortage throughout the year (chronic food insecurity); occasional food shortage (transitory food insecurity); no food shortage but no surplus (break-even); and food surplus throughout (food secure). Food secure households are represented by those who responded that they either had "no food shortage but no surplus i.e. break-even" or they had "food surplus". Food insecure households were those who responded that they either faced "food shortage throughout the year" or had "occasional food shortage".

Independent variables: In the first–step probit estimation of the determinants of agricultural commercialization, the independent variables were exactly similar to those that were used in the first-step of the double hurdle model that was estimated and exhaustively discussed in chapter four (Table 2). As already mentioned, transaction costs explanatory variables were assessed for their suitability as instrument variables using a simple falsification test following Di Falco *et al.,* (2011) and Kassie *et al.,* (2014a). Those transaction costs variables that passed the suitability test were used accordingly i.e. excluded in the second stage of estimating the treatment outcome

equations. The summary of independent variables used in the first step selection model of determinants of agricultural commercialization model and second step food security outcome models, respectively, are shown in Table 8. These independent (explanatory) variables were broadly categorized into demographic characteristics, physical and financial assets, social capital and transaction costs variables (see Eqn. 5.1).

Table 8. Definition and measurement of variables in impact assessment of agricultural commercialization on household food security probability

Variable definition	Variable measurement	Expected sign	
		Selection model	Outcome model: Food security
Dependent variables:			
Output market participation	Binary (1=Participating; 0=Otherwise)	√	na
Food security	Binary (1=Food secure; 0=Otherwise)	na	√
Independent variables:			
a) Demographic characteristics:			
Household head sex	Binary (1=Male; 0=Otherwise)	+	+
Household head age	Continuous (years)	+	-
Household head education	Continuous (years)	+	+
Household size	Continuous (adult equivalent)	+/-	-
Dependency ratio	Continuous (between 1 and 0)	+/-	-
b) Physical & financial assets:			
Livestock owned	Continuous (Tropical Livestock Units i.e. TLU)	+	+
Per capita own farm size	Continuous (ha/adult equivalent)	+	+
Weighted mean soil fertility score of cultivated plots	Continuous (weighted mean score of soil fertility)	+	+
Total annual non-farm income	Continuous (KSh)	+/-	+/-
Access to agricultural input credit	Binary (1=Yes; 0=Otherwise)	+	+
Contacts with agricultural extension staff	Binary (1=Yes; 0=Otherwise)	+	+
Ox-plough ownership	Binary (1=Yes; 0=Otherwise)	na	+
c) Social capital:			
Membership to agricultural production networks/groups (APN)	Binary (1=Yes; 0=Otherwise)	+	+
Number of dependable relatives in village	Continuous (absolute numbers)	+	+
Trust grain traders	Binary (1=Yes; 0=Otherwise)	+	+
d) Transaction costs:			
Mobile phone ownership	Binary (1=Yes; 0=Otherwise)	+	+
Average transport cost to main market	Continuous (KSh/person/trip)	-	-
Own any local transport means (bicycle, carts, wheelbarrow, motorbike)	Binary (1=Yes; 0=Otherwise)	+	+
Regional dummy	Binary (1=Eastern; 0=Western	+/-	+/-

Source: Author's compilation
Note: na stands for not applicable

5.2.2 Estimation strategy for the endogenous switching regression (ESR)

Because this study is based on two wave panel data, there was the option of using the traditional panel data models in estimating the selection model and the two treatment outcome models i.e. either random effects (RE) or fixed effects (FE) models. However due to the intrinsic weakness of each of the two approaches, this study adopted a hybrid panel data analysis framework that preserves the advantages of RE and FE. On one hand, though RE model allows the inclusion of time invariant explanatory variables, it is problematic in many applications because it requires the strong assumption that unobserved heterogeneities have to be uncorrelated with the observed explanatory variables. On the other hand, while FE is attractive in the sense that it allows arbitrary correlation of unobserved and observed explanatory variables, it does not allow the inclusion of time invariant explanatory variables however important they could be to an investigator.

The RE and FE hybrid model adopted in this study is called correlated random effects model (Cameron and Trivedi, 2009; Wooldridge, 2010) and it dates back to Mundlak (1978) and Chamberlain (1982) under the so called "*Mundlak-Chamberlain* device". In this correlated random effects (CRE) approach, the averages of time varying explanatory variables are used in the model as additional explanatory variables. Cameron and Trivedi (2009) and Wooldridge (2010) give detailed theory of CRE while Burke and Jayne (2014) have empirically applied the CRE with extensive interpretation of the arising "within" and "between" household effects. The time varying explanatory variables (excluding variables that were mostly the same for all observations in any given period, such as region dummy for each household or gender and education level of the household head) were averaged across the two panel periods to form the *Mundlak-Chamberlain* device. The detailed definition and measurement of these variables were as indicated in Table 8.

The efficient method to estimate ESR models is by full information maximum likelihood (FIML) estimation (Lokshin and Sajaia, 2004). An alternative estimation method is fitting one equation at a time by either 2SLS or maximum likelihood estimation. However, these later methods are less efficient than FIML because they require some potentially cumbersome adjustments to derive consistent standard errors (Lokshin and Sajaia, 2004). The 2SLS or maximum likelihood estimation also shows poor performance in case of high multicollinearity between the covariates

of the selection model (Maddala, 1983). The FIML approach, according to Lokshin and Sajaia (2004), relies on joint normality of the error terms in the selection and outcome equations and thus more efficient.

5.3 Results and discussion

The descriptive and econometric results of the ESR model using correlated random effects (CRE) approach are presented and discussed in this section. Also, the results of the treatment (commercialization) under actual and counterfactual frameworks are presented and discussed in details before conclusions and recommendations and then policy implications.

5.3.1 Descriptive statistics

The summary descriptive statistics for the variables used in this model disaggregated by treatment regime (commercialized versus non-commercialized households) were as presented in Table 3 and discussed in section 4.3.1 of chapter four. However, for the purposes of this section, descriptive statistics for the same variables but disaggregated by household food security outcome regime (food security status) were generated and presented in Table 9. In terms of commercialization, food secure households were more commercialized than their food insecure counterparts. About 85% of the food secure households were commercialized and their commercialization intensity was about 34% compared 62% and 19%, respectively, among the food insecure households (Table 9). The difference in these statistics across the two groups of households was statistically different at 1% level of significance. While no causality is implied, these descriptive statistics show some positive correlation between household agricultural commercialization and food security.

Household demographic variables also showed some marked differences across the food secure and food insecure households (Table 9). From a gender perspective, a higher proportion of food secure households were male headed (86%) compared to food insecure households (81%). This higher proportion of male headed households being food secure might be related with the ability of male heads accessing agricultural production assets that enables them to produce enough to feed their households. It might also be related to the ease at which male heads can access non-farm income generating activities that enables them to buy food to meet the deficit. Also, it is important to note that the average household size in terms of adult equivalent and the

dependence ratio showed statistically significant difference between the food secure and food insecure households. Food secure households had a smaller household size and lower dependence ratio compared to food insecure households (Table 9). Food insecure household could be constrained by their resources to feed their bigger families and could also be straining their few economically active members to provide for the many households members who are not economically active (high dependence ratio).

The descriptive statistics of physical and financial asset variables showed that food secure households had on average bigger per capita owned farm sizes compared to food insecure households. On average, the per capita owned farm size of food secure households was about 0.26 ha compared to 0.20 ha among the food insecure households (Table 9). The bigger farm size among food secure households could be the one enabling them to produce enough food for their members compared to smaller farm sizes among the food insecure households. Similarly, food secure households had higher average soil fertility score of all operated plots and higher non-farm income compared to their food insecure counterparts. The higher soil fertility score among food secure households could be contributing to high food crop productivity. On the other hand, high non-farm income could be enhancing the food security among food secure households through purchases of food deficits from the markets. It is important also to note that the proportion of food secure households that accessed agricultural input credit (18%) was significantly different from the proportion of food insecure households that accessed this important facility (10%). The higher proportion of food secure households that accessed credit (Table 9) could have used this credit to buy food directly from the market or buy food crop productivity enhancing inputs like fertilizer and improved seed and thus securing their food security.

Membership to agricultural production networks/groups (APNs) was the only social capital variable that showed a significant difference between food secure and food insecure households (Table 9). A higher proportion of food secure households (57%) belonged to APNs compared to food insecure households (44%). APNs could be used by members to get food at relatively affordable prices in lean seasons. Also APNs could be a source of agricultural technologies like information, improved crop varieties and even fertilizer that increases own-farm productivity of food crops.

On the other hand, descriptive statistics for all transaction cost variables included in the model were statistically different between food secure and food insecure households (Table 9). A higher proportion of food secure households owned mobile phones and local means of transport compared to food insecure households. Food secure households also incurred less transport costs to the nearest main market compared food insecure households (Table 9). These results mean that food secure households face less market transaction costs compared to their food insecure counterparts. Less transaction costs among food secure could lead them to procure food crop productivity enhancing inputs and food to meet their deficits more competitively compared to food insecure households.

Table 9. Descriptive statistics for the Endogenous Switching Regression Model: Food security

Variable label	Food secure (N=497)		Food insecure (N=417)		Total (N=914)		Difference
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	
Commercialized households	0.8491	0.3583	0.6211	0.4857	0.7451	0.4361	0.2280***
Proportion of value of crop produced sold	0.3449	0.2711	0.1915	0.2352	0.2749	0.2664	0.1534***
Demographic characteristics:							
Household head sex	0.8632	0.3440	0.8106	0.3923	0.8392	0.3676	0.0526**
Household head age	50.6519	13.9085	50.8561	13.5423	50.7451	13.7355	-0.2042
Household head education	8.1362	3.7991	7.1583	3.7460	7.6900	3.8043	0.9779***
Household size	4.7801	2.1998	5.4062	2.3346	5.0658	2.2825	-0.6261***
Dependency ratio	0.8126	0.7005	1.0869	0.9060	0.9377	0.8119	-0.2742***
Physical and financial assets:							
Per capita owned farm size	0.2617	0.2395	0.2037	0.2056	0.2353	0.2264	0.0580***
Tropical livestock units (TLU)	1.7567	2.0382	1.5151	1.6229	1.6465	1.8632	0.2416*
Mean soil fertility score	2.1808	0.5710	2.0024	0.6480	2.0994	0.6135	0.1784***
Total annual non-farm income (1000 KSh)	130.4707	272.6154	58.6484	106.1973	97.7027	216.3209	71.8222***
Had contacts with extension staff	0.4930	0.5005	0.4988	0.5006	0.4956	0.5003	-0.0058
Household got agricultural credit	0.1751	0.3804	0.0959	0.2948	0.1389	0.3461	0.0791***
Household owns ox-plough	0.0765	0.2660	0.1199	0.3252	0.0963	0.2951	0.0435**
Social capital:							
Household belongs to APN	0.5694	0.4957	0.4436	0.4974	0.5120	0.5001	0.1258***
Number of dependable relatives in village	5.9195	10.5353	6.0600	10.7790	5.9836	10.6416	-0.1404
Trusts in grain traders	0.7545	0.4308	0.7170	0.4510	0.7374	0.4403	0.0375
Transaction costs:							
Owns mobile phone	0.8873	0.3165	0.7722	0.4199	0.8348	0.3716	0.1151***
Transport cost to main market	47.7143	34.1472	52.2974	35.7174	49.8053	34.9279	-4.5831**
Own local transport means	0.7243	0.4473	0.5707	0.4956	0.6543	0.4759	0.1536***
Regional dummy	0.6258	0.4844	0.3381	0.4736	0.4945	0.5002	0.2876***

Significance level: *** at 1%; ** at 5%; * at 10%

Source: Author's computations

5.3.2 Econometric results

The results from the ESR model in a correlated random effects (CRE) framework were as presented in Table 10. Determination of the validity of the instruments used in this model was guided by theory and empirical evidence. Theoretically, all transaction cost variables used in the model were assumed to be more directly related to agricultural commercialization than to food security outcomes of the households i.e. transaction costs were assumed to affect household food security outcome through market participation (commercialization). Empirically, Goetz (1992) and Key *et al.,* (2000) have demonstrated in Senegal and Mexico, respectively, that transaction costs are very important in determining agricultural market participation (commercialization).

Following Lokshin and Glinskaya (2009), Di Falco *et al.*, (2011) and Kassie *et al.*, (2014a), this study went further to test the validity of the identified instrument candidate variables (all transaction cost variables). This test involved a simple falsification procedure where two probit models, one for the selection model and another for the food security outcome model were estimated (Appendix 1). In both probit models, the proposed instruments were used as explanatory variables among other variables. Only those instrument candidate variables that were significant in the selection model and insignificant in the outcome model were used as valid instruments in the ESR model. Based on the results presented in Appendix 1, only household ownership of mobile phone variable met this criterion and was used as an instrument in the subsequent ESR model. Similarly, the test for endogeneity of the treatment (agricultural commercialization) returned an IMR of 0.9716 that was statistically significant at 5%. This implied that the treatment variable (agricultural commercialization) was endogenous thus justifying the use of ESR. It is also important to note that the results for the selection model in the ESR were an exact replica of those presented and discussed in section 4.3 of chapter four. Therefore, they are not discussed in this section to avoid repetition.

Turning to the econometric results of the determinants of household food security probability, only two household demographic characteristic variables were found to affect significantly the household food security probability outcome among the surveyed households. First, education level of the household head had a positive and significant “between-household” effect on the food security outcome of commercialized households (Table 10). The average partial effects results showed that a commercialized household that had one more year of formal education was

about 1.3% more likely to be food secure compared to a similar household that had one year less of formal education (Table 11). This finding may highlight the importance that formal education has in enabling commercialized households to access modern agricultural production technologies and market information that they need to produce surplus for the market and participate in the markets more profitably. Secondly, dependence ratio was found to have had a negative and significant "between-household" effect on food security outcome of non-commercialized households (Table 10). A non-commercialized household that had one unit more of dependence ratio was about 25% more likely to be food insecure compared to a similar household that had one unit less of dependence ratio (Table 11). This finding could be related to the possibility that non-commercialized households with higher dependency ratio were likely to be food insecure because of increased burden on the actively working members to provide food for the non-productive members of the household.

The econometric results of physical and financial asset variables showed that the "within-household" effects was more important in explaining the food security probability of non-commercialized households than the commercialized ones (Table 10). These "within-household" effects among the non-commercialized households were mainly positive. These positive effects highlight the importance of household wealth in explaining the food security among non-commercialized households. Starting with livestock ownership, the tropical livestock units (TLU) had a positive and significant "within-household" effect on the food security probability among non-commercialized households (Table 10). A 100% increase in livestock (TLU) owned by non-commercialized households was likely to increase their food security by almost 1% (Table 11). This finding could mean that non-commercialized households might be depending on selling off some of their livestock to buy food.

Household soil fertility score for all operated plots had a positive and significant "within-household" effect on household food security probability among non-commercialized households (Table 10). A one unit increase in the average soil fertility score of all operated plots by non-commercialized households was likely to increase their food security by about 17% (Table 11). This could be attributed to the possibility that non-commercialized households are more dependent on own produced foods and therefore those with more fertile plots have a higher probability of producing more of their own food (Govereh and Jayne 2003, Rios *et al.,* 2009 and

Mather *et al.,* 2011). This soil fertility finding has a far reaching policy implication as outlined in section 5.5 of this chapter.

Table 10. Endogenous Switching Regression: Impact of agricultural commercialization on household food security outcome

Variable label	Selection model: Determinants of household agricultural commercialization		Outcome models: Determinants of household food security outcome			
			Commercialized households		Non-commercialized households	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Demographic characteristics:						
Household head sex	-0.0903	0.1546	0.0874	0.1693	-0.1211	0.3126
Household head age	0.0089	0.0144	0.0054	0.0148	0.0143	0.0275
Household head education	0.0342**	0.0167	0.0414**	0.0169	0.0385	0.0318
Household size	0.0265	0.0627	-0.0305	0.0704	-0.0397	0.1169
Dependence ratio	-0.0539	0.1280	-0.0719	0.1334	0.4422	0.2858
Physical and financial capital:						
Owned livestock size	0.0147*	0.0080	-0.0021	0.0087	0.0264*	0.0161
Per capita owned land	3.8204**	1.6995	-1.2190	1.7845	-1.0003	3.7695
Per capita owned land squared	-1.7225**	0.8657	1.3666	1.1780	0.0909	1.7762
Soil fertility score	-0.1511	0.1283	0.1275	0.1400	0.6040**	0.2441
Annual non-farm income	-0.0093*	0.0049	0.0073	0.0046	0.0166*	0.0102
Got agricultural input credit	0.0569	0.2492	0.2192	0.2232	-0.5613	0.5707
Contacts with extension	0.2137	0.1554	-0.2202	0.1593	-0.0324	0.3129
Ox-plough ownership	na	na	-0.2410	0.3156	-0.1811	0.6678
Social capital:						
Membership to APNs	0.5515***	0.1153	0.2838**	0.1198	0.5145**	0.2334
Dependable relatives in village	0.0010	0.0051	-0.0088*	0.0050	-0.0098	0.0150
Trust grain traders	0.1804	0.1203	0.2764**	0.1251	0.3372	0.2413
Transaction costs:						
Own mobile phone	0.8913***	0.2171	na	na	na	na
Transport to nearest main market	-0.0156**	0.0078	-0.0111*	0.0067	-0.0300	0.0194
Own transport means	0.1327	0.1125	0.3787***	0.1173	0.6914***	0.2263
Regional dummy	0.9400***	0.1405	0.7489***	0.1393	-0.4514	0.3329
Mundlak - Chamberlain device:						
Household head age	-0.0116	0.0151	-0.0064	0.0156	-0.0152	0.0294
Household size	-0.0342	0.0692	-0.0333	0.0776	0.0403	0.1320
Dependence ratio	0.1346	0.1500	-0.2047	0.1603	-0.9026**	0.3542
Owned livestock size	-0.0063	0.0107	0.0080	0.0115	-0.0100	0.0205
Per capita owned land	-1.6208	1.7661	1.5496	1.7241	0.2693	3.9939
Per capita owned land squared	0.3784	0.9639	-1.0921	1.0211	0.5232	2.2847
Soil fertility score	0.4152**	0.1753	0.1460	0.1776	-0.4520	0.3642

Annual non-farm income	0.0078	0.0064	-0.0035	0.0060	-0.0204	0.0139
Got agricultural input credit	0.7084**	0.3317	-0.0402	0.3091	2.0555***	0.7076
Contacts with extension	-0.1432	0.2137	0.5442**	0.2200	-0.2803	0.4359
Own mobile phone	-0.2894	0.2895	na	na	na	na
Ox-plough ownership	na	na	0.1337	0.3972	0.0328	0.7307
Constant	-1.7167***	0.4261	-1.2708***	0.4695	-0.9832	0.6994

Significance level: *** at 1%; ** at 5%; * at 10%

Note: na stands for not applicable

Model description:

Descriptor	Selection model	Commercialized households	Non-commercialized households
Number of obs	914	681	233
LR chi2(30)	244.8800	141.2900	58.8000
Prob > chi2	0.0000	0.0000	0.0013
Pseudo R2	0.2360	0.1562	0.2008
Log likelihood	-396.4215	-381.6888	-116.9893

Source: Author's computations

Non-farm annual household income was also found to have had a positive "within-household" effect on food security of the surveyed households. However, this effect was only significant among the non-commercialized households (Table 10). An increase in non-farm income of non-commercialized households by about one thousand units (KSh. 1,000) was likely to increase their food security by about 5% (Table 11). This positive and significant relationship could be attributed to the fact that non-farm income is usually used by non-commercialized households to buy food to make up for the shortfall in own produced food staples. This might be contrary to commercialized households who are more likely to produce surplus of consumed food crops some of which they sell in the markets as demonstrated by Govereh and Jayne (2003).

Another physical and financial asset variable that was found to have significantly affected household food security outcome was access to agricultural credit. Though this variable had no significant "within-household" effect on food security probability outcome among the sampled households, it had a positive and significant "between-household" effect on food security of non-commercialized households (Table 10). A non-commercialized household is 58% likely to be food secure compared to a similar household that did not access this credit (Table 11). This finding could be suggesting that all crop enterprises on the farms of non-commercialized households are food crops and accessing this input credit goes directly to boost their food crop

production. The increased food crop production in turn improves their food security tremendously compared to when they had not accessed agricultural input credit.

Contacts with extension staff had a positive and significant "between-household" effect on the food security of commercialized households (Table 10). Holding else constant, a commercialized household that had contacts with extension was about 17% more likely to be food secure compared to a similar household that did not have contacts with extension (Table 11). This finding highlights the importance of extension information in enabling commercialized households produce more food crops beyond their subsistence levels. It could also be pointing to the importance of extension information in enabling commercialized households choose the most profitable crop enterprises on their farms.

While physical and financial assets were significant in explaining the food security mainly among the non-commercialized households, social capital and transaction costs were more important in explaining food security among commercialized households (Table 10). These empirical findings seem to support the new institutional economics theory which postulates that social capital type of institutions and transaction costs variables are important in reducing the costs incurred by commercialized households in concluding their market transactions (North, 1990).

The econometric results showed a positive and significant "between-household" effect of membership to agricultural production networks/groups (APNs) and household food security status regardless of the household commercialization status (Table 10). A commercialized household that belonged to an APN was about 9% more likely to be food secure compared to a similar household that did not belong to an APN (Table 11). Similarly, a non-commercialized household that belonged to an APN was about 15% more likely to be food secure compared to a similar household that did not belong to the APN (Table 11). This finding could be associated with the possibility that APNs are important rural institutions used by smallholder farming households to reduce transaction costs associated with accessing improved agricultural production technologies and output niche markets as demonstrated by Shiferaw *et al.*, (2014). These technologies and markets enable households to increase their agricultural productivity and could also be enabling them to buy back food grains in lean seasons at relatively lower prices.

Number of dependable relatives living in the same village with a household was found to have had a negative and significant "between-household" effect on the food security of commercialized households (Table 10). Commercialized households with one additional dependable relative living in the village was almost 0.3% more unlikely to be food secure compared with a similar household that had one dependable relative less (Table 11). This finding could be associated with the possibility of some of these dependable relatives having food deficits. As such, the reciprocity attitude among rural farming households could influence commercialized households' probability of supporting their dependable relatives thereby compromising the former's food security.

Also, trust in grain traders as an explanatory variable had a positive and significant "between-household" effect on food security of commercialized households (Table 10). Commercialized households that trusted grain traders were about 9% more likely to be food secure compared to similar households that did not have trust in grain traders (Table 11). This means that a commercialized household's food security probability is likely to improve if it trusts grain traders. This finding might be related to the possibility that those trusting grain traders could be the ones receiving better prices for their crop sales. Equally, these commercialized households that trust grain traders could be getting fair prices for food grains when buying from same traders in lean seasons as it commonly happens with main staples like maize. The trust in traders is also likely to occur over time after continuous or repeated interactions with these traders who could advance credit to the same household. The advanced credit could be used to improve household agricultural productivity and thus produce more than its home consumption needs as empirically shown by Govereh and Jayne (2003).

Further analysis was conducted to assess the effects of transaction costs on household food security among the surveyed households. All transaction costs variables included in the model, except mobile phone ownership, were treated as time invariant given the short panel period of the data used in this study. From the econometric results presented in Table 10, it was evident that transport costs to the main market (a proxy measure of remoteness) had a negative and significant "between-household" effect on the food security of the commercialized households. A commercialized household was about 4% more likely to be food insecure if its transport to the nearest main market was one thousand units (KSh. 1000) more compared to a similar household

with one thousand units less (Table 11). This finding could be associated with the fact that commercialized households derive substantial amount of their income from market participation which they in turn use to buy foods that they don't produce on their own farms. However, when these commercialized households are located in very remote areas (higher transport costs to the main market), they are likely to get poor prices for their farm produce. The poor prices of farm produce translate into reduced ability to buy foods that they do not produce on their farms.

Table 11. Average Marginal Effects of the ESR: Impact of commercialization on food security

	Selection model: Determinants of commercialization		Outcome models: Determinants of food security			
			Commercialized households		Non-commercialized households	
	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Demographic characteristics:						
Household head sex	-0.0220	0.0376	0.0277	0.0537	-0.0342	0.0881
Household head age	0.0022	0.0035	0.0017	0.0047	0.0040	0.0078
Household head education	0.0083**	0.0040	0.0131**	0.0053	0.0109	0.0089
Household size	0.0065	0.0153	-0.0097	0.0223	-0.0112	0.0330
Dependence ratio	-0.0131	0.0312	-0.0228	0.0423	0.1249	0.0801
Physical and financial capital:						
Owned livestock size	0.0036*	0.0019	-0.0007	0.0027	0.0074*	0.0045
Per capita owned land	0.9304**	0.4104	-0.3866	0.5655	-0.2825	1.0635
Per capita owned land squared	-0.4195**	0.2094	0.4334	0.3726	0.0257	0.5016
Soil fertility score	-0.0368	0.0312	0.0404	0.0443	0.1706***	0.0659
Annual non-farm income	-0.0023*	0.0012	0.0023	0.0015	0.0047*	0.0028
Got agricultural input credit	0.0139	0.0607	0.0695	0.0707	-0.1585	0.1602
Contacts with extension	0.0520	0.0377	-0.0698	0.0503	-0.0092	0.0884
Ox-plough ownership	na	na	-0.0764	0.1000	-0.0511	0.1885
Social capital:						
Membership to APNs	0.1343***	0.0271	0.0900**	0.0376	0.1453**	0.0640
Dependable relatives in village	0.0002	0.0013	-0.0028*	0.0016	-0.0028	0.0042
Trust grain traders	0.0439	0.0292	0.0877**	0.0393	0.0952	0.0674
Transaction costs:						
Own mobile phone	0.2170***	0.0516	na	na	na	na
Transport to nearest main market	-0.0038**	0.0019	-0.0035*	0.0021	-0.0085	0.0054
Own transport means	0.0323	0.0273	0.1201***	0.0364	0.1952***	0.0602
Regional dummy	0.2289***	0.0319	0.2375***	0.0414	-0.1275	0.0929
Mundlak - Chamberlain device:						
Household head age	-0.0028	0.0037	-0.0020	0.0049	-0.0043	0.0083
Household size	-0.0083	0.0169	-0.0105	0.0246	0.0114	0.0372
Dependence ratio	0.0328	0.0365	-0.0649	0.0506	-0.2549***	0.0971
Owned livestock size	-0.0015	0.0026	0.0025	0.0037	-0.0028	0.0058

Per capita owned land	-0.3947	0.4295	0.4914	0.5461	0.0761	1.1278
Per capita owned land squared	0.0922	0.2347	-0.3463	0.3231	0.1478	0.6452
Soil fertility score	0.1011**	0.0423	0.0463	0.0562	-0.1276	0.1017
Annual non-farm income	0.0019	0.0016	-0.0011	0.0019	-0.0058	0.0039
Got agricultural input credit	0.1725**	0.0803	-0.0128	0.0980	0.5805***	0.1884
Contacts with extension	-0.0349	0.0520	0.1726**	0.0690	-0.0792	0.1226
Own mobile phone	-0.0705	0.0704	na	na	na	na
Ox-plough ownership	na	na	0.0424	0.1259	0.0093	0.2063

Significance level: *** at 1%; ** at 5%; * at 10%
Source: Author's computations
Note: na stands for not applicable

Ownership of local transportation means had a positive and significant "between-household" effect on the food security outcome of the surveyed households regardless of their commercialization status (Table 10). Commercialized households who owned local transportation means were 12% more likely to be food secure compared to similar households that did not own these important transaction costs reducing farm equipment (Table 11). Similarly, non-commercialized households that owned local means of transport were about 20% more likely to be food secure compared to similar households who did not own these equipment (Table 11). Among the commercialized households, this finding could be pointing to the possibility that ownership of means of transport enables them to access better markets for their produce. Access to better markets is likely to increase their income which eventually can be used to buy foods that they do not produce on their farms. Also, owning these transportation equipment among commercialized households could mean that they can procure productivity improving technologies like improved seed and fertilizer more easily. On the other hand, among the non-commercialized households, ownership of such equipment could also improve their access to productivity improving technologies just like the commercialized households. Besides, when this latter group owns transportation equipment assets, they can lease them out to earn cash and in-kind income that they use to buy food.

The econometric results presented in Table 10 also showed that commercialized households in eastern region of Kenya are more likely to be food secure compared to their counterparts in western region. A commercialized household in eastern region was about 24% more likely to be food secure compared to a commercialized household in western Kenya (Table 11). This finding could be associated with the possibility that western Kenya households are more remote and thus

can't rely on markets for food security compared to their eastern Kenya counterparts. This remoteness is informed by the fact that the cost of transport to the nearest market was significantly higher in western than eastern Kenya. The descriptive statistics showed that while the cost of transport to the main market in western Kenya was about KSh. 56, it was about KSh 43 in eastern Kenya.

5.3.3 Treatment effects of agricultural commercialization on household food security

To disentangle the impacts of the treatment (agricultural commercialization) on household food security outcome stemming from the observed and unobserved heterogeneities between households who got the treatment (commercialized) and those who didn't get the treatment (non-commercialized), a counterfactual analysis was built from the ESR estimates using the post estimation procedures (Lokshin and Sajaia, 2004). In Table 12, cell (a) and cell (b) represent the actual (observed) expected household probability of being food secure among the commercialized and non-commercialized households, respectively. This means that, among the commercialized households, the observed expected probability of a household being food secure was about 62% compared to 32% among the non-commercialized households (Table 12). These results compares very well with descriptive statistics generated directly from the data as presented in Figure 2. These descriptive statistics in Figure 2 were found to be statistically different at 1% level of significance.

A quick and direct simple comparison of these statistics shows that agricultural commercialization helped the commercialized households to have a food security probability advantage of almost 30 percentage points. However, such simple and direct comparison could be misleading without taking into consideration the observed and unobserved characteristics of both commercialized and non-commercialized households that could be correlated with respective food security outcome. This calls for building counterfactual scenarios of the expected values for the two groups of households i.e. cell (c) and cell (d) in Table 12 to decompose the sources of this 30% difference in food security probability between the two groups of the households (commercialized and non-commercialized).

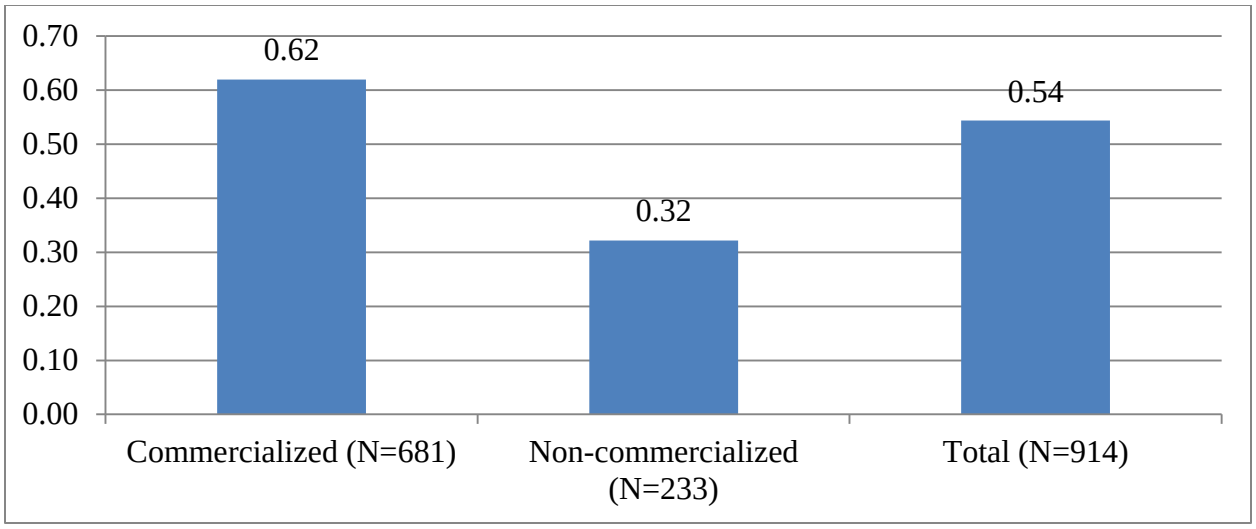

Figure 2. Proportion of households that are food secure
Source: Author's compilation

The counterfactual analysis and decomposing the 30% food security gap between the commercialized and non-commercialized households followed the Oaxaca (1973) wage decomposition seminal work. This food security gap decomposition revealed that the food security probability outcome of the commercialized households would be reduced significantly by almost 23% if the efficiency of their currently held resources was to be the same like the efficiency of the non-commercialized households – cell (a) less cell (d) in Table 12. This is what is commonly referred to as "returns effect" in recent literature (Kassie *et al.*, 2015). Similarly, the food security probability outcome for commercialized households could be reduced significantly by about 7% - cell (d) less cell (b) in Table 12 if this group of households had the same amount of resources like the ones held currently by the non-commercialized households. This is what is now commonly called the "level effect" (Kassie *et al.,* 2015). Therefore, the 30% food security probability outcome advantage that commercialized households have over non-commercialized households stems from commercialized households' superior efficiency in use of resources (23%) and the advantage in amount of resources that they currently hold (7%). Basically, these results means that for commercialized households food security probability to come down from almost 62% to the level of non-commercialized households food security of 32%, then commercialized households' efficiency use of their resources have to come down and at the same time their level or amount of resources have to be reduced too. However, no policy maker will be interested in pursuing interventions that could result in such a scenario.

Table 12. Average expected household food security probability outcomes

Type of household	Household food security probability outcome		
	Commercialized characteristics	Non-commercialized characteristics	Returns effects
Commercialized (N=681)	0.6195 (a)	0.3906 (d)	0.2289***
Non-commercialized (N=233)	0.4377 (c)	0.3218 (b)	0.1158***
Level effects	0.1818***	0.0687***	**0.2976**

Significance level: *** at 1%; ** at 5%; * at 10%
Source: Author's compilation

On the other hand, the food security probability outcome for the non-commercialized households could significantly be improved by almost 12% if the efficiency of their currently held resources could be improved to the efficiency level of the commercialized households. This means that if non-commercialized households were as efficient as the commercialized households in the use of their currently held resources, the 30% food security gap will be reduced by about 12% points to 18% due to what is commonly called the "returns" effect – cell (c) less cell (b) in Table 12. The remaining 18% food security gap can be closed by improving the amount of resources held by the non-commercialized households. In other words, if the resources held by the non-commercialized households can be increased to the level of the amount of resources held by commercialized households while holding else constant (ceteris paribus), then their food security probability outcome will increase by 18% as a result of what is usually referred to as the "level" effect. Basically, these counterfactual results for non-commercialized households implies that the main source of the observed food security gap between commercialized and non-commercialized households (30%) is the differences in the amount of resources held by the two groups. The low amount of resources held by the non-commercialized households compared to commercialized households contributes to about 61% of the food security gap. The remaining 39% of the food security gap is due to poor efficiency in use of the resources by the non-commercialized households compared to commercialized households.

5.4 Summary and conclusion

Global economic and demographic changes in terms of rising incomes and increasing urbanization, respectively, have provided smallholder farmers in developing countries with immense opportunity to commercialize their agricultural activities. However, the implication of this agricultural transformation process on the welfare of rural farming households is not clear.

Particularly not clear in theoretical and empirical literature is the effect of agricultural commercialization on household food security. Arguments for agricultural commercialization have been premised on the assumption that commercializing smallholder agriculture will increase productivity beyond subsistence levels thus ensuring food security. On the other hand, anti-agricultural commercialization protagonists have argued that commercialization will divert production resources from food crops to non-food cash crops thereby exposing smallholder farmers to risks associated with markets. Most of the previous empirical studies that addressed this theoretical impasse were based on either cross sectional data and/or pooled regression models to assess the impact of agricultural commercialization. However panel data and use of switching regression models could be more informative.

In this study, two wave balanced panel data collected from smallholder farmers in western and eastern parts of Kenya were used. The study applied endogenous switching regression using correlated random effects panel data analytical framework to analyze the impact of smallholder agricultural commercialization on household food security. The results showed that physical and financial assets were more positively and significantly related to food security outcome among non-commercialized households. On the other hand, social capital and transaction costs were more important in determining the food security outcome of commercialized households. Therefore, non-commercialized households seemed to be more dependent on physical and financial assets to be food secure while commercialized households seemed to be more dependent on the efficient working of agricultural markets for their food security.

On the impact assessment of agricultural commercialization on the welfare of rural smallholder farmers, the results showed that agricultural commercialization has a positive and significant effect on household food security. The counterfactual analysis revealed that commercialized households could have significantly lowered their food security if they were not commercialized. On the other hand, non-commercialized households could have improved their food security significantly if they were commercialized. The observed probability of a commercialized household being food secure was about 62% while that of a non-commercialized household was 32%. This 30% food security gap between commercialized and non-commercialized households was decomposed into two main sources, that is, that emanating from differences in the resource use efficiency between the two groups and the amount of resources held by each group. The food

security of non-commercialized households would improve significantly by almost 12% if they were as efficient in using their currently held resources as commercialized household are. This difference in resource use efficiency accounted for about 39% of the observed food security gap (30%). The other 18% gap (that is, 61% of the gap) was due to differences in the amount of resources held by the two groups of households. This means that the food security gap between commercialized and non-commercialized households can only be fully closed if both efficiency of resource use and the amount of resources held by non-commercialized households can be improved.

5.5 Policy implications

This study has empirically demonstrated that agricultural commercialization can significantly address food security among the rural smallholder farmers. On this basis, policies that can stimulate and enhance agricultural commercialization as discussed in section 4.5 of this thesis are viable options of addressing rampant food insecurity among rural smallholder farmers. Among commercialized households, food insecurity among commercialized households can be reduced further if policies that promote social capital and reduce market transaction costs among smallholder farmers can promoted. On the other hand, policy options that encourage increased physical assets among non-commercialized households can improve the food security probability of this group of households.

CHAPTER SIX: IMPACT OF AGRCIULTURAL COMMERCIALIZATION ON POVERTY AMONG SMALLHOLDER FARNMERS IN KENYA

6.1 Introduction

By the turn of the 21st century, poverty in sub-Saharan Africa (SSA) had increased from 42% in the 1980s to 46% while in Asia it had dropped from about 50% to 15% over the same period (Ravallion and Chen, 2004; Christiaensen and Demery, 2007). Majority of the poor people in SSA (over 70%) reside in rural areas mainly dependent on smallholder agriculture to earn their livelihoods (Hazell, 2005; World Bank, 2008). Reversing this increasing rural poverty trend in SSA will require transforming the agricultural sector from its current subsistence or semi-subsistence dominated system to a more commercialized system (Govereh *et al.,* 1999; Mathenge *et al.,* 2010; Kirsten *et al.,* 2012). Furthermore, the changing global demographic and economic environment mainly driven by increasing population, urbanization and income coupled with food industry restructuring (i.e. explosion of supermarkets) and climate change have presented enormous opportunities for smallholders to commercialize their farm enterprises (Zhou *et al.,* 2013).

However, though it seems attractive to promote smallholder commercialization, past empirical studies have found inconclusive impacts of agricultural commercialization especially on the welfare of the poor (Binswanger and von Braun 1991). While there is literature of positive impacts of agricultural commercialization on household welfare, there exists also literature on the negative impacts of this transformation process. At household level, early IFPRI led studies in developing countries found that agricultural commercialization increased significantly household income and welfare in general (von Braun *et al.,* 1994). Similar positive impacts of commercialization on household incomes have been documented empirically in Kenya (Muriithi and Matz 2015), Zimbabwe (Govereh and Jayne 2003), Botswana (Timan *et al.,* 2004) and Malawi (Poulton *et al.,* 2004). These empirical studies confirm the positive role that smallholder agricultural commercialization play in in reducing rural poverty. On the other hand, smallholder agricultural commercialization has been criticized for the widening household income inequalities (Pingali and Rosegrant, 1995) and being an expensive undertaking especially for the poorest of smallholder farmers (Pingali *et al.,* 2005). It is on the basis of these inconclusive

empirical findings that Zhou *et al.,* (2013) have recommended further empirical research on the effects of agricultural commercialization to determine more convincing results.

The inconclusive impact assessment results of agricultural commercialization on household welfare could be due to lack of standardized definition and measurement of this concept and probably the type of data available together with the analytical methods used in past studies. While some authors have considered agricultural commercialization as growing of cash crops, others have defined agricultural commercialization as not limited to cash crops only because even food crops are sold for cash (von Braun *et al.,* 1994). Agricultural commercialization also can also occur on the input side (von Braun *et al.,* 1994). On the other hand, while Pingali and Rosegrant (1995) and Pingali (1997) have defined agricultural commercialization as production that purposively targets markets, Gebremedhin and Jaleta (2010) argued that agricultural commercialization is a combination of both market orientation and market participation. This study adopts the definition by Gebremedhin and Jaleta, (2010) i.e. produce offered for sale and use of purchased inputs in the production process though the later component of this definition (use of purchased inputs) is beyond the scope of this study due to data limitations. Therefore, based on this adopted definition, a more comprehensive household commercialization index (HCI) that incorporates all crop enterprises on the farm is developed and used.

Despite the pessimism arguments about smallholder commercialization, many SSA national governments and donors have prioritized commercialization of smallholder agriculture as a means of achieving poverty reduction (Leavy and Poulton, 2007). For example, in Kenya, the government has in the last one and half decade developed two economic blueprints (Economic Recovery Strategy and Kenya Vision 2030) that identified agriculture as the main economic pillar with agricultural commercialization as the main transformation driver of this sector (Republic of Kenya, 2010). The assumption in this kind of development approach is that agricultural commercialization is a viable "pro-poor" rural development strategy. However, empirical studies to ascertain this assumption in Kenya are very few if any. In fact, most of the past empirical studies in Kenya on the impact of agricultural commercialization either considered just one main crop on the farm or a few selected crop enterprises (Mathenge *et al.*, 2010; Zhou *et al.,* 2013; Muriithi and Matz 2015). Also, most of these past studies used cross sectional data and even those that used panel data like Muriithi and Matz (2015), they were based on pooled

regression models which assumes that the treatment variable (commercialization) is just an intercept shifter of the outcome variable (household welfare). This might not be true if the outcome variable is correlated with other household individual characteristics (observed and unobserved). Therefore, the current study aims at analyzing the impact of smallholder agricultural commercialization on household poverty using not just panel data but also endogenous switching regression (ESR) that estimates two outcome equations for each treatment group of households alongside the selection model.

The rest of the chapter is organized as follows:- Section 6.2 outlines methods used in assessing the impact of agricultural commercialization on household poverty. Results are presented and discussed in section 6.3. First, results based on descriptive statistics are presented and discussed followed by the econometric results before presenting the actual and counterfactual treatment effects that are estimated from the ESR model. Section 6.4 is devoted to the summary and conclusions while policy implications are outlined in section 6.5.

6.2 Methods

Evaluating the impact of a treatment using non-experimental data is very challenging because of the difficult involved in establishing a counterfactual against which impact can be assessed i.e. it is not possible to observe the treatment outcome variable on the treated group had it not been treated and the vice versa. In experimental studies, this problem can be addressed by randomly assigning the treatment to a given sample from the population of interest (Kassie *et al.*, 2014a). However, if the treatment is not randomly assigned, then the outcome variable observed on the treated and untreated groups is likely to be influenced by the observed and unobserved characteristics of each sample (treated and untreated samples).

Econometric approaches that have been adopted in past empirical studies to deal with this problem include propensity score matching (PSM) in a binary treatment framework, generalized propensity score (GPS) matching in a continuous treatment framework; instrumental variable (IV) approaches and switching regressions. PSM and GPS approaches control for observed but not unobserved heterogeneity. On the other hand, though IV frameworks control for both observed and unobserved heterogeneity, their treatment effect models with one selection equation and one outcome equation assumes that the impact can be represented as a simple parallel shift with respect to the outcome variable (Kassie *et al.*, 2014a). However, on the

contrary, the impact of the treatment on household welfare for treated and non-treated households could be different because the two groups of households may systematically have different characteristics (Kassie *et al.,* 2014a; Shiferaw *et al.,* 2014). The two-step switching regression frameworks on the other hand control for both observed and unobserved heterogeneity. These switching regressions also relax IV assumptions by estimating two separate treatment outcome equations alongside the selection model.

In this study, the impact of agricultural commercialization on household food security is modelled following the random utility formulation adapted from the non-separable household utility maximization theoretical model discussed in section 3.2 of this thesis. The two-step endogenous switching regression (ESR) model is specified to assess the impact of agricultural commercialization on household poverty following Lokshin and Sajaia (2004). The first step involves estimation of the binary selection model of commercialization decision based on Eqn. 6.1.

$$H_{it} = f(DC_{it}; PF_{it}; SC_{it}; TC_{it}) \quad (6.1)$$

Where:

H_{it} = Binary indicator of commercialization i.e. 1 if commercialized and 0 if otherwise

DC_{it} = Demographic characteristics of the households

PF_{it} = Physical and financial endowments of the households

SC_{it} = Social capital proxies of the household

TC_{it} = Transaction costs variables of the household

Subscript *i* and *t* indexes household and time, respectively

The second step of this ESR model involves two OLS regressions that estimate the poverty outcome of the household as it faces the two treatment regimes of commercializing or not commercializing. The two household poverty outcome functions conditional on commercialization decision are written in an endogenous switching regression regime model as follows:-

Regime 1: $Y_{Pit} = \beta_P X_{Pit} + \varepsilon_{Pit}$: If $H_{it} = 1$ (6.2a)

Regime 2: $Y_{Nit} = \beta_N X_{Nit} + \varepsilon_{Nit}$: If $H_{it} = 0$ (6.2b)

Where:

Y_{Pit} = Outcome indicator variables of agricultural commercialization for commercialized household *i* at time *t* (per capita annual household expenditure on food and non-food items including own produced and consumed food)

Y_{Nit} = Outcome indicator variables of agricultural commercialization for non-commercialized household *i* at time *t* (per capita annual household expenditure on food and non- food items including own produced and consumed food)

X_{Pit} = Observed vectors of covariates determining agricultural commercialization outcome (poverty) for commercialized household *i* at time *t*

X_{Nit} = Observed vectors of covariates determining agricultural commercialization outcome (poverty) for non-commercialized household *i* at time *t*

β_P and β_N = Vectors of parameters to be estimated

ε_{pit} and ε_{Nit} = Error terms that are normally distributed with zero mean and constant variance

For ESR model to be identified, it is important for the explanatory variables in Eqn. 6.1 (selection model) to contain at least one selection instrument in addition to those automatically generated by the non-linearity of the selection model of commercialization (Kassie *et al.,* 2014a; Shiferaw *et al.,* 2014). These instrument variables should affect directly the endogenous selection variable (commercialization) but not the outcome variables (household poverty). In this study, all the transaction costs outlined in Eqn. 6.1 were selection instrument candidates subject to verification to ascertain their suitability as valid instruments. It was hypothesized that transaction costs affect agricultural commercialization more directly and only affect household poverty outcome (annual per capita household expenditure) indirectly through agricultural commercialization. Since Y_{Pit} and Y_{Nit} are not observed simultaneously (they are mutually exclusive), the covariance between ε_{Pi} and ε_{Ni} is not defined (Maddala, 1983; Lokshin and Sajaia, 2004). Therefore, Eqn. 6.2a and Eqn. 6.2b are used to estimate the average counterfactual household poverty outcome distribution i.e. what could have been the household poverty outcome of the commercialized households had they not commercialized and the vice versa.

Following the wage decomposition literature by Oaxaca (1973), this ESR analytical framework is also used to decompose the household poverty outcome gap between commercialized and non-commercialized households. The poverty gap is decomposed into the portion that is caused by differences in the amount of resources held by the two groups of households (quantity or level effect) and that component due to differences in the resource use efficiency (efficiency or return effect). The actual expected poverty outcomes for commercialized and non-commercialized households are computed using Eqn. 6.3a and Eqn. 6.3b, respectively. On the other hand, the counterfactual expected poverty outcome are estimated using Eqn. 6.4a and Eqn. 6.4b for commercialized and non-commercialized households, respectively.

Actual scenarios (observed from the sample data):

Commercialized: $E(Y_{Pit} \backslash H = 1; X) = \beta_P X_{Pit} + \gamma_{P\varepsilon}\lambda_{Pit} - - - - - - - - - - - - - (6.3a)$

Non-commercialized: $E(Y_{Nit} \backslash H = 0; X) = \beta_N X_{Nit} + \gamma_{N\varepsilon}\lambda_{Nit} - - - - - - - - - - (6.3b)$

Counterfactual scenarios:

Commercialized if they didn't commercialize: $E(Y_{Pit} \backslash H = 0; X) = \beta_P X_{Nit} + \gamma_{P\varepsilon}\lambda_{Nit} - - (6.4a)$

Non-commercialized if they commercialized: $E(Y_{Nit} \backslash H = 1; X) = \beta_N X_{Pit} + \gamma_{N\varepsilon}\lambda_{Pit} - - (6.4b)$

Applying these conditional expectations and using commercialization as the treatment variable, decomposition of the observed poverty outcome gap between commercialized and non-commercialized households (Eqn. 6.3a less Eqn. 6.3b) is computed as shown in Table 13. The difference in poverty outcome of commercialized households emanating from their differences in efficiency of use of their currently held resources compared to the efficiency of non-commercialized households is obtained by subtracting Eqn. 6.4a from Eqn. 6.3a. Similarly, the difference in poverty outcome of non-commercialized households emanating from their differences in efficiency of use of their currently held resources compared to the efficiency of commercialized households is obtained by subtracting Eqn. 6.3b from Eqn. 6.4b (Table 13). On the other hand, the difference in poverty outcome of commercialized households as a result of their differences in the amount of resources held compared to the amount of resources held by non-commercialized households, holding efficiency constant, is obtained by subtracting Eqn. 6.3b from Eqn. 6.4a. Finally, the difference in poverty outcome of non-commercialized households originating from their differences in the amount of resources held by commercialized

household, holding their resource use efficiency constant, is obtained by subtracting Eqn. 6.4b from Eqn. 6.3a (Table 13).

Table 13. Conditional expectations, treatment effects and heterogeneity effects

Household type	Market participating households' response to characteristics	Non-market participating households' response to characteristics	Returns effects (difference caused by difference in resource use efficiency)
Commercialized households	(6.3a) $E(Y_{Pi}/H=1)$	(6.4a) $E(Y_{Ni}/H=1)$	(6.3a) – (6.4a)
Non-commercialized households	(6.4b) $E(Y_{Pi}/H=0)$	(6.3b) $E(Y_{Ni}/H=0)$	(6.4b) – (6.3b)
Level effect (difference caused by differences in resource quantities)	LE_N = (6.3a) – 6.4b)	LE_P = (6.4a) – (6.3b)	(6.3a) – (6.3b)

Source: Author's compilation

6.2.1 Variable definition and measurement

Dependent variables: In the first-step of the two-step ESR, the binary estimation of the determinants of agricultural commercialization based on Eqn. 6.1 is estimated using the probit model where the dependent variable is binary i.e. 1 if the household is commercialized and 0 if not commercialized. On the other hand, the second step of the ESR is based on the OLS estimation of Eqn. 6.2a and Eqn. 6.2b where unlike in the first step, the dependent variable in both equations (average annual per capita household expenditure on food and non-food items including own produced and consumed foods) is a continuous variable (Table 13).

Independent variables: In the first–step probit estimation of the determinants of agricultural commercialization, the independent variables were exactly similar to those that were used in the first-step of the double hurdle model discussed in chapter four (Table 2). As already mentioned, transaction costs explanatory variables were assessed for their suitability as instrument variables using a simple falsification test following Di Falco *et al.*, (2011) and Kassie *et al.*, (2014a). Those transaction costs variables that passed the suitability test were used accordingly. The summary definition and measurement of independent variables are shown in Table 14.

Table 14. Definition and measurement of variables in impact assessment of agricultural commercialization on household poverty

Variable definition	Variable measurement	Expected sign	
		Selection model	Outcome model: Household poverty
Dependent variables:			
Output market participation	Binary (1=Participating; 0=Otherwise)	√	na
Household poverty	Continuous (average annual per capita household expenditure on food and non-food items including own produced and consumed foods)	na	√
Independent variables:			
a) Demographic characteristics:			
Household head sex	Binary (1=Male; 0=Otherwise)	+	+
Household head age	Continuous (years)	+	-
Household head education	Continuous (years)	+	+
Household size	Continuous (number of adult equivalents)	+/-	-
Dependency ratio	Continuous (ratio >=0)	+/-	-
Household size/dependence ratio interaction term	Continuous (interaction term i.e. household size * dependence ratio)	na	-
b) Physical & financial assets:			
Livestock owned	Continuous (Tropical Livestock Units i.e. TLU)	+	+
Per capita own farm size	Continuous (ha/adult equivalent)	+	+
Weighted mean soil fertility score of cultivated plots	Continuous (mean soil fertility score)	+	+
Total annual non-farm income	Continuous (KSh)	+/-	+/-
Access to agricultural input credit	Binary (1=Yes; 0=Otherwise)	+	+
Contacts with agricultural extension staff	Binary (1=Yes; 0=Otherwise)	+	+
Ox-plough ownership	Binary (1=Yes; 0=Otherwise)	na	+
c) Social capital: Membership to agricultural production networks/groups (APN)	Binary (1=Yes; 0=Otherwise)	+	+
Number of dependable relatives in village	Continuous (absolute numbers)	+	+
Trust grain traders	Binary (1=Yes; 0=Otherwise)	+	+
d) Transaction costs:			
Mobile phone ownership	Binary (1=Yes; 0=Otherwise)	+	+

Average transport cost to main market	Continuous (KSh/person/trip)	-	na
Own any local transport means (bicycle, carts, wheelbarrow, motorbike)	Binary (1=Yes; 0=Otherwise)	+	+
Regional dummy	Binary (1=Eastern; 0=Western)	+/-	+/-

Source: Author's compilation
Note: na stands for not applicable

6.2.2 Estimation strategy for the endogenous switching regression (ESR)

This study applies a hybrid of random effects (RE) and fixed effects (FE) panel data method called correlated random effects (CRE). The CRE framework produces FE estimates while at the same time it allows the inclusion of time invariant variables as explanatory variables in the same way RE estimates are generated (Wooldridge, 2010; Cameron and Trivedi, 2009). The time varying explanatory variables were averaged across the two panel periods to form the *Mundlak-Chamberlain* device (Wooldridge, 2010). The detailed definition and measurement of these variables were as indicated in Table 14.

The efficient method to estimate ESR models is by full information maximum likelihood (FIML) estimation (Lokshin and Sajaia, 2004). An alternative estimation method is fitting one equation at a time by either 2SLS or maximum likelihood estimation. However, these later methods are less efficient than FIML because they requires some potentially cumbersome adjustments to derive consistent standard errors (Lokshin and Sajaia, 2004) and they also show poor performance in case of high multicollinearity between the covariates of the selection model (Maddala, 1983). On the other hand, the full information maximum likelihood (FIML) can be utilized to simultaneously fit the selection (binary) model and the outcome (continuous or binary) parts of the model to yield consistent standard errors. This approach according to Lokshin and Sajaia, (2004) relies on joint normality of the error terms in the selection and outcome equations.

6.3 Results and discussions

This section presents the descriptive statistics of the variables in the ESR model that was used to analyze the impact of agricultural commercialization on household poverty. Thereafter, the ESR econometric results on the determinants of household poverty among the commercialized and non-commercialized households are presented and discussed. However, particular focus of this chapter is on the results from the counterfactual analysis conducted from the ESR model to

estimate the poverty gap between the commercialized and non-commercialized households and the subsequent decomposition of the estimated poverty gap.

6.3.1 Descriptive statistics

The descriptive statistics of the variables used in the ESR under this section were exactly like those used in section 4.3.1 of chapter four and section 5.3.1 of chapter five. Therefore, these descriptive statistics are not presented and discussed in this section to avoid repetition. However, it is important to mention that the dependent variable in the outcome model of this section i.e. per capita household annual expenditure on food and non-food items including own produced and consumed crops was not included in the previous descriptive statistics of chapter four and chapter five. Therefore, the descriptive statistics of this outcome variable disaggregated by the treatment regime (commercialized and non-commercialized) were as presented in Figure 3. Overall, the average per capita annual household expenditure on food and non-food items including own produced and consumed food among the surveyed households was about Ksh. 31,414. On the other hand, the average per capita annual household expenditure of commercialized households was about KSh. 34,423 while that of non-commercialized households was about KSh. 22,617. The t-test for significance of the difference in the means of per capita annual household expenditure between the two groups of households showed a statistically significant difference at 1% when equal variance was assumed.

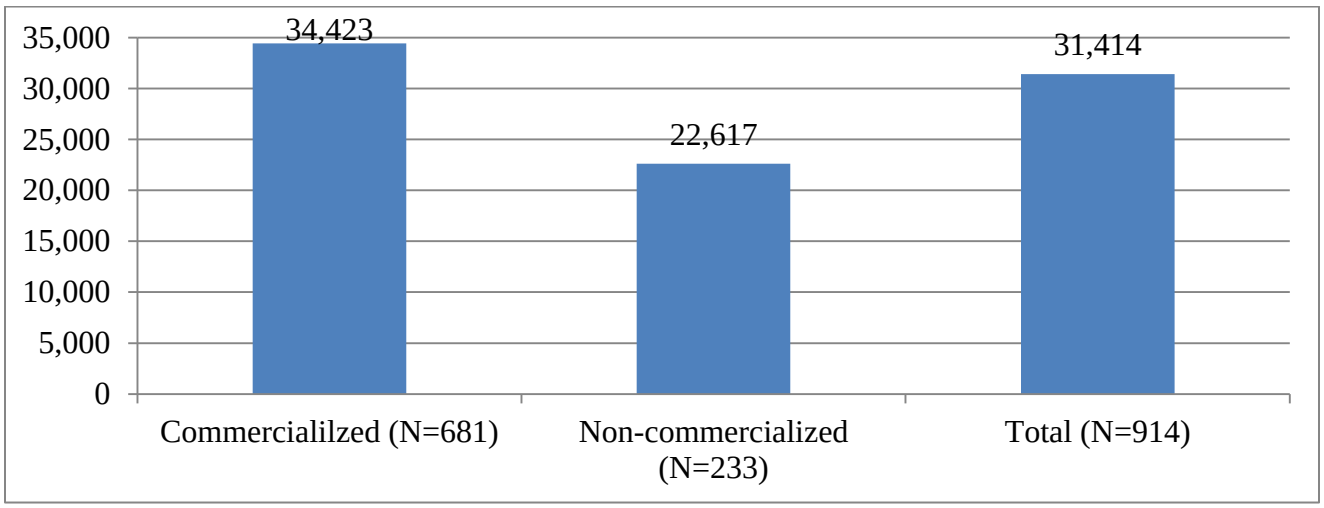

Figure 3. Average per capita annual household expenditure on food and non-food items (KSh/adult equivalent)
Source: Author's compilation

Also, exploratory descriptive analysis of the data revealed a positive relationship between the poverty outcome measure and the commercialization intensity. The results showed that per capita annual household expenditure increases at an increasing rate as commercialization intensity increases up to about 0.3 when it continues increasing but at a decreasing rate (Figure 4). This means that the commercialization intensity point of 0.3 (or 30%) is the point of inflexion. Generally, the results presented in Figure 4 show that per capita annual household expenditure increases progressively with an increase in the intensity of agricultural commercialization. This non-parametric analysis clearly indicates the importance of commercialization in addressing the poverty problem among the rural smallholder farming households. Given that the average commercialization intensity among commercialized farmers is about 0.37 of 37% (Table 3), this means that policies that can increase commercialization intensity even further are needed to reduce poverty among the targeted households.

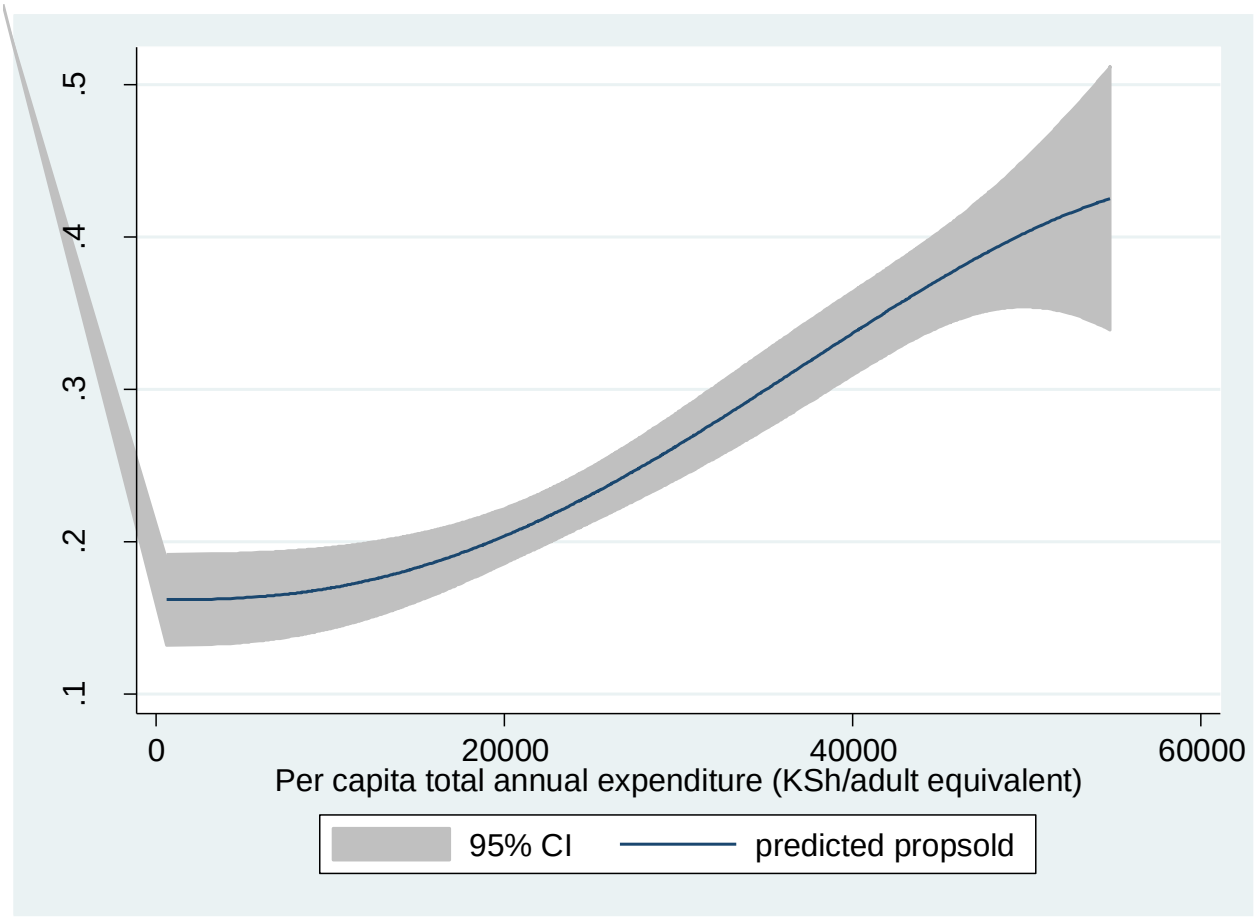

Figure 4. Relationship between per capita expenditure and agricultural commercialization intensity

Source: Author's compilation

6.3.2 Econometric results

The econometric results of the ESR model used to assess the impact of agricultural commercialization on household poverty are as presented in Table 15. Again, the results from the selection model are not discussed in this section because they are exactly similar to the ones presented in Table 5 and discussed exhaustively under section 4.3.2 of chapter four. Therefore, this section delves directly into the determinants of poverty among the commercialized and non-commercialized households as presented in Table 15. Since the outcome models were estimated using OLS method, the coefficients were interpreted directly as marginal contribution of the independent variable to the dependent variable.

A simple falsification procedure following Lokshin and Glinskaya (2009), Di Falco *et al.,* (2011) and Kassie *et al.,* (2014a) was used to test the validity of instrument variables that were to be used in identifying this ESR model. This test involved estimation of a probit model to assess the determinants of agricultural commercialization among the sampled households and an OLS model to assess the determinants of household poverty outcome among the surveyed households. In both models, same explanatory variables were used and a valid instrument was the transaction costs variable/s that significantly determined the commercialization decision but was insignificant in determining the household poverty outcome. The results of this test showed that transport costs to the main market was the only variable that passed this verification tests i.e. significantly affected the decision to commercialize but was insignificant in determining the household poverty outcome (Appendix 2). Therefore, transport cost to the main market was used as a valid instrument in the subsequent ESR model. Similarly, the test for endogeneity of the treatment (agricultural commercialization) returned an IMR of -696.1274 that was statistically significant at 1%. This implied that the treatment variable (agricultural commercialization) was endogenous thus justifying the use of ESR.

Turning back to the regression results, household demographic variables that affected household poverty outcome significantly were education of the household head, household size, dependence ratio and interaction term of household size and dependence ratio. Education level of the household head had a positive and significant "between-household" effect on average annual per capita household expenditure among commercialized and non-commercialized households (Table 15). A commercialized household whose head had one additional year of education was

likely to have about KSh. 667 more of per capita annual household expenditure compared to a similar household whose household head had one year less of education. Similarly, a non-commercialized household whose household head had one more year of education was likely to have KSh. 541 more per capita annual household expenditure compared to a similar household whose household head had one year less of education (Table 15). The positive and significant "between-household" effect of education level on household annual per capita expenditure could be related to the possibility that higher education level of the household head enables commercialized households to accurately process market information. This accurate processing of market information enables commercialized households to access niche markets as compared to those who are less educated (Jaleta *et al.*, 2009). While for non-commercialized households, this finding might be attributed to the possibility that they might be deriving most of their income from non-farm activities like salaried employment where higher levels of education is critical.

Household size and dependence ratio had a negative "within-household" effect on the average annual household expenditure (Table 15). However, these two variables were only significant among non-commercialized households i.e. they were likely to increase poverty in this group of households. A unit increase in household size of non-commercialized household was likely to reduce its average annual household expenditure by about KSh. 2,062 while on the other hand, a unit increase in dependence ratio was likely to reduce annual per capita household expenditure by about KSh. 10,839. Dependence ratio also had a significant though unexpectedly positive "between-household" effect on the average annual household per capita expenditure of non-commercialized households (Table 15). A non-commercialized household with one more unit of dependence ratio was likely to have about KSh. 12,128 more of average per capita annual expenditure compared to a similar household with one unit less of dependence ratio. The negative and significant "within-household" effect of household size on the average annual household per capita expenditure among non-commercialized households might have been as a result of limited growth in household income compared to increases in household size. Also, the negative and significant "within-household" relationships of dependence ratio with average annual household per capita expenditure among non-commercialized households could be associated with the possibility that non-commercialized households might be more dependent on household family labour that is engaged in non-farm income generating activities to raise more income. Therefore a high dependence ratio implies less income and thus less per capita annual

expenditure (higher poverty outcome). The unexpected positive and significant "between-household" effect of dependence ratio on average annual per capita household expenditure could have been as a result of those with high dependence ratio working extra hard to earn more income.

However, a surprising and unexpected finding was the positive and significant effect of the household size/dependence ratio interaction term's "within-household" effect on average annual household per capita expenditure among the non-commercialized households (Table 15). Theoretically, this variable was expected to have a negative effect on average annual household per capita expenditure because as a household's size grows bigger with increased dependence ratio, it is likely to strain its available resources thereby lowering its average annual household per capita expenditure (increasing its poverty level). One explanation to this unexpected result could be that as a household's grows bigger in size with increasing dependence ratio, the working members of such a household work extra harder to provide for the dependent household members. This means that complacency effect might be at play among the non-commercialized households that have smaller household sizes with decreasing dependence ratio. On the other hand, the "between-household" effect of this interaction term was negative and significant among non-commercialized households as it had been expected theoretically (Table 15). A household that has a bigger household size and higher dependence ratio is likely to have lower per capita annual household expenditure compared to a similar household that has a smaller household size and lower dependence ratio.

Among the physical and financial asset variables, livestock asset base (TLU) had a positive and significant "between-household" effect on average annual per capita household expenditure of commercialized households. Commercialized households with 100% more of TLU was likely to have about KSh. 264 more of average annual household per capita expenditure compared to a similar household that had 100% less of TLU (Table 15). This positive effect might be associated with the fact that commercialized households could be using their livestock wealth to boost their agricultural productivity in two ways. First, they could be using the farm yard manure to improve their soil fertility and thereby producing surplus crops for the market that eventually boost their annual per capita expenditure. Secondly, they could be selling some of their livestock to buy crop productivity enhancing inputs like improved seed and/or fertilizer.

Per capita own farm size had a positive and significant "within-household" effect on average annual household per capita expenditure among the non-commercialized households (Table 15). Holding all else constant, an increase in per capita owned farm size by one hectare for a non-commercialized household was likely to increase its average annual household per capita expenditure by about KSh. 45,073. This result could be influenced by the possibility that non-commercialized households could be renting out land to commercialized households thereby earning extra income. However, this relationship is quadratic because when per capita own farm size variable was squared, it had a negative and significant "within-household" relationship with average annual household per capita expenditure among the non-commercialized households (Table 15).

The econometric results also showed that non-farm income had a positive and significant "between-household" effect on the average annual per capita household expenditure of non-commercialized households. A non-commercialized household with 100% more average annual non-farm income was likely to have about KSh. 161 more of per capita annual household expenditure compared to a similar household that had 100% less of average annual non-farm income. The reasons for this kind of relationship among non-commercialized household could be that non-farm income received by this group of households is likely to be re-invested in other income generating non-farm activities. For example, salaried income by non-commercialized could be partly re-invested in other income generating activities like retail shops that generate more income which eventually boosts their annual expenditure.

Also, access to agricultural credit had a positive and significant "within-household" effect on the average annual household per capita expenditure of commercialized households. However, this same variable had a negative and significant "between-household" effect on average annual household per capita expenditure of same commercialized households. The positive and significant "within-household" effect showed that a commercialized household that accesses credit over time to buy agricultural inputs was likely to increase its per capita annual household expenditure by about KSh. 8,983 (Table 15). This finding clearly indicates that credit access is very critical in enabling commercialized households increase their expenditures and thereby reduces poverty prevalence. On the other hand, the negative and significant "between-household" effect of agricultural credit on poverty outcome among the same group of

commercialized households was contrary to what was theoretically expected. A commercialized household that receives agricultural credit was likely to have lower per capita annual expenditure of almost KSh. 7,656 annually compared to a similar commercialized household that did not access this agricultural credit (Table 15). This unexpected finding could be due to misuse of credit received by commercialized household and this finding call for proper training of these households on how to use their agricultural input credit more prudently.

Table 15. Endogenous Switching Regression: Impact of agricultural commercialization on household poverty outcome

Variable label	Selection model		Poverty outcome			
			Commercialized households		Non-commercialized households	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Demographic characteristics:						
Household head sex	-0.0903	0.1546	1,610.09	2,132.17	1,968.45	1,912.95
Household head age	0.0089	0.0144	230.47	189.75	-49.91	173.74
Household head education	0.0342**	0.0167	666.71***	211.20	541.40***	203.66
Household size	0.0265	0.0627	-1,567.85	1,085.21	-2,061.63**	893.77
Dependence ratio	-0.0539	0.1280	-3,740.54	3,783.63	-10,838.77***	3,861.54
Household size/dependence ration interaction	na	na	-237.18	722.54	1,707.58***	601.09
Physical and financial capital:						
Owned livestock size	0.0147*	0.0080	-26.88	108.25	9.57	95.84
Per capita owned land	3.8204**	1.6995	18,521.26	22,020.81	45,073.29*	25,599.92
Per capita owned land squared	-1.7225**	0.8657	-6,576.31	14,008.38	-20,016.79*	11,940.53
Soil fertility score	-0.1511	0.1283	1,816.39	1,744.63	218.82	1,563.11
Annual non-farm income	-0.0093*	0.0049	33.42	58.14	-58.82	64.08
Got agricultural input credit	0.0569	0.2492	8,982.69***	2,739.17	-3,116.24	3,845.29
Contacts with extension	0.2137	0.1554	1,352.23	1,969.15	-352.32	2,036.03
Social capital:						
Membership to APNs	0.5515***	0.1153	8,345.60***	1,561.23	7,796.03***	1,548.10
Dependable relatives in village	0.0010	0.0051	257.90***	64.12	4.69	62.76
Trust grain traders	0.1804	0.1203	-1,667.13	1,574.00	559.78	1,488.80
Transaction costs:						
Own mobile phone	0.8913***	0.2171	7,600.09**	3,399.05	3,239.94	2,486.59
Transport to nearest main market	-0.0156**	0.0078	na	na	na	na
Own transport means	0.1327	0.1125	2,832.62*	1,525.52	149.30	1,415.56
Regional dummy	0.9400***	0.1405	-2,971.68*	1,711.38	3,624.68*	2,021.69
Mundlak-Chamberlain device:						
Household head age	-0.0116	0.0151	-280.53	199.14	36.83	183.56

Household size	-0.0342	0.0692	-1,337.13	1,229.16	923.74	1,049.18
Dependence ratio	0.1346	0.1500	-3,701.46	4,730.75	12,127.64**	4,948.33
Household size/dependence ration interaction	na	na	702.69	869.60	-2,100.51**	832.32
Owned livestock size	-0.0063	0.0107	264.39*	147.66	-52.74	128.06
Per capita owned land	-1.6208	1.7661	-9,240.01	21,611.01	-37,936.59	27,232.64
Per capita owned land squared	0.3784	0.9639	4,588.53	12,779.83	16,764.26	15,276.34
Soil fertility score	0.4152**	0.1753	252.53	2,239.83	-1,275.81	2,320.62
Annual non-farm income	0.0078	0.0064	75.50	75.75	161.21*	88.02
Got agricultural input credit	0.7084**	0.3317	-7,655.74***	3,833.21	-1,827.38	4,588.79
Contacts with extension	-0.1432	0.2137	2,224.00	2,734.12	2,728.66	2,728.77
Own mobile phone	-0.2894	0.2895	-2,643.33	4,008.93	-469.69	3,501.43
Constants	-1.7167***	0.4261	31,372.88***	6,611.70	19,051.30***	5,181.93

Significance level: *** at 1%; ** at 5%; * at 10%

Model description

Selection model (Probit)	**Outcome model (OLS)**	
	Commercialized hholds	**Non-commercialized hholds**
Number of obs = 914	Number of obs = 681	Number of obs = 233
LR chi2(30) = 244.88	F(31, 649) = 9.23	F(31, 201) = 3.42
Prob > chi2 = 0.0000	Prob > F = 0.0000	Prob > F = 0.0000
Pseudo R2 = 0.2360	R-squared = 0.3060	R-squared = 0.3453
Log likelihood = -396.4215	Adj R-squared = 0.2729	Adj R-squared = 0.2443
	Root MSE = 17219	Root MSE = 9290

Source: Author's computations
Note: na stands for not applicable

From a social capital point of view, membership to agricultural production networks/groups (APNs) was found to have a positive and significant "between-household" effect on average per capita annual household expenditure among commercialized and non-commercialized households (Table 15). A commercialized household that belonged to an APN was likely to have a higher per capita annual household expenditure of up to about KSh. 8,346 compared to a similar commercialized household that was not a member of an APN. Similarly, a non-commercialized household that belonged to an APN was likely to have a higher per capita household annual expenditure of up to almost KSh. 7,796 compared to a similar non-commercialized household that was not a member of any APN. These results on APN membership highlight the importance of informal institutions in addressing rampant poverty among the rural farming households. Past empirical literature has demonstrated that these types of informal rural institutions play an important role in easing households' ability to access markets and other important services like credit and improved technologies (Shiferaw *et al.*, 2008, Govereh and Jayne 2003).

Another important social capital variable that was found to have a significant "between-household" effect on the average annual household per capita expenditure was the number of dependable relatives living in the same village with the sampled household. There was a positive and significant "between-household" effect of the number of dependable relatives in the same village on annual household per capita expenditure among the commercialized households. A commercialized household that had one more dependable relative living in the same village was likely to have a higher per capita annual household expenditure of almost KSh. 258 compared to a similar household that had one less dependable relative living in the same village (Table 15). This finding could be associated with the possibility that with more relatives in the same village, commercialized households might be tempted to increase their risk taking attitude because these relatives act as a source of reliable technology information and also as insurance against future risk. With reduced risk, these commercialized households might be in a better position to adopt riskier but more productive agricultural technologies that end up paying off in terms of good yields and thus higher incomes.

Household ownership of mobile phone had a positive and significant "within-household" effect on per capita household annual expenditure among commercialized (Table 15). By owning a

mobile phone, a commercialized household was likely to have about KSh. 7,600 more of annual household per capita expenditure compared to as when it did not own a mobile phone. This relationships could be attributed to the possibility that a commercialized household that owns a mobile phone uses it to collect market information for their farm products (see its positive and significant impact on the decision and intensity of agricultural commercialization in chapter four).

Ownership of any of the local transportation means (that is, bicycle, wheelbarrow, ox/donkey carts) was found to have had a positive and significant "between-household" effect on the per capita annual household expenditure among commercialized households. The per capita annual household expenditure of a commercialized household that owned either of these local means of transport was likely to be higher by almost KSh. 2,833 compared to a similar commercialized household that did not own any of these local means of transport (Table 15). This means that ownership of these transport equipment could enable commercialized households access niche markets thus earning more income which in turn increases their disposable income to spend.

Lastly, regional location of the households had a significant "between-household" effect on the per capita annual household expenditure among the surveyed households. A commercialized household located in eastern Kenya was likely to have a lower per capita annual household expenditure of almost KSh. 2,972 compared to a similar commercialized household located in western Kenya (Table 15). This result means that commercialized households in western Kenya are likely to be richer than their counterparts from eastern Kenya. On the other hand, a non-commercialized household in eastern Kenya was likely to have a higher per capita annual household expenditure of about KSh. 3,625 than a similar non-commercialized household in western Kenya. This latter finding could mean that there might be more non-farm opportunities in eastern Kenya where non-commercialized households could derive their income compared to western Kenya.

6.3.3 Treatment effects of agricultural commercialization on household poverty

Following the same approach adopted in chapter five of disentangling the impacts of agricultural commercialization on household food security, this section presents and discusses the results of the impact of agricultural commercialization on household poverty (per capita annual household

expenditure on food and non-food items including the value of own produced and consumed food). The per capita annual household expenditure is compared under actual and counterfactual scenarios for the commercialized and non-commercialized households generated from ESR with a probit and OLS models as presented in Table 16.

The statistics reported in cell (a) and cells (b) of Table 16 were generated from Eqn. 6.3a and Eqn. 6.3b, respectively. The figures in cell (a) and cell (b) represent the actual (observed) per capita annual household expenditure for commercialized and non-commercialized households, respectively, as observed from the sample. Therefore, the average per capita household annual expenditure among the commercialized households as generated from Eqn. 6.3a was about KSh. 34,423 while that of non-commercialized households generated using Eqn. 6.3b was KSh. 22,617. These figures are perfectly in agreement with those generated using descriptive statistics as presented in Figure 3 which were statistically different at 1% level of significance. A quick comparison of these two figures reveals that commercialized households have about KSh. 11,807 advantage of per capita annual household expenditure over their non-commercialized counterparts. Theoretical and empirical literature of ESR (Mare and Winship 1987, Lokshin and Sajaia 2004, Lokshin and Sajaia 2011, Kassie *et al.,* 2014a) show that this quick and direct comparison might not tell so much without isolating (decomposing) the causes of this poverty gap between the two groups of households.

Table 16. Average Expected household poverty outcome

Type of household	Household poverty outcomes (Per capita annual household expenditure – KSh/adult equivalent)		
	Commercialized characteristics	Non-commercialized characteristics	Returns effects
Commercialized (N=681)	34,423 (a)	27,376 (d)	7,047***
Non-commercialized (N=233)	27,792 (c)	22,617 (b)	5,176***
Level effects	6,631***	4,760***	**11,807**

Significance level: *** at 1%; ** at 5%; * at 10%
Source: Author's computations

Following Oaxaca (1973) wage decomposition framework, the per capita annual household expenditure difference (poverty gap) of KSh. 11,807 can be decomposed into two components. First, there is the component arising from the differences in the amounts of the resources that commercialized and non-commercialized households hold. Secondly, there is the component due

to the differences in resource use efficiency between the two groups of households. The poverty gap arising from differences in amounts of resources held is normally referred to as the level effect while that emanating from resource use efficiency differences is called the returns effect.

Therefore, starting with the returns effect, the results presented in Table 16 shows that if commercialized households had their current level of resources, and hypothetically adopted the resource use efficiency level of the non-commercialized households, then the former's per capita annual household expenditure could reduce significantly by about KSh. 7,047 i.e. cell (a) less cell (b) in Table 16. On the other hand, if non-commercialized households were to have hypothetically the same efficiency level like that of commercialized households while holding the former group's resource amounts constant, then their per capita annual household expenditure could increase significantly by about KSh. 5,176 i.e. cell (c) minus cell (b) in Table 16. These results imply that improving the resource use efficiency levels of non-commercialized households only will not be able to close the observed poverty gap between commercialized and non-commercialized households because that will only reduce the poverty gap by about KSh. 5,176 (44 percentage points).

The analysis of level or resource amount effect shows that if the non-commercialized households were to have the same amount of resources like the ones held by the commercialized households while keeping their resource use efficiency levels constant, then the non-commercialized households' per capita annual household expenditure could increase significantly by about KSh. 6,631 i.e. cell (a) less cell (c) in Table 16. Similarly, if the commercialized households were to have the same amount of resources like what non-commercialized households have while keeping their resource use efficiency level constant, then the former's per capita annual household expenditure could significantly decrease by almost KSh. 4,760 i.e. cell (d) less cell (b) in Table 16. The implication of this finding, like in the previous returns effect, is that boosting the amount of resources held by the non-commercialized households alone will not close the observed poverty gap between commercialized and non-commercialized households. Instead, such approach will only manage to reduce the poverty gap by about KSh. 6,631 (56 percentage points).

6.4 Summary and conclusions

There exists inconclusive theoretical and empirical literature on the impact of agricultural commercialization on smallholder welfare. Despite this research gap, many developing countries with majority of their population engaged in smallholder agriculture continue to pursue this agricultural sector transformation process. The justification for such policy approaches has been that the negative impacts of agricultural commercialization have been methodologically flawed and where real negative evidence exists, then it has been more of policy failures rather than commercialization process per se. Therefore, where the intended positive impacts of agricultural commercialization have not been achieved, then there is need for "social engineering" to ensure that those benefits of commercialization reach the targeted group of households.

Using a more innovative analytical model applied mostly in labour economics and agricultural technology adoption studies, the current study fits an endogenous switching regression (ESR) model on household level panel data collected from rural smallholder farming households in Kenya to analyze the impact of agricultural commercialization on household poverty. The results show that household demographic characteristics are more important in explaining the household poverty outcome (per capita annual household expenditure) among non-commercialized than commercialized households. On the other hand, transaction costs variables are more important in determining the poverty outcome among commercialized than non-commercialized households. Demographic characteristic like education level of the household head and social capital variable i.e. membership to agricultural production networks (APNs) are very important in reducing poverty (increasing annual per capita household expenditure) among both commercialized and non-commercialized households. Therefore, poverty could substantially be reduced among the surveyed households if education level can be improved and households enabled to join APNs. Also, it is equally important to note that easing of transaction costs is particularly critical in reducing poverty among commercialized households who depend on markets to earn their incomes.

Impact analysis of agricultural commercialization on household poverty level showed that agricultural commercialization is a viable way of tackling poverty among the rural smallholder farming households. Commercialized households stand to lose a significant amount of their average per capital annual household expenditure if they were not to commercialize. On the

other hand, non-commercialized households will benefit significantly by increased per capita annual household expenditure if they were to commercialize. Decomposing the observed poverty gap between commercialized and non-commercialized households shows that by improving the resource use efficiency level of non-commercialized households only will not be able to close this gap because this will only reduce the gap by about 44 percentage points. The other 56 percentage points can only be covered if the amount of resources currently held by non-commercialized households can be improved. This means that the current poverty gap between commercialized and non-commercialized (in favour of commercialized households) can only be closed completely if both efficiency and resource amount issues among the non-commercialized households can be improved to the level of commercialized households. Therefore, contrary to the doubts that have existed in theoretical and empirical literature, this particular empirical study demonstrates that agricultural commercialization can effectively address the rampant poverty among the rural smallholder farming households.

6.5 Policy implications

The empirical findings in this study have demonstrated that smallholder agricultural commercialization can significantly increase average annual per capita household expenditure (reduce poverty). The implication of these findings is that there is need to develop policy interventions that can fast track commercialization process of the non-commercialized households and increase the commercialization intensity of the already commercialized households. Such policy interventions are as detailed in section 4.5 of this thesis. These prescribed policies are likely to assist in stimulating and enhancing smallholder agricultural commercialization. They are also the best bet for boosting the resource level base and resource use efficiency of non-commercialized households that will be critical in increasing household per capita expenditure and thus reducing poverty among this group of households.

CHAPTER SEVEN: SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

The first section of this chapter summarizes the background information of the study including the problem on which the study is anchored. It also gives an overview of the methods used and the main results. Thereafter, conclusions based on the key findings are outline. On the other hand, the second part of the chapter gives an overview of the policy implications of the key findings.

7.1. Summary and Conclusion

There exists abundant and largely uncontested empirical literature that has demonstrated how food insecurity and poverty are characteristic features of rural farming communities in many developing countries including Kenya. Various public and private efforts have been put in place to address these twin rural problems with agricultural commercialization having taken the center stage especially in Kenya as clearly elaborated in various government development blue prints (e.g. Swynnerton Plan 1954; Sessional Paper No. 10 of 1965; Sessional Paper No. 1 of 1986; Economic Recovery Strategy of 2003; Kenya Vision 2030 of 2008; Agricultural Sector Development Strategy 2010-2020 and Strategy for Revitalizing Agriculture). However, to date, a non-trivial proportion of rural farming households are still practicing subsistence farming. Furthermore, despite the fact that smallholder agricultural producers account for over 70% of marketed agricultural products in Kenya, only 20% of market participating households control over two thirds of the marketed volumes. Yet little empirical evidence exists on what drives or hinters these households from commercializing their agricultural enterprises. Similarly there is a dearth of empirical literature, especially in Kenya, to demonstrate the impact of agricultural commercialization in addressing rural food insecurity and poverty. This study therefore shades light on the drivers of smallholder agricultural commercialization in Kenya and empirically analyzes the impact of this agricultural transformation process on smallholder rural farming households' welfare (food security and poverty). The study uses household level two-wave panel data and more innovative analytical methods.

While there is no universally agreed definition of agricultural commercialization, this study adopted the definition that regards agricultural commercialization as participation in agricultural crop output markets as sellers. Similarly, household welfare has no universally accepted definition. However, for the purposes of this study, welfare has been defined as food security and poverty. Food security

is based on household self-assessment of food security i.e. whether the household was food secure or not after considering all sources of food in the past twelve months. Poverty was measured by annual household per capita expenditure on food and non-food items including the value of own produced and consumed food crops. Therefore, a comprehensive household commercialization index based on the value of all crops produced and marketed within one cropping year was developed and used.

The determinants of the binary decision to commercialize or not to commercialize and the continuous decision of commercialization intensity conditional on having decided to commercialize were simultaneously analyzed using the two-tier double hurdle model. On the other hand, the impacts of agricultural commercialization on household welfare were assessed using the endogenous switching regression approach that accounts for both the observable and unobservable covariates in a counterfactual framework. Both, the two-tier double hurdle and endogenous switching regression models were estimated using a panel data hybrid analytical framework of random and fixed effects models called correlated random effects (CRE). CRE derives fixed effects type of estimators while at the same time it allows inclusion of time invariant variables as part of the covariates.

The results from the analysis show that about three quarters of the surveyed households were found to have at least sold some of their crop produce. The average proportion of the value of all crops produced that was sold was about 33% for those who participated in the output market (commercialized households). Therefore, about a quarter of the surveyed farming households were practicing pure subsistence agriculture. These figures are not quite promising given the fact that agriculture is the main source of livelihood among the surveyed households who have other non-subsistence food needs like health care and education among many others. It is therefore imperative to find ways of commercializing the 25% that are currently not commercialized and increase commercialization intensity of the commercialized households beyond the present 33%.

Further, econometric results from the analysis of agricultural commercialization determinants showed that several policy variables were significant in explaining the commercialization process among the surveyed households. First, the positive and significant relationship between the probability and intensity of commercializing and per capita farm size means that continuous sub-

division of agricultural land into smaller and smaller units is likely to stifle the smallholder agricultural commercialization efforts and thereby expose these households to higher risks of food insecurity and poverty as demonstrated in the findings of this study. Secondly, the study results show that soil fertility is critical in enabling households to commercialize their farm enterprises. This finding implicitly points to the importance of agricultural productivity in enabling the commercialization process. Thirdly, the econometric results of agricultural input credit access showed that credit constraint need to be relaxed for agricultural commercialization to take root. On the other hand, transaction costs (both fixed and proportional/variables) were very important in determining agricultural commercialization among smallholder farmers. For example, mobile phone ownership was positively related with agricultural commercialization while transport costs to the nearest main market were found to be negatively related with agricultural commercialization.

In terms of the impacts of agricultural commercialization on household welfare among the surveyed households, the results were significantly in support of commercializing smallholder agriculture. Starting with agricultural commercialization impacts on food security, the results were very conclusive that agricultural commercialization can significantly improve the probability of food security outcome among the commercialized households. Also, the counterfactual results showed that the non-commercialized households could significantly improve their probability of being food secure if they were enabled to commercialize. The observed food security gap between commercialized and non-commercialized households could be closed if both the resource returns or efficiency and amount of resources of the non-commercialized households could be improved to the level of the commercialized households. Addressing resource endowments alone or efficiency use of resources alone will not be able to close the existing food security gap between these two groups of households.

Similarly, findings on the impacts of agricultural commercialization on household poverty were strongly in support of agricultural commercialization of smallholder farmers. Again, the poverty gap between commercialized and non-commercialized households could be closed if the resource returns (efficiency effect) and amount of resources (level effect) of the latter could be improved to the level of the former. In this regard, it is important to note that a bigger proportion of the poverty gap originates from the resource level effect than the returns effect.

7.2 Policy implications

Based on the evidence adduced in this study, bold and clear policies should be put in place to stimulate and enhance smallholder agricultural commercialization. These policy options could include, but not limited to legislation on the minimum and maximum land holding acreage of agricultural land to control the continuous subdivision of agricultural land into uneconomical units. This minimum and maximum land holding is already suggested in the *Minimum and Maximum Land Holding Acreage Bill 2015* that is before the National Assembly of Kenya as provided in the constitution of Kenya Article 68 (C) (*i*). However, this should be done very carefully given the fact that it could be culturally retrogressive and also economically not feasible if it will increase the number of landless poor without an alternative source of livelihoods.

Also, policy interventions that could help farmers improve soil fertility of their farms are recommended. Such policy options could be interventions by the government to create an enabling environment that will make fertilizer more accessible and affordable to farmers. Others include testing soil nutrient requirements in different agro-ecological zones for targeted fertilizer recommendations and other land management agronomic practices that enhance soil fertility like conservation agriculture (CA) and sustainable agricultural intensification practices (SAIPs).

There is also need for concerted effort to put in place policies that encourage the emergence and growth of both informal and formal credit institutions in rural areas that target the agricultural sector. Such policies could include government establishing rural warehousing credit receipt system where by smallholders can borrow against their produce held in the warehouse. Also, closely related to credit access was the high positive and significant impact of membership to agricultural production networks/groups (APNs) on agricultural commercialization. This later finding implies that government should develop and implement policies that encourage the emergence and growth of transparent and accountable APNs. These APNs could be critical in reducing input and output marketing transaction costs. Even empirical literature like Shiferaw *et al.,* (2014) and Fischer and Qaim (2012) have summarized evidence showing how these APNs can mediate output and input market transactions among smallholder farmers. In some of the cases, APNs can ease credit access constraints among its members.

7.3 Areas for further research

While it could be true that agricultural commercialization entails market orientation and market participation, this study concentrated on market participation only. Though the study went a step further by building on previous empirical work in terms of incorporating all crops produced on the farm, future studies could enrich this approach more by also considering input market participation and livestock farm enterprises to give a holistic picture of smallholder commercialization. This is because some of smallholder farmers in developing countries also buy crop production inputs from markets and practice mixed farming whereby they produce both crops and keep livestock on their farms. Again like the input market participation and livestock farm enterprise that were beyond the scope of this study due to data limitations, a much richer household commercialization index should include household labour sold for income. Such comprehensive index will be drifting away from the partial equilibrium analyses like the ones done before including this study to a quasi-general equilibrium analysis. Finally, since this study has shown that there is need to set a minimum and maximum land holding in order to entrench agricultural commercialization, further and timely empirical research is needed to establish exactly the minimum and maximum economical agricultural land holding among the surveyed households.

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APPENDICES

Appendix 1. Instruments for food security impact assessment

Variable label	Selection Model: Determinants of commercialization		Outcome model: Food security probability	
	Coef.	Std. Err.	Coef.	Std. Err.
Demographic characteristics:				
Household head sex	-0.0903	0.1546	-0.0646	0.1394
Household head age	0.0089	0.0144	0.0102	0.0124
Household head education	0.0342**	0.0167	0.0373***	0.0144
Household size	0.0265	0.0627	0.0060	0.0571
Dependence ratio	-0.0539	0.1280	0.0166	0.1136
Physical and financial capital:				
Owned livestock size	0.0147*	0.0080	0.0065	0.0072
Per capita owned land	3.8204**	1.6995	0.8256	1.3944
Per capita owned land squared	-1.7225**	0.8657	-0.3582	0.7364
Soil fertility score	-0.1511	0.1283	0.2061*	0.1152
Annual non-farm income	-0.0093*	0.0049	0.0070*	0.0041
Got agricultural input credit	0.0569	0.2492	0.0799	0.2021
Contacts with extension	0.2137	0.1554	-0.1720	0.1362
Social capital:				
Membership to APNs	0.5515***	0.1153	0.3773***	0.1011
Dependable relatives in village	0.0010	0.0051	-0.0089**	0.0043
Trust grain traders	0.1804	0.1203	0.2678**	0.1061
Transaction costs:				
Own mobile phone	0.8913***	0.2171	-0.0097	0.2009
Transport to nearest main market	-0.0156**	0.0078	-0.0126**	0.0061
Own transport means	0.1327	0.1125	0.4198***	0.0998
Regional dummy	0.9400***	0.1405	0.6548***	0.1162
Mundlak-Chamberlain device:				
Household head age	-0.0116	0.0151	-0.0109	0.0131
Household size	-0.0342	0.0692	-0.0523	0.0633
Dependence ratio	0.1346	0.1500	-0.2833**	0.1352
Owned livestock size	-0.0063	0.0107	0.0011	0.0099
Per capita owned land	-1.6208	1.7661	-0.0338	1.4973
Per capita owned land squared	0.3784	0.9639	0.0924	0.8795
Soil fertility score	0.4152**	0.1753	0.0691	0.1533
Annual non-farm income	0.0078	0.0064	-0.0057	0.0053
Got agricultural input credit	0.7084**	0.3317	0.3289	0.2739
Contacts with extension	-0.1432	0.2137	0.3652*	0.1886
Own mobile phone	-0.2894	0.2895	0.4920*	0.2596

Constants	-1.7167***	0.4261	-1.7708***	0.3913

Statistical significance: *** at 1%; ** at 5%; * at 10%

Model description

Descriptor	Selection model	Outcome model
Number of obs	914	914
LR chi2(30)	244.8800	214.5100
Prob > chi2	0.0000	0.0000
Pseudo R2	0.2360	0.1702
Log likelihood	-396.4215	-522.7767

Source: Author's computations

Appendix 2. Instruments for poverty impact assessment

Variable label	Selection model		Poverty outcome model	
	Coef.	Std. Err.	Coef.	Std. Err.
Demographic characteristics:				
Household head sex	-0.0903	0.1546	1,252.8040	1,623.8650
Household head age	0.0089	0.0144	173.3495	147.8346
Household head education	0.0342**	0.0167	760.6562***	167.7151
Household size	0.0265	0.0627	-1,435.4020**	673.9008
Dependence ratio	-0.0539	0.1280	-4,163.9090***	1,335.3700
Physical and financial capital:				
Owned livestock size	0.0147*	0.0080	-20.6289	83.5107
Per capita owned land	3.8204**	1.6995	29,498.0100*	16,277.5300
Per capita owned land squared	-1.7225**	0.8657	-12,516.9800	8,739.5440
Soil fertility score	-0.1511	0.1283	763.2824	1,344.8720
Annual non-farm income	-0.0093*	0.0049	4.7123	47.6020
Got agricultural input credit	0.0569	0.2492	7,021.2330***	2,327.8320
Contacts with extension	0.2137	0.1554	1,124.6060	1,581.9590
Social capital:				
Membership to APNs	0.5515***	0.1153	8,811.2990***	1,188.1160
Dependable relatives in village	0.0010	0.0051	200.0288***	51.1140
Trust grain traders	0.1804	0.1203	-1,151.1910	1,235.4610
Transaction costs:				
Own mobile phone	0.8913***	0.2171	7,143.0940***	2,400.4730
Transport to nearest main market	-0.0156**	0.0078	-32.8887	70.9301
Own transport means	0.1327	0.1125	2,609.2250**	1,182.9530
Regional dummy	0.9400***	0.1405	-343.2840	1,371.4440
Mundlak-Chamberlain device:				
Household head age	-0.0116	0.0151	-203.1833	155.0934
Household size	-0.0342	0.0692	-855.5738	741.2142
Dependence ratio	0.1346	0.1500	697.1051	1,569.6890
Owned livestock size	-0.0063	0.0107	172.5065	114.4103
Per capita owned land	-1.6208	1.7661	-17,099.3300	17,292.6600
Per capita owned land squared	0.3784	0.9639	6,960.3210	9,988.0710
Soil fertility score	0.4152**	0.1753	741.1543	1,808.2910
Annual non-farm income	0.0078	0.0064	93.3956	62.4697
Got agricultural input credit	0.7084**	0.3317	-5,094.9850	3,189.2150
Contacts with extension	-0.1432	0.2137	2,012.6550	2,188.7790
Own mobile phone	-0.2894	0.2895	-2,269.6790	3,077.3420
Constants	-1.7167***	0.4261	23,496.5700***	4,505.3500

Statistical significance: *** at 1%; ** at 5%; * at 10%

Model description:

Selection model (probit)	**Outcome model (OLS)**
Number of obs = 914	Number of obs = 914
LR chi2(30) = 244.88	F(30, 883) = 13.62
Prob > chi2 = 0.000	Prob > F = 0.000
Pseudo R2 = 0.236	R-squared = 0.3163
Log likelihood = -396.422	Adj R-squared = 0.2931
	Root MSE = 15936

Source: Author's computations

Household Identification Number.....

Appendix 3. Survey questionnaire used by CIMMYT and its partners

Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA) Project

Baseline Survey Household Questionnaire for Kenya – 2011

Kenya Agricultural Research Institute (KARI)
in Partnership with
International Maize and Wheat Improvement Center (CIMMYT)

PART 0. INTERVIEW BACKGROUND

1. Date of interview: Day:..... Month:..... Year:.....
Interviewed by (enumerator's name):.....
Province..... 4. County.....
5. District:..... 6. Division .....
7. Location.....8. Village.....
Respondent's name:.....
Mobile phone No..... 11. Landline phone no.....
12. GPS readings of village: a) Altitude.....; b) Latitude.....; c) Longitude.....
Date checked: Day:..... Month:..... Year:.....
Checked by (supervisor's name) .....
Date entered: Day:..... Month:..... Year:.....
Entered by:.....

PART 1. FARMERS IDENTIFICATION AND VILLAGE CHARACTERISTICS

Major family language.....
Religion of the household head (Codes A).....
Does main residential house have the following inbuilt? (Codes B) 1. Kitchen..... 2. Grain store.....; 3. Livestock pen.....
Main walling material of main residential house.....(Codes C)
Main roofing material of main residential house.....(Codes D)
Experience in cultivating maize (years).....
Experience in cultivating legumes (years) Common bean..... Climbing beans .....Soybean..... Pigeonpea… Groundnut……Cowpea……
(Other, specify name) .....Years of experience.....
Taking into consideration ALL your food sources (own food production + food purchase + help from different sources + food hunted from forest and lakes, etc), how would you define your family's food consumption last year? (Codes E).....
Distance to the village market from residence (km) .....minutes of walking time .....
What means of transport do you use mainly to get to the village market? (Code F).....
Average single trip transport cost per person to village market using this means of transport (KSh/person).....
Distance to the nearest main market from residence (km).....minutes of walking time.....
Number of months road to main market is passable for cars in a year.....
Quality of road to the main market (Codes G).....
Average single transport cost (per person) to the main market using a car (KSh/person) .....
Distance to the nearest source of seed dealer from residence (km) .....minutes of walking time .....
Distance to the nearest source of fertilizer dealer from residence (km) .....minutes of walking time .....
Distance to nearest source/dealer of herbicides/pesticides from residence (km).....minutes of walking time …
Distance to the nearest farmer cooperative from residence (km).....minutes of walking time .....
Distance to the nearest farmers group from residence (km).....minutes of walking time .....
Distance to the nearest agricultural extension office from residence (km).....minutes of walking time.....
Distance to the nearest health center from residence (km).....minutes of walking time.....
Type of toilet used .....1. Flash toilet private; 2. Flash toilet shared;
3. Pit latrine private; 4. Pit latrine shared; 5. Bucket latrine; 6. No toilet/use open air
Main source of drinking water.....(Codes H)
Do you boil water for drinking?.....(Codes B)
Distance to main water source for drinking from residence (km).....minutes of walking time.....
Codes A: 1. No religion/atheist; 2. Orthodox Christian; 3. Catholic; 4. Protestant; 5. Other Christian 6. Muslim; 7. Other, specify.....
Codes B: 1. Yes: 0.No
Codes C: 1. Burned bricks; 2. Unburned bricks; 3. Stone; 4. Earth; 5. Wooden (timber); 6. Other, specify.....
Codes D: 1. Grass thatch; 2. Iron sheet; 3. Tiles; 4. Other, specify.....
Codes E: 1. Food shortage throughout the year, 2. Occasional food shortage, 3. No food shortage but no surplus, 4. Food surplus.
Codes F: 1. Walking; 2. Bicycle; 3. Tractor; 4. Minibus/*matatu*; 5. Motorcycle 6. Other, specify.....
Codes G: 1= Very poor; 2= Poor; 3= Average; 4=Good; 5= Very good;
Codes H: 1. Piped; 2. Borehole protected and covered; 3. Borehole unprotected & uncovered; 4. Stream; 5. River; 6. Lake; 7. Ponds/dams or floods. Note: protected refers to water sources internally plastered and covered with a cap of wood, stone or concrete)

PART 2: CURRENT HOUSEHOLD COMPOSITION AND CHARACTERISTICS

ily cod	Name of household member	Sex Cod	es A stat us	Age (yea rs) A	on (yea rs)	to HH Hea d	Occupation	Own farm	For those under the age of 6

	(start with respondent)						Codes E		labour contribution Codes F	(see column 5)		
							Main	Secondary		Weight (kg)	Height (cm)	Had diarrhea in 2010 Codes G
01												
02												
03												
04												
05												

A/ For the under 6 year olds, give age to the nearest 3 decimal places

Codes A	Codes B	Codes C	Codes D	Codes E	Codes F	Codes G
0. Female 1. Male	1. Married living with spouse 2. Married but spouse away 3. Other, specify……	0. None/Illiterate 1. Adult education or 1 year of	1. Household head 2. Spouse 3. Son/daughter 4. Parent 59. Other, specify……	1. Farming (crop + livestock) 2. Salaried employment 3. Self-employed off-farm 4. Casual labourer on-farm 510. Other, specify……	1. 100% 2. 75% 3. 50% 4. 25% 5. 10% 6. Not a worker	0. No 1. Yes

PART 3: SOCIAL CAPITAL AND NETWORKING

Have you or your spouse (s) been a member in formal and informal institutions since 2008, fill the table below (husband and wife/wives only. One group membership per row.)

Family code	Type of group the husband/wife is/was a member of: (codes A)	Three most important group functions: (codes B)			Year joined (YYYY)	Role in the group (codes C)	Still a member now? (codes D)	If No in column 8, reason/s for leaving the group (codes E), Rank 3		
		1st	2nd	3rd				1st	2nd	3rd

Codes A		Codes B	Codes C	Codes D	Codes E
1. Input supply/farmer coops/union 2. Crop/seed producer and marketing group/coops 3. Local administration	9. Funeral association 10. Government team 11. Water User's Association 13. Other, specify……	1. Produce marketing 2. Input access/marketing 3. Seed production 4. Farmer research group 5. Savings and credit 6.	1. Official 2. Ex-official 3. Ordinar member	1. Yes 0. No	1. Left because organization was not useful/profitable 2. Left because of poor

Section B. Social networks

Number of years the respondent has been living in this village .....

Number of people that you can rely on for critical support in times of need within this village

Relatives .....Non-Relatives .....

Number of people you can rely on for support in times of need outside this village

Relatives ……; Non-Relatives

Are any of your friends or relatives in leadership positions in formal or informal institutions within and outside this village ?..... Codes: 1. Yes, 0. No

Number of grain traders that you know in this village who could buy your grain.....

Number of grain traders that you know outside this village who could buy your grain……

Generally speaking, you can say that most traders can be trusted.....(Codes A below)

If answer in Question 7 above is 1, 2 or 3, then which types of traders do you trust more.....?

Codes: 1.Wholesalers; 2. Retailers; 3. Assemblers; 4. Brokers; 5. Others ....

And why do you trust these types of traders more?.....

Do you think you can rely on government support (subsidies, food aid etc) if your crop fails?.....Codes: 1.Yes; 0. No

You are confident of the skills of government officials including extension workers to do their job?.....(Codes A)

Codes A: 1. Strongly disagree; 2. Disagree; 3. Slightly disagree; 4. Slightly agree; 5. Agree; 6. Strongly agree

PART 4. HOUSEHOLD ASSETS

Section A: Production equipments and major household furniture

Asset	Current Number (if no equipment put zero)	Purchase price (KSh) (if more than two items reported in column 2 take average price)	If you would sell [….] how much would you receive from the sale? (KSh) (if more than two items reported in column 2 take average price)	Total current Value
1. Horse/mule cart				
2. Donkey/Ox cart				
4. Push cart				
5. Ox-plough				
9. Hoe/Jembe				
10. Knapsack sprayer				
14. Water mill				
15. Mechanical water pump (hand, foot)				

18. Radio, cassette or CD player				
19. Cell phone				
22. Bicycle				
23. Motorbike				
24. Cars				
25. Pick-ups				
26. Trucks				
Tractors				
28. Trailers				

Section B: Land holding (acres) during the 2009/10 cropping year

Land category	Sept-Nov rain season (2009)		Mar-Apr rain season (2010)	
	Cultivated (annual + permanent crops)	Uncultivated (e.g. grazing, homestead etc)	Cultivated (annual + permanent crops	Uncultivated (e.g. grazing, homestead)
1. Own land used (A)				
2. Rented in land (B)				
3. Rented out land (C)				
4. Borrowed in land (D)				
5. Borrowed out land (E)				
6. Total owned land (A+C+E)				
7. Total operated land (A+B+D)				
8. Bought land during Mar/Apr season				
9. Sold land during Mar/Apr season				

Total owned land in 2006 – (Acres)……..

PART 5. IMPROVED CROP* VARIETY KNOWLEDGE AND ADOPTION

Section A. Crop variety knowledge, sources of information and seed, adoption and disadoption

Improved crop varieties aware/heard of Codes Annex 2	If you have a local name for this variety, what is it? If no local name, put 0	Year variety known/ heard YYYY	Sources of variety information Codes A, Rank 3	Ever planted? Codes B	If NO in Column 5, Why? Codes C Rank 3	If YES in column 5, year first planted YYYY	If Yes in column 5					If NO in column 12	
							First seed						
							Main source of first seed Codes D	Amount kg	Means of acquiring first seed Codes E, Rank 3	No. of seasons variety has been planted	Planted variety in 2010 Codes B	Will plant variety in future Codes B	If No in Column 13, why not, Codes C Rank 3

*Improved crop of interest: Maize, Teff, Common beans, Pigeonpea, Groundnut, Soybean, Cowpea

Codes A		Codes B	Codes C		Codes D		Codes E	
1. Government extension	6. Seed/grain stockist	0. No	1. Seed not available	5. Low yielding variety	1. On-farm trials	7. Farmer to farmer seed exchange	1. Gift/free	6. Subsidy and cash
2. Farmer Coop/Union	7. Another farmer relative	1. Yes	2. Lack of cash to buy seed (credit)	6. Low grain prices	2. Extension demo plots	8. Provided free by NGOs/govt	2. Borrowed seed	7. Advance pay from coop
3. Farmer group	8. Another farmer neighbour		3.Susceptible to diseases/pests	7. No market	3. Farmer groups/Coops	9. Govt subsidy program	3. Bought with cash	8. Other, specify……
4. NGO/CBO	9. Radio/newspaper/TV		4. Poor taste	8. Theft during green stage	4. Local seed producers	10. Other (specify)……	4. Payment in kind	
5. Research centre (trials/demos/field days)	10.Other, Specify……			9. Lack of enough land	5. Local trader		5. Exchange with other seed	
				10. Requires high skills	6. Agro-dealers/Agrovets			
				11. Other, specify……				

Section B: Characteristics of maize varieties grown during 2009 and/or in the past [main local variety first]

Characteristics	Maize varieties (main local variety first column, Codes in Annex 2)									
	1……	2……	3……	4……	5……	6……	7……	8……	9……	10……
Variety type according to farmer (1=OPV; 2=Hybrid; 3=don't know)										
Agronomic										
1. 1. Grain yield										
2. Stover (crop residue) yield										
3. Palatability of stover to livestock										
Market and economics										
14. Marketability (demand)										
Cooking & utilization										
18. Storability										
22. Overall variety score										

Codes A 1. Very poor, 2. Poor, 3. Average 4. Good, 5. Very Good

Section C: Common beans varieties characteristics grown during 2009/10 and/or in the past [main local variety first]

Characteristics	Beans varieties (main local variety first column, Codes in Annex 2)									
	1…..	2……	3……	4……	5……	6……	7……	8……	9……	10……
Agronomic										

1. Grain yield										
2. Stover (crop residue) yield										
3. Palatability of Stover to livestock										
Market and economics										
13. Marketability (demand)										
14. Grain colour										
Cooking & utilization										
17. Storability										
20. Overall variety score										

Section D: Pigeonpea varieties characteristics grown during 2009/10 and in the past [main local variety first]

Characteristics	Pigeonpea varieties (main local variety first column, Codes in Annex 2)									
	1…..	2……	3……	4……	5……	6……	7……	8……	9……	10……
Agronomic										
1. Grain yield										
2. Stover (crop residue) yield										
3. Palatability of Stover to livestock										
Market and economics										
13. Marketability (demand)										
14. Grain colour										
Cooking & utilization										
17. Storability										
20. Overall variety score										

Codes A 1. Very poor, 2. Poor, 3.Average, 4. Good, 5. Very Good

Section E: ……. varieties (specify) characteristics grown during 2009/10 and in the past [main local variety first]

Characteristics	Other SIMLESA legume varieties (main local variety first column, Codes in Annex 2)									
	1…..	2……	3……	4……	5……	6……	7……	8……	9……	10……
Agronomic										
1. Grain yield										
2. Stover (crop residue) yield										
Market and economics										
13. Marketability (demand)										
14. Grain colour										
Cooking & utilization										
17. Storability										
18. Cooking time										
20. Overall variety score										

Codes A 1. Very poor, 2. Poor, 3.Average, 4. Good, 5. Very Good

Section F: Main sources and quantity of seed for Maize, Common beans, Pigeonpea, Groundnut, Soybean, Cowpea and other major legumes grown last cropping year (2009)

Season Codes A	Crop Codes (See attached Annex 1)	Crop variety Codes (See attached Annex 2)	Total amount of seed (kg)	Quantity of seed and sources							
				Source 1		*Source 2*		*Source 3*		*Source 4*	
				Codes B	*Amount (kg)*	*Codes B*	*Amount (kg)*	*Codes B*	*Amount (kg)*	*Codes B*	*Amount (kg)*

Codes A
1. Mar-Apr.2009
2. Sep-Nov. 2009

Codes B
1. Own saved
2. Gift from family/neighbor
3. Farmer to farmer seed exchange
4. On-farm trials
5. Extension demo plots
6. Farmer groups/Coops
7. Local seed producers
8. Local trader
9. Agro-dealers/agrovets
10. Bought from seed company
11. Provided free by NGOs/govt
12. Govt subsidy program
13. Other (specify)……

PART 6. CROP PRODUCTION (2009 crop calendar)

Section A. Plot characteristics, investment and input use

Definitions: A plot is a piece of land physically separated from others; a subplot is a subunit of a plot. If more than one crop is grown on a plot (that is, on different subplots), repeat the plot code in next row and use subplot code. If the (sub) plot is intercropped, use same row and separate the different intercrops by comma e,g.,(1,2) for maize and beans. Consider only 3 main intercrops if more than 3 on a (sub) plot.

Serial number	Season Codes A	Plot code (start with one next to residence)	Plot location name (as called by farmer)	(Sub)plot code	(Sub)plot size (acres)	Crop(s) grown (Annex 1 codes)	Crops variety (Annex 2 codes)	Crop variety knowledge Codes B	Intercrop 1=Yes; 0=No	Percent of area under each intercrop (e.g. 50: 50)	Plot distance from residence (walking minutes)	(Sub)plot ownership Codes C	(Sub)plot manager Codes D	Soil fertility Codes E	Soil slope Codes F	Soil depth Codes G	Soil type Codes H	Soil & water conservation method – Rank 3 Codes I	No. of mature trees in the (sub)plot	Crop residue left on (sub)plot 1=Yes; 0=No	Irrigation (Codes J)	zero or minimum tillage on the (sub)plot? (1= yes, 0= no)	
																						Ever practiced before	Practiced 2009
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	23

Codes A
1. Mar-Apr.2009
2. Sep-Nov. 2009

Codes B
1. Very sure
2. Sure
3. Not sure

Codes C
1. Owned
2. Rented in
3. Rented out
3. Borrowed in
4.Borrowed out
5. Other, specify….

Codes D
0. Women
1. Men
2. Both equally

Codes E
1. Good
2. Medium
3. Poor

Codes F
1. Gently slope (flat)
2. Medium slope
3. Steep slope

Codes G
1. Shallow
2. Medium
3. Deep

Codes H
1. Black
2. Brown
3. Red
4.Grey
5. Other, specify…

Codes I
0. None
1. Terraces
2. Mulching
3. Grass strips
4. Trees on boundaries
5. No till
6.Minimum till
7.Soil bunds
8.Stone bunds
9. Other, specify…

Codes J
1. Irrigated
2. Rainfed

Section B: Input use

(Serial number, plot code, sub-plot code, and crop(s) grown in this Section should be in exactly the same order as in Section A above)

Serial number	Season	Plot code	Subplot code	Crop(s) grown	Previous season 3 main crops grown (Annex 1 codes)	Inorganic fertilizers (If not used, put Zero)				Seed use (if intercropped, separate by comma)					Manure (dry equivalent)			Herbicides	
						Amount for planting (Kg)	Total cost (KSh)	Amount for topdressing (Kg)	Total cost (KSh)	Main seed source Codes A	Non-bought seed (own saved, gift etc) kg/No	Number of seasons own saved recycled	Bought		own	Bought		litres	Total cost (KSh)
													Amount (kg)	Total cost (KSh)	kg	kg	Total cost (KSh)		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Codes A
1. Own saved
2. Gift from family/neighbor
3. Farmer to farmer seed exchange
4. On-farm trials
5. Extension demo plots
6. Farmer groups/Coops
7. Local seed producers
8. Local trader
9. Agro-dealers/agrovets
10. Bought from seed company
11. Provided free by NGOs/govt
12. Govt subsidy program
13. Other (specify)……

Section C: Input use and crop harvested

(Serial number, plot code, sub-plot code, and crop(s) grown in this Section should be in exactly the same order as in Section A above)

Serial number	Season	Plot code	Subplot code	Crop(s) grown	Pesticides		Oxen days	Total labour (family and hired) use in person days Intercrops: record harvesting and threshing/shelling separately (by comma)				Cost of oxen hired (KSh)	Cost of hired labour (KSh)	incidence on plot	Total harvested per (sub)plot Intercrops: separate by comma	
					litres	Total cost (KSh)		Land preparation &	Weed control	Harvesting	Threshing or shelling				Fresh or green (kg)	Dry (kg)

									planting													
							Plowing Freq	Total Plowing days	Male	Female	Weeding freq	Male	Female	Male	Female	Male	Female					
1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Codes A: 0. No stress; 1. Pests; 2. Diseases; 3. Water logging; 4. Drought; 5. Frost; 6. Hailstorm; 6. Other, specify……

Section D: Utilization of crops produced and household food security

Different from Sections A-C: one row per crop and season (e.g. add production from all maize (fresh and dry) plots together for season 1)

Crop (From section C)	Season (From section C)	Form Codes A	Stock before Mar-Apr. 2009 harvest (kg)	Production of 2009/10 (last columns of Section C) (kg)	Total available stock after 2009/10 harvest (kg)	From the total available stock after 2009/10 harvest (Column 6)…					Ending stock (Stock before 2009/10 harvest) (kg)	If total available stock of 2009/10 was not sufficient for consumption until harvest:	
						Quantity sold after 2009/10 harvest (kg)	In-kind payments (labour, land & others) paid during 2009/10 cropping year (kg)	Seed used during 2009/10 cropping year (kg)	Gift, tithe, donations given out during 2009/10 cropping year (kg)	Consumption during 2009/10 cropping year (kg)		Amount bought (kg)	Food aid/gifts received (kg)
1	2	3	4	5	6 =4+5	7	8	9	10	11	12=6-7-8-9-10-11	13	14

Codes A: 1. Fresh/green; 2. Dry

Section E: Marketing of crops

Different from Sections A-D: one row per sale (different months, different buyers), per crop and per season

Crop (From Column 1 of Section D)	Season (From Column 2 of Section D)	Form (From Column 3 of Section D)	Market type Codes A	Month sold Codes C	Quantity sold (kg) (sum should be equal to Column 7 of Section D)	Who sold Codes B	Price (KSh. /kg)	Buyer Codes D	Period to payment after selling, weeks (if immediate write zero)	Relation to buyer Codes E	Quality Codes F	Sales tax or charges (KSh.)	Time taken to sell crop (minutes)	Time taken to get to the market (minutes)	Mode of transport Codes G	Actual transport cost (KSh.)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Codes A	Codes B	Codes C		Codes D		Codes E	Codes F	Codes G
1. Farmgate	0. Female	1. January	7. July	1. Farmer group	7. Rural wholesaler	1. No relation but not a long time buyer	1. Below average	1. Bicycle
2. Village market	1. Male	2. February	8. August	2. Farmer Union or Coop	8. Urban wholesaler	2. No relation but a long term buyer	2. Fair and Average	2. Hired truck
3. Main/district market		3. March	9. September	3. Consumer or other farmer	9. Urban grain trader	3. Relative	3. Above average	3. Public transport
		4. April	10. October	4. Rural assembler	10. Exporter,	6. Other, specify……		7. Other, specify….
					11. Other, specify……			

Section F: Percent utilization of crop residues of 2009/10 season (%)

Same order of crops and seasons as section D. Note that percentages need to add up to 100% for every row.

Crop (same order as in section D above)	Season (From Column 2 of Section D)	Total production of crop residues (kg)	Burnt in the field (%)	Used as firewood (%)	Left on land for soil fertility (%)	Feed for livestock (%)	Used for construction (%)	Sold (%)	Other uses (%)
1	2	3	4	5	6	7	8	9	10

Section G: Grain storage practices of 2009/10 season

Crop	Main storage facility Codes A	Form stored Codes B	Reasons for preferring the storage facility Codes C Rank 3	Amount stored at beginning (kg)	Length of storage Months	Amount at end of storage period (kg)	Amount lost due to pest or other attacks (kg)	Did quality deteriorate during storage Codes D	If Yes in column 9, % of stored grain affected	Cause of storage loss Codes E Rank 3	Storage loss control measures Codes F Rank 3	Storage pests seen Codes G Rank 3
1	2	3	4	5	6	7	8	9	10	11	12	13
1. Maize												
2. Beans												
3. Pigeonpea												

Codes A	Codes B	Codes C	Codes D	Codes E	Codes F	Codes G
1. Traditional crib 2. Improved granary 3. Wooden store 4. Metal silo 7. Other, specify……	1. Shelled/threshed 2. Unshelled/unthreshed 3. Other, specify……	1. It is cheap 2. It dries well 3. Keeps off rodents 4. Keeps off other pests 5. Other, specify……	0. No 1. Yes	1. Pest damage 2. Moisture loss 3. Rotting 4. Moulds 6. Other, specify….	1. None 2. Actellic Super 3. Spin dust 4. Scanner dust 7. Other, specify…	1. Large Grain Borer (*Osama/Scania/Nissan*) 2. Weevil 3. Rodents 4. Fungal attack 6. Others, specify…

PART 7: LIVESTOCK PRODUCTION AND MARKETING

Section A: Livestock production activities during 2009/10 cropping year

Livestock type	Number of livestock at end of 2009/10 cropping season (including bought ones)	If you would sell […], how much would you receive from the sale? (KSh) (more than take average price)	Average total days milked per animal	Average daily milk yield per animal (liters)	Total milk production (liters) & honey production per beehive (kg)	Total Cost of Production (KSh)					
						Fodder	Labour	Veterinary care	Artificial insemination	Salt	Others
1	2	3	4	5	6=2x4x5	7	8	9	10	11	12
Cattle											
1. Indigenous milking cows											
2. Cross-bred milking cows											
5. Trained oxen for ploughing											
Goats											
9. Mature milking goats											
Sheep											
13. Mature female sheep											
Other livestock											
17. Mature trained donkeys											

Section B: Livestock and livestock products selling and buying activities during 2009/10

Animal	Selling				Buying			
	Quantity sold	Unit	Who sold 1 = Men; 0 = Women 2= Both	Average per unit price (KSh/unit)	Quantity bought	Unit	Who Bought 1 = Men; 0 = Women 2= Both	Average per unit price (KSh/unit)
1	2	3	4	5	6	7	8	9
1. Indigenous milking cows								
31. Other, specify								
Animal products								
34.Milk								
45. Other, specify								

PART 8: TRANSFER AND OTHER SOURCES OF INCOME DURING 2009/10 CROPPING YEAR

Sources	Who earned/ received? 0= None; 1=Women 2=Men; 3=Both	No. of units worked/ received	Unit (e.g. month, week, day, year)	Amount per unit (Cash & in-kind)		Total income (cash & in-kind)		Total income (KSh)
				Cash (KSh)	Payment in kind Cash equivalent	Cash (KSh)	Payment in kind Cash equivalent	
1	2	3	4	5	6	7= 3x5	8=3x6	9= 7+8
1. Rented/sharecropped out land								
2. Rented out oxen for ploughing								
3. Salaried employment								
4. Farm labour wages								
24.Other, specify								

PART 9: ACCESS TO FINANCIAL CAPITAL, INFORMATION AND INSTITUTIONS

Section A: Household credit need and sources during 2009/10 cropping year

Reason for loan	Needed credit? Codes A	If No in column 2, then Why? Codes B	If Yes in column 2, then did you get it? Codes A	If NO in column 4, then why not? Rank 3 (codes C)			If Yes in column 4				
				1st	2nd	3rd	Source of Credit, Codes D	How much did you get (KSh)	Did you get the amount you requested Codes A	Annual interest rate charged (%)	Debt outstanding including interest rate at end of season (KSh)
1	2	3	4	5	6	7	8	9	10	11	12
1. Buying seeds											
2. Buying fertilizer											
3. Buy herbicide and pesticides											
4. Buy farm equipment/implements											
7. Buy other livestock											

Codes A
0. No
1. Yes

Codes B
1. Not cash constrained
2. Borrowing is risky
3. Indebted in the past
4. Other, specify

Codes C
1. Borrowing is risky
2. Interest rate is high
3. Too much paper work/ procedures
4. Expected to be rejected, so did not try it
5. I have no asset for collateral
6. No money lenders in this area for this purpose
7. Lenders don't provide the amount needed
8. No credit association available
9. Other, specify……

Codes D
1. Money lender
2. Farmer group/coop
3. Merry go round
4. Microfinance
5. Bank
6. SACCO
7. Relative
8. AFC
9. Other, specify..

Section B: Household savings

Saving family member (1=Husband; 2=Wife; 3= both)	Has bank account (0=No; 1=Yes)	Saving with (codes A)	Total amount saved during 2009/10 (KSh)
1	2	3	5

Codes A
1. Saving at home (personal)
2. Commercial or other banks
3. Rural micro-finance
4. SACCO (credit society)
5. Merry go-round
6. Mobile phone banking (e.g. M-Pesa)
7. Saving by lending to money lender
8. Other, specify……

Section C: Access to extension services

Issue	Did you receive training or information on [……] before 2009/10? (Codes A)	Received training or information on [……] during 2009/10? (Codes A)	Main information source for 2009/10, Rank 3 (Codes B)			Number of contacts during 2009/10 (days/year)		
			1st	2nd	3rd	Govt extension	NGOs	Private Companies
1	2	3	4	5	6	7	8	9
1. New varieties of maize								
11. Output markets and prices								
12. Input markets and prices								

Codes A
0. No
1. Yes

Codes B
1. Government extension service
2. Farmer Coop or groups
3. Neighbour farmers
4. Seed traders/Agrovets
5. Relative farmers
6. NGOs
7. Other private trader
8. Private Company
9. Research center
10. School
11. Radio/TV
12. Newspaper
Mobile phone
Other, specify……

Section D. Market access during 2009/10 (See page 14 column 7)

Household Identification Number……

Crop	Did you get market information before you decided to sell the crop? (Codes A above)	If yes in column 2, where did you get the information? (Codes B above) Rank 3	Ever failed to sell due to lack of buyers or poor price? Codes A above		No. of buyers who came to buy at farm gate last season (2009/10)				If you did not sell to some of these buyers, then why? Codes C below (Rank 3)			
			Lack of buyers	Poor price	Assemblers or brokers	Wholesalers	Farmer group or coops	Consumers	Assemblers or brokers	wholesalers	Farmer group or coops	Consumer
1	2	3	4	5	6	7	8	9	10	11	12	13

Codes C:
1. No buyer came
2. Price offered was low
3. Unreliable scale or weight
4. Unable to meet the desired quality
5.Deferred payment
6.Other, specify……

Section E: Constraints in access key inputs and crop production (SIMLESA crops only)

Input and production constraints	Maize		Common beans		Pigeonpea		Groundnut		Teff		Other, specify……	
	Constraint? Codes A	Rank its importance (only those with Yes in column 2)	Constraint? Codes A	Rank its importance (only those with Yes in column 4)	Constraint? Codes A	Rank its importance (only those with Yes in column 6)	Constraint? Codes A	Rank its importance (only those with Yes in column 8)	Constraint ? Codes A	Rank its importance (only those with Yes in column 10)	Constraint? Codes A	Rank its importance (only those with Yes in column 12)
1	2	3	4	5	6	7	8	9	10	11	12	13
Socioeconomic												
1. Timely availability of improved seed												
2. Prices of improved seed												
3. Quality of seed												
4. Availability of credit to buy seed												
6. Price of fertilizer												
7. Availability of credit to buy fertilizer												
8. Access to markets and information												
Biophysical												
10. Drought												
11. Floods												
13. Diseases												
14. Soil fertility												

Codes A: 0. No; 1. Yes

Rainfall assessment in 2008/09

1. Did the rainfall season come on time? (Codes A) ……..
2. Was there enough rain at the beginning of the growing season? (Codes A)……..
3. Was there enough rain during the growing season? (Codes A)……..
4. Did the rains stop on time? (Codes A)……..
5. Did it rain near the harvest time? (Codes A)……..

PART 10: RISK, LIVELIHOOD SHOCKS AND COPING STRATEGIES

Risk factor	How many times did […] occur in the past ten years?	Rank importance of […] in affecting household livelihood (1=most important)	Important coping strategies before (mitigation) […], Codes A; Rank 3			Important copping strategy after (adaptation) […] occurrence Code B; Rank 3			How did […] affect production of main food crop of the household (% reduction)	As a result of […] did you lose (part of) your income (% reduction)	Do you think […] will become more important in future due to climate change Codes C	If Yes, how often do you think […] will occur in the next ten years?	Which crops were most susceptible – rank 3 Codes in Annex 1 - attached sheet
			1st	2nd	3rd	1st	2nd	3rd					
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Drought													
2. Too much rain or floods													
3. Crop pests/diseases													
4. Hail storm													

Codes A				Codes B			Codes C
1. Planting drought tolerant crops	4. Plant disease/pest tolerant varieties	6. Increase seed rate	9. Soil and water conservation	1. Replanting	4. Selling other assets	7. Borrowing	0. No
2. Plant drought tolerant varieties	5. Crop diversification	7. More non-farm work	10. None	2. Selling livestock	5. Eat less (reduce meals)	10. None	1. Yes
3. Early planting		8. Saving	11. Other, specify……	3. Selling land	6. Out-migration	11. Other, specify……	

PART 11. HOUSEHOLD EXPENDITURE

(*Here, wife and/or the person involved in purchases should be the principal respondent/s).*

Section A: Food consumption

Item	Total consumed in the last 7 days for only members of the family				Bought in the last 12 months					
	Unit (e.g. kg, liter,)	Own produced	Bought	Cost of bought (KSh)	Unit (e.g. kg, liter, packet, bundle)	Frequency of buying)	Average quantity each time	Total quantity per year	Price per unit (KSh)	Total cost (KSh)
1	2	3	4	5	6	7	8	9	10	11= 9x10
Staple foods										
1. Maize (dry)										
24. Other specify..										
Vegetables										
27. Tomatoes										
39. Other specify…...										

Section A: Food consumption (cont'd)

Item	Total consumed in the last 7 days for only members of the family				Bought in the last 12 months					
	Unit (e.g. kg, liter, packet, bundle)	Own produced	Bought	Cost of bought (KSh)	Unit (e.g. kg, liter, packet, bundle)	Frequency of buying	Average quantity each time	Total quantity per year	Average price per unit (KSh)	Total cost of purchased (KSh)
1	2	3	4	5	6	7	8	9	10	11= 9*10
Fruits										
41. Oranges										
50. Other specify.										
Meat & other animal products										
52. Beef										
67. Other specify.										
Beverages and drinks										
69. Tea (leaves)										
71. Coffee (powder)										

Section A: Food consumption (contd)

Item	Unit (e.g. kg, liter, packet, bundle)	Total consumed in the last 7 days for only members of the family			Bought in the last 12 months					
		Own produced	Bought	Cost of bought (KSh)	Unit (e.g. kg, liter,)	Frequency of buying)	Average quantity each time	Total quantity per year	Average price per unit (KSh)	Total cost of purchased (KSh)
1	2	3	4	5	6	7	8	9	10	11= 9*10
Beverages and drinks (contd)										
80. Water for livestock										
82. Other specify..										
Fats, oils, sweeteners, snacks and others										
85. Cooking fat										
98. Other specify..										
Meals eaten away from home (specify)										
100.										

Section B: Expenditure on non-food items in the last 12 months

Expense Item	Unit (e.g. numbers, bundles)	Frequency of purchase (e.g., 2 times per month)	Average quantity each time	Total quantity per year	Per unit price (KSh)	Total cost (KSh)
1	2	3	4	5	6	7=5*6
1. Clothing						
10. Others, specify…..						

FARMERS WILLINGNESS TO GIVE MAIZE SEED FOR FINGERPRINTING

Variety	Seed recycling			Willingness to provide seeds & availability		If stopped growing			
Maize varieties grown in 2009/2010 season Codes in Annex 2 – See page 11	Do you have seeds of this variety at home? 1=Yes; 0=No	If not, when will you get the seeds for planting next season? (Which month?)	After harvest, how do you store seeds of this variety Codes A below	Are you willing to provide 40 seeds for hybrids and 200 seeds for OPVs ? 1=Yes 0=No	If not willing to provide seeds free, how much will you charge for the seeds? KSh	When did you stop growing YYYY?	Give the three main reasons for stopping (Code C on Page 7)		
							1st	2nd	3rd
1	2	3	4	5	6	7	8	9	10

Codes A
1. Each cob separately,
2. Seed bulk of the variety irrespective of the plot
4. Other, specify……

NNEX 1: CROP CODES

SIMLESA Crops	Other cereals	Other Pulses (legumes)	Oil Crops	Root crops/tubers/vegetables	Perennial crops	Fodder
1. Maize	11. White eff	26. Faba bean	41. Nigerseed	56. Cassava	71. Coffee	86. Lablab
2. Haricot bean	12. Red Teff	27. Lentil	42. Sunflower	57. Irish potato	72. Chat (*khat/miraa*)	87. Clover
3. Soybean	13. Mixed Teff	28. Grass pea	43. Sesame	58. Sweet potato	73. Banana	88. Vetch
5. Pigeonpea	14. Bread Wheat	29. Kabuli Chickpea	44. Linseed	59. Onion	74. Organe	89. Alfalfa
6. Groundnut	15. Durum Wheat	30. Desi chickpea	45. Rapeseed	60. Gralic (*Saumu*)	75. Mango	90. Sesbania
7. Cowpea	16. Barley	31. Field pea	46. Lupin	61. Pepper	76. Hop	91. Grazing land
8. Other, ……	17. Sorghum	32. Other ……	47. Other ……	62. Tomato	77. Enset	92. Napier grass
9……	18. Finger Millet	33……	48. ……	63. Ginger	78. Sugar cane	93……
10……	19. Pearl millet	34……	49……	64. Cabbage	79. Eucalyptus	94……
	20. Rice	35……	50……	65. Kale (*sukuma wiki*)	80……	95……
	21. Other……	36……	51……	66. Carrot	81……	96……
	22……	37……	52……	67…Other ……	82……	97……
	23……	38……	53……	68……	83……	98……
	24……	39……	54……	69……	84……	99……
	25……	40……	55……	70……	85……	100……

ANNEX 2: CROP VARIETY CODES

Maize			Common bean		Soybean	Pigeonpea	Groundnut	Cowpea	Other crops
1. DK8031	11. WS 505	21……	31. Wairimu	41……	51.Gazelle	61. 00040-LD (*Agric.mrefu)*	76. Homa Bay local	86. M-66	96. Improved
2. H513	12. PH B3253	22……	32. Mwitemania	42……	52.SB 11	62. 00777-LD	77. Nyauyoma red	87.K-80	97. Local
3. H512	13. DH O4	23……	33. Roscoco	43……	53.SB 29	63. 00554 -MD	78. Virginia	88. K7-1	
4. H511	14. DUMA 41	24……	34. Nyayo	44……	54……	64. 00557-MD	79. Mani Pinta	89. IT82C	
5. H624	15. DUMA 43	25……	35. Gacera	45……	55……	65. 00068-MD *(Syombonge)*	80. White Valencia/Uganda stripes/teso	90. Kunde 1	
6. H629	16. PIONEER 3250	26……	36. Katheri	46……	56……	66. 60/8-MD *(Mbaazi I)*	local	91. Black eye	
7. H625	17. Makueni	27……	37. Gacugu	47……	57……	67. 87091-SD *(Keritu/mwezi moja)*	81.Nyahela/Uganda red	92 ……	
8.H614	18……	28……	38. KK8	48……	58……	68. Local-LD	82.Small red/kabonge	93. ……	
9. H627	19……	29……	39……	49……	59……	69. 00932-LD	83……	94. ……	
10. WS 502	20……	30……	40……	50……	60……	70. 00835-MD	84……	95. ……	
						71. ……	85……		
						72……			
						73. ……			
						74. ……			
						75. ……			

ENDING TIME……