Determinants and Welfare Effect of Smallholder Farmers' Commercialization in Kenya

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Abstract

Transforming smallholder agriculture from subsistence production to commercialized agriculture, remain a key policy concern for developing countries such as Kenya. Although great efforts have been made to promote commercialization, smallholder farming in the country is dominated by subsistence with little participation in the market system. This study aimed at investigating the factors that influence commercialization and the level of commercialization as well as the effect of smallholder farmers' commercialization on smallholder farmers' welfare in Kenya. The study utilized national cross section data collected by the Agricultural Sector Development Support Programme (ASDSP) on agricultural households in the country and analysis was performed using a two-stage selectivity model. In addition, it used the propensity score matching approach to examine the effect of commercialization on smallholder farmers' welfare in Kenya. The results showed that the level of commercialization for crops is still low and varies across agro-climatic zones. The factors that influence smallholder commercialization were found to be the years of schooling of the household head, farm income, agricultural savings, asset holding, amount of annual crop produce sold, the sex of the person making the decision on crop production being female, non-farm income, access to agricultural extension services, access to insurance services and the amount of produce produced. Conversely, the factors that influence the level of commercialization were non-farm income, extension services, amount of product produced, the household's head number of schooling years, the decision on crop production being made by a person of the female sex, farm income, agricultural savings, access to agricultural insurance, asset holding and amount of annual crop product sold. On the welfare of smallholder farmers, the study found a general improvement due to commercialization. The study therefore recommends a close collaboration between the State Department of Agriculture and County Governments so as to commit more resources for the promotion of smallholder commercialization.

Abbreviations and Acronyms

AIDS	Acquired Immune Deficiency Syndrome
ASDSP	Agricultural Sector Development Support Programme
ATE	Average Treatment Effect on the Treated
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
HCI	Household Commercialization Index
HDDS	Household's dietary diversity score
HIV	Human Immunodeficiency Virus Infection
IMR	Inverse Mills Ratio
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
MC	Marginal cost
MoA	Ministry of Agriculture
MR	Marginal Revenue
NAAIAP	National Accelerated Agricultural Input Access Programme
SHDP	Small-scale Horticulture Development Project
SMAP	Standards and Market Access Programme
SPSS	Statistical Package for the Social Sciences
VCE	Variance-Covariance Estimator
VIF	Variance Inflation Factor

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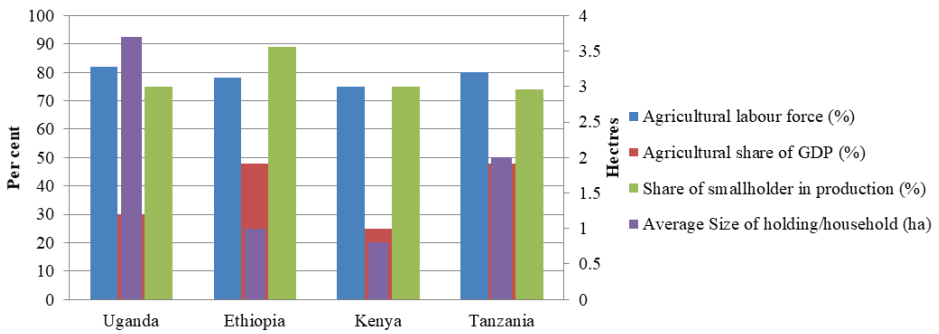
1. Introduction

1.1 Background Information

Smallholder farmers form a considerable proportion of farmers in the world forming about 66 per cent of the developing world's population and provide employment for approximately 2.5 billion people around the globe (Nagayets, 2005; Walpole, 2013). In Africa, there are approximately 45 million smallholder farms that contribute to about 70 per cent of the continent's food needs (Nagayets, 2005; FAO, 2011). With most of the economies in sub-Saharan Africa being agricultural based, smallholder farmers are part of an essential component of not only ensuring food security but also economic growth.

In the Kenyan economy agriculture plays a pivotal role with the sector being the largest contributor to the Gross Domestic Product (GDP), contributing about 30 per cent to the GDP in 2015 (KNBS, 2016). Most of the agricultural activity is done by farmers with small land holding who produce 75 per cent of livestock, food crop and cash crop in the country as shown in Figure 1 (FAO, 2009; MoA, 2010).

Figure 1: Economic Contributions of the Agricultural Sector in 2009



Source: Salami et al., (2010).

While most of the times the term smallholder farmers has been used to refer to farmers with land holding of less than five acres, some scholars have extended its meaning to encompass the farmers with limited capital and limited access to factors of production such as inputs (Chipeta *et al.,* 2003: Asuming-Brempong, *et al.,* 2013). While these factors can be used in the definition of smallholder farmers, in the Kenyan setting, land holding is the common factor used in the definition of the term (Salami *et al.,* 2010; Rapsomanikis, 2014). In this study, smallholder farmers are defined as farmers who own 5 acres and below.

Despite the immense contribution of smallholder farmers to the country, most of these farmers still practice subsistence farming as opposed to commercial farming. Research shows that subsistence agriculture does not offer a sustainable way of increasing the farmers' welfare and thus there is a need of the smallholder farmers to move to a productivity-driven commercial agriculture (Livingstone *et al.,* 2011). While commercialization offers the farmers an opportunity to increase their incomes and food security, the motivation of the farmers towards commercialization is anchored on the benefits that accrue to the smallholder farmers in shifting towards commercial agriculture. This realization informed the envisioning of a commercialized agricultural sector in the country's development blueprint. As articulated in the Kenya Vision 2030, Kenya aims to increase farmers' incomes in the agricultural sector through commercially oriented agriculture, livestock and fisheries sector and increased smallholder specialization in the cash crop sector. This has seen the government invest considerable amounts of resources in subsidizing inputs for smallholder farmers through programs such as the National Accelerated Agricultural Inputs Access Program (NAAIAP) and enhancing market access by smallholder farmers through programs such as the Smallscale Horticulture Development Project (SHDP) and the Standards and Market Access Programme (SMAP) in an effort to commercialize agriculture in the country.

Regardless of these government effort in promoting commercialization, evidence shows that smallholder production is largely subsistence. Agricultural productivity has stagnated over the last decade and little growth in smallholder farmers' participation in markets except in the milk market (Olwande *et al.,* 2015; KIPPRA, 2016). As such, it shows that there has not been a substantial move from subsistence to commercial agriculture.

The definition of commercialization is dependent on the indicators chosen in its calculation (Jaleta *et al.,* 2009; Muriithi *et al.,* 2015). One of the way of calculating it is considering if the household produces a significant amount of cash crops, a marketable commodity or if it sells a significant amount of output (Immink and Alarcon 1993; Strasberg *et al.,* 1999). On the other hand, in defining commercialization, Von Braun *et al.,* (1994) and Pingali (1997), go beyond the supply of surplus products to markets to consider the input and output sides of production coupled with the decision-making behaviour of farm households in production and marketing. The underlying factor in these definitions is that the target of commercialization is the market rather than the amount of production and consumption (Pingali and Rosegrant 1995).

Therefore, the main difference between a commercialized farmer and subsistence or non-commercialized farmer is that while the commercialized farmers' decisions are made dependent on the market forces and profit making goal, subsistence

farmers' decisions are depended on production possibility. With these diverse definitions, this study chose to adopt the definition of commercialization advanced by Govereh *et al.,* (1999) and Strasberg et al (1999), as the proportion of the gross value of the entire crop sales to the proportion of the gross values of the entire crops produced. It is noteworthy that under this definition, commercialization encompasses both cash crops and traditional food crops.

1.2 Statement of the Problem

Despite efforts to increase productivity and commercialization, Kenya's smallholder farming remains predominantly subsistence. This has not only rendered the farmers unable to benefit from commercialization opportunities but also slowed down the countries agriculture dependent economy. Moreover, while Kenya aims to increase incomes in agriculture and generate additional Ksh 80 to 90 billion in additional revenue from agriculture by the year 2030 (Government of Kenya, 2007) through a commercially oriented agriculture, with less than 13 years to the proposed date of attainment of this vision Kenya's smallholder agriculture remains predominantly subsistence.

The 2010 Kenya Constitution established two levels of government; the National and County Governments. This saw agriculture being devolved to the County Governments. The County Governments therefore have functions and powers on crop and animal husbandry, plant and animal disease control and fisheries. In this new dispensation, the County Government will play a key role in steering agriculture to the level of commercialization envisioned in the Vision 2030 blueprint. Therefore, in this new dispensation, there is need for empirical literature on the level of commercialization that will inform agricultural investments in the devolved units. Similarly, there is lack evidence on the impact of commercialization on smallholder farmers' welfare.

There is need therefore to inform policy on the benefits achieved though commercialization of smallholder farmers in the country. With Kenya's economy remaining agriculture dependent and a majority of the population depending on agriculture for their livelihood, the transformation of agriculture from subsistence to commercial agriculture is not only a precondition to improvement of the country's populace welfare but also for economic development of the country.

1.3. Objectives

The main objective of this study is to investigate the factors that influence commercialization and the level of commercialization and the effect of smallholder farmers' agricultural commercialization on the farmers' welfare.

1.3.1 Specific Objectives

1. To investigate the factors that influence smallholder farmers' commercialization in Kenya.
2. To investigate the factors that influence the extent of commercialization among smallholder farmers in Kenya.
3. To examine the effect of commercialization on smallholder farmers' welfare in Kenya.

1.3.2 Research Questions

1. What are the factors that influence smallholder farmers' commercialization in Kenya?
2. What are the factors that influence the extent of commercialization among smallholder farmers in Kenya?
3. What is the effect of commercialization on smallholder farmers' welfare in Kenya?

1.4 Justification

Smallholder farmers in the Kenya face production and market challenges that are specifically peculiar to subsistence farming. In production, due to a burgeoning population, smallholder farmers in the country are facing declining size of land (Jayne and Muyanga, 2012). This has resulted in a declining land to labour ratio, constraints in distribution of land within the farm and an imminent landlessness (Woolverton *et al.,* 2012). Apart from the challenge of associated with land size, farmers in the country have been facing a stagnant crop and livestock productivity (KIPPRA, 2016). Some of the factors that have led to stagnation in productivity are low input and technology use, lack of sufficient support services, inadequate skills and capacity to participate in markets and poor infrastructure. On the markets, smallholder farmers operate in poorly functioning input markets especially as it relates to credit facilities, market information, extension services and technical support and insurance. These farmers are also poorly integrated in the output markets that offer better prices due to factors such as small volume of trade, low productivity, distance between farmers that makes pooling of produce difficult and costly and high transaction costs. Smallholder commercialization is seen as a holistic solution in addressing these challenges. With the above stated constraints facing smallholder farmers, a need arises to investigate the causal factors to their commercialization.

Additionally, research done on commercialization has largely been biased towards specific crops or group of crops and in specific regions (Muricho, 2015). This has seen researchers neglect the overall commercialization of the farmer at the household level and the country. Under this predisposition research gaps also arise in the estimation of the effect of farm commercialization to the farmer's welfare across the different parts of the country. There is therefore a need for further research on what factors contribute to commercialization and the welfare effects of smallholder farmers' commercialization in order to inform policy review that will steer the country to the attainment of the Vision 2030. This study therefore addresses this gap in research and policy framework by looking at the factors that not only determines smallholder farmers' commercialization but also the factors that influences the level of commercialization. In addition, commercialized agriculture is vital to country's attainment of its Vision 2030 Blueprint. As one of the components of the economic pillar in the Kenya Vision 2030 blueprint, Agriculture is expected to contribute to the 10 per cent economic growth through a "commercially oriented and modern agriculture, livestock and fisheries sector" (Government of Kenya, 2007). The outputs from this study will therefore be of great use in the policy framework on the gains made so far in achieving commercialization as aspired in the Kenya Vision 2030.

2. Literature Review

2.1 Theories underlying Commercialization

Commercialization as a way of achieving agricultural development has been advocated for by many scholars and development experts over the years. The advancement of this theory is as a result of the lack of improvement in the subsistence farmers' welfare and economy of countries where farmers practice subsistence farming (Livingstone *et al.*,, 2011).

Therefore, the advocates of agricultural transformation draw attention to commercialization as a way of increasing farmers' welfare and spurring economic growth. This theoretical underpinning can be traced to the work of Jorgenson (1961) who developed the theory of dual economy divided into two sectors modern sector (manufacturing) and traditional sector (agriculture). In his analysis, the agricultural sector was assumed to be a function of land and labour without capital accumulation.

In analyzing the contribution of agriculture to economic growth under the context of Jorgenson's dual economy, Johnston and Mellor (1961) pointed out five ways in which agriculture contributes to economic growth. These were: providing food in face of rising demand; increasing incomes and foreign exchange earnings through agricultural exports; providing labour by pushing labour from agriculture to manufacturing; provision of capital since it is the dominant sector in developing countries; and increasing incomes for the rural farm population as a stimulus to industrial growth. However, Johnston and Mellor (1961) gave increased agricultural output and productivity as a precondition to agriculture contributing to economic growth. Johnston and Mellor (1961) posed that the increasing output and productivity could be achieved through commercialization, a view supported by Khan (1966).

Many scholars see agricultural commercialization as a product of a series of stages. The farmer is postulated to move from subsistence farming to a mixed family farming and then to commercialized agriculture. In the subsistence farming system, inputs are mainly generated in the home (e.g. manure) and there is no trading of outputs. The goal of this farming model is food sufficiency (Todaro, 1981; Pingali and Rosegrant, 1995). In the mixed family farming, though the goal is still food sufficiency, the farmers use home generated and market sourced inputs and part of the produce (mainly the surplus) is sold (Wharton, 1963; Todaro, 1981; Pingali and Rosegrant, 1995). In the commercial agriculture, the farmer is fully engaged with the input market (with the aim of increasing productivity and

enhance specialization) and output markets (in order to maximize profits) (Todaro 1989; Pingali and Rosegrant 1995; Pingali 1997). Therefore, in this process, the smallholder farmers undergoes an agricultural transformation process by shifting from subsistence agriculture to specialized production that interacts with both the inputs and outputs markets (Jaleta *et al.,*, 2009). Under this premise, it is noteworthy that though commercialization is mostly viewed as a specialization in cash crops, this is not essentially the case with commercialization of staple or traditional food crops being a common phenomenon especially among smallholder farmers (Jaleta *et al.,* 2009). Moreover, market failures and barriers to entry in to the export markets by smallholder farmers in developing countries makes these farmers diversify into non-staples but not to fully specialize depending on their agro-ecological and market circumstances (Muricho, 2015).

Agricultural production in commercialized farms is market oriented (Von Braun, (1995). Therefore, commercialization at the farm level goes beyond increasing production in order to have surplus production to the market to include the household's choice behaviour on input use and production motivated by profit maximization (Pingali and Rosegrant, 1995). This study as a result employed profit maximization theory since the decision to commercialize is increasingly guided by the objective of profit maximization as a farmer moves from subsistence farming to commercialization of the farm (Omiti *et al.,* 2009; Awotide *et al.,* 2016). With the profits being the difference between the revenue and the costs, then the relationship between profit, revenue and cost can be represented by the equation below:

$$\pi = R - C \quad \text{..... Equation 1}$$

Where π is profit, R is revenue and C is cost.

However, revenue and cost are determined by price and quantity such that:

$$R = P_o * Q \quad \text{..... Equation 2}$$

and

$$C = P_i * Q \quad \text{..... Equation 3}$$

Where P_o is the farmers' output price, P_i is the price of the farmers' inputs and Q is the quantity produced by the farmers.

Therefore, equation 1 can be written as:

$$\pi = R - C = P_o * Q - P_i * Q \quad \text{..... Equation 4}$$

However, since the farmers are operating in a perfectly competitive market, the price is determined by the market forces and cannot be determined by the farmer. Therefore, farmers are price takers thus making the quantity the only factor that the farmers can control. Furthermore, research has shown that farmers are usually price takers with their profits dependent on quantity rather than price (Okello *et al.,* 2010, Djafar *et al.,* 2016). This makes equation 4 become:

$$\pi = R(Q) - C(Q) \quad \text{..... Equation 5}$$

Therefore, by derivative of equation 5 equal to zero, we can get the quantity which the farmer can produce that maximizes profit. Thus:

$$\delta\pi / \delta Q = \pi'(Q) = \delta R / \delta Q - \delta C / \delta Q = 0 \quad \text{..... Equation 6}$$

Thus:

$$\delta R/\delta Q = \delta C/\delta Q \quad \text{..... Equation 7}$$

But $(\delta R/\delta Q)$ is marginal revenue (MR) which is the is the additional revenue accrued by increasing the product(s) sold by one unit and $(\delta C/\delta Q)$ is marginal cost (MC) which is the cost of the farmer producing one additional unit of the product(s). Consequently:

$$MR = \delta R/\delta Q = \delta C/\delta Q = MC \quad \text{..... Equation 8}$$

The farmer who maximizes profit will therefore produce output at the level where marginal revenue equals marginal cost and thus marginal profit (derivative of π) is zero. However, profits are maximized at the level at which the marginal profits are reducing. Therefore, the second order differentiation for marginal revenue must be less than zero. Therefore:

$$(\delta^2\pi)/(\delta Q^2) = [\delta\pi'(Q)]/\delta Q < 0 \quad \text{..... Equation 9}$$

2.2 Empirical Literature

2.2.1 Factors affecting Commercialization

Several factors that determine agricultural commercialization have been recognized. For instance, Govereh and Jayne (2003) examined factors that influence commercialization of cotton in Zimbabwe. The study using an ordinary

least squares model found that commercialization of cotton is positively linked to the size of the farm, farm capital value, quantity of cotton sprayers, household head's education and villages time of tsetse fly clearing. Conversely, the size of the family, distance to the cotton purchaser and female-headed households were found to be negatively correlated to commercialisation of cotton.

Asuming-Brempong *et al.,* (2013) used a regression analysis to investigate the determinants of commercialization for smallholder tomato and pineapple farmers in Ghana. The study found that land productivity and labour productivity had a positive influence on household's judgment to commercialize tomatoes while land productivity and savings had a positive and significant influence on household's decision to commercialize pineapples.

Given that, market participation is an integral part of commercialization, Goetz (1992), employed a selectivity model, in investigating the agricultural households' choice to take part in markets of coarse grain in sub-Saharan Africa. The study found that access to market information (which was used as a proxy for fixed transaction costs) significantly affected the decision to participate in coarse grain markets while access to cereal processing technology (which was used as a proxy for proportional transaction costs) influenced the amount of grain to be marketed conditional on participation.

In a study in central Tanzania, Mutabazi *et al*., (2013) using a Tobit and Cragg's double-hurdle models found out that age of the household heads, perception of price risk of the farmer, savings of the farmer, road network and participating in a water user organization were factors that influenced commercialization of smallholder farmers. The study found that households with younger household heads, risk takers on pricing, having savings, those with diverse crops in their farms and membership to water grouping had a greater likelihood of commercializing their enterprise. In addition, farmers in areas with a good road network were found to be more commercialized and with a higher production per hectare. As relates to gender issues, female farmers were found to be less commercialized since they did not have access to irrigated land.

Omiti *et al.,* (2009), used a regression model to examine the factors that influence the intensity of market participation among smallholder farmers in Kenya. The study investigated three products: milk, vegetable and maize. On the marketed milk, the study found that the use of informal market information channels, total output for the pooled sample and the unit price had a positive influence on milk sold. Conversely, market distance (especially in the rural setting) and household size (particularly where the number of children was high) significantly reduces the amount of milk sold. The study also found that the factors that positively influenced the intensity of market participation for vegetables to be price, output,

informal market information sources and the household head being of the male gender. The distance to the market and the number of persons in the household significantly reduced the proportion of vegetables sold especially for farmers in the rural areas. Likewise, the study established that household head's level of education and market information channels access increased the intensity participation in the market while non-farm income considerably decreases the vegetables sold by peri-urban farmers. As relates to maize, the study found that the overall output and household head's level of education positively influence the intensity of market participation. In the peri-urban areas the value of maize and official information sources positively influenced the intensity of maize market participation while non-farm income and market distance negatively affect intensity of the supply of maize for rural and peri-urban markets.

A review of further literature shows that most of the studies in determinants of commercialization are not only commodity specific but also area specific. For example, using a year panel data Muricho (2015) made use of the double hurdle model to investigate the determinants of commercialization decision and intensity. The study found that farm size and soil fertility, access to farm input credit, contacts with extension staff, membership to rural agricultural production networks, mobile phone ownership and ownership of local means of transport affected smallholder commercialization positively while transport costs was negatively related to commercialization. On the other hand, Kirui and Njiraini (2013) using a Tobit regression analysis evaluated the determinants of commercialization. The study used data from three districts in Kenya. The study found that education level, farmer's age, farm distance to bank, diversification of crops, farm and non-farm income, membership to a farmer group and use of mobile phones significantly and positively determines commercialization while gender of the household head being female, farming know-how, and distance to the output market influences commercialization negatively.

Further, factors that in affect commercialization and its level thereof can be disaggregated into internal household factors and external factors. Internal household factors that affect commercialization have been found to include such as the households' resources for instance land, labour and capital and external factors for example infrastructure, technological advances, demography and market-oriented institutional development, introduction of new commodities, infrastructure, market institutions, economic development, changes in policies (macroeconomic, trade and sectoral), property rights, land tenure, alteration in consumption preferences and agro-climatic conditions (von Braun *et al.,* 1991; Pender *et al.,* 2006; Jaleta *et al.,* 2009; Tirkaso, 2013)

As evidenced above, several researchers have applied diverse methodologies to investigate the factors that influence commercialization. However a limitation to most of the studies is a focus on defined food items thus ignoring the fact that in transiting from subsistence to commercial production does not necessarily imply a shift to specialization but rather a mixed staple and cash crop production can exist in a commercialized farm (Pingali *et al.,*, 2005; Gebre-ab, 2006). However, despite these limitations, these studies were instrumental in this study.

2.2.2 Effect of Commercialization on Farmer Welfare

While it is generally agreed in theory that agricultural commercialization increases household income as compared to subsistence farming (Kennedy and Cogill 1987; Dorsey 1999), the structure of markets influences the welfare effects of the farmers' households. For example, if the markets are not functional, commercialized households may be exposed to unpredictable market prices. Therefore, if market failure exists, commercialization may have adverse outcome on smallholder farmers' welfare (Jaleta *et al.,* 2009). Researchers on effect of commercialization on smallholder farmers define welfare differently depending on the variable of interest. This has seen the impact of commercialization on farmer welfare include income, health, food security and nutrition, employment, assets, and HIV/AIDS (Jaleta *et al.,* 2009).

Though literature on impact of smallholder commercialization exists, its effect on farmers' welfare is still obscure and at times contradictory (Maertens *et al.,* 2012). In their contribution to literature, Kirimi *et al.,* (2013) sought to determine if household participation in commercialization affects household food security. The findings showed that commercialization was related to reduction in risk of being chronically food poor.

With the use of an ordinary least square, Muriithi and Matz, (2015) used panel data for Kenya to look into the welfare effects of smallholder vegetable commercialization through domestic and exports markets. The study used income and asset ownership as a measurement of smallholder farmers' welfare. The study found a positive link between export market commercialization and income as well as between domestic market vegetable commercialization and asset ownership.

Muricho (2015) investigated the impact of commercialization on smallholder farmers' welfare (food security and poverty) in Kenya by the use of an endogenous switching regression. The study found that commercialization significantly reduces food insecurity and poverty. On the measurement of poverty, the study also used the average annual per capita household expenditure. However, in

theory, household expenditure is a factor of other variables such as earnings, family characteristics and lifecycle, social division, culture (race) and location (Viljoen, 1998). Thus, by using expenditure only as a measure of poverty, the study is limited in its findings.

2.3 Overview of Literature

Agricultural commercialization is seen as a product of a series of stages where the farmer moves from subsistence farming to a mixed family farming and then to commercialized agriculture. This movement from subsistence to commercial agriculture is motivated by market forces rather than consumption. Based on this, the study was based on profit maximization theory.

Generally, most of the studies have leaned on market participation rather than commercialization with a rich array of literature on the determinants of market participation decision. In addition, the literature leans on specific crops rather than using a holistic farm commercialization index. Similarly, in the review of the effect of commercialization, the studies lean on market participation indices. Furthermore, there is scarcity of literature that evaluates the effect of commercialization. This study sought to attend to this gap by using a comprehensive household commercialization index and using robust methods in evaluating the determinants and effects of commercialization.

3. Methodology

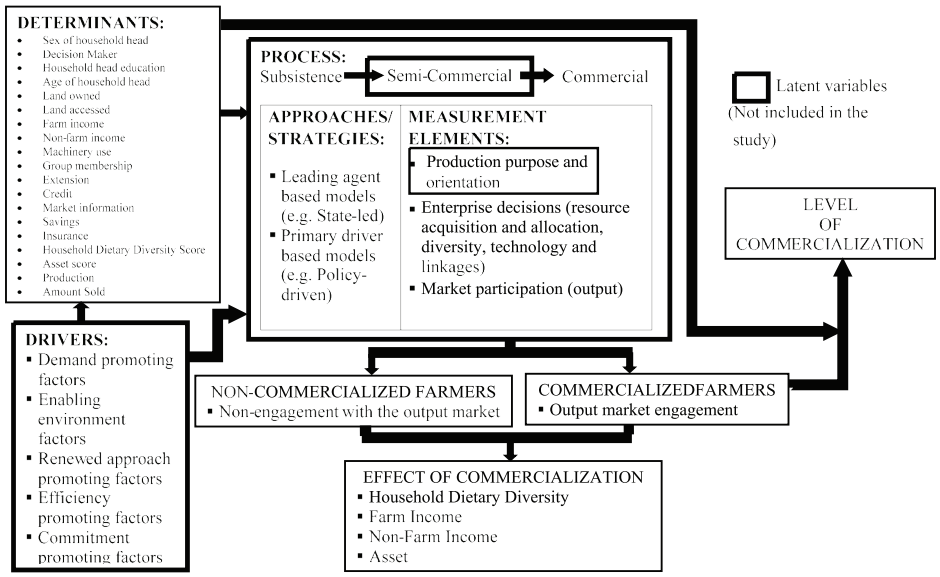
3.1 Conceptual Framework

The conceptual framework for this study is founded on the works if Zhou *et al.,* (2013). Commercialization at the household level was conceptualized to be driven by factors such as increased demand, favourable environment, new farming methods, technological change and entrepreneurship. However, in this framework, these drivers are taken as latent in the sense that they cannot be measured but rather one can only estimate the resulting consequences of these drivers of commercialization. It was also hypothesized that these drivers also influenced the determinants and process of commercialization. In turn, the determinants of commercialization, both external and internal influence the process of commercialization whereby the farmer progressively moves from subsistence agriculture to semi-commercial agriculture and then to commercial agriculture. However, in this study the semi-commercial agriculture stage is taken as latent. Based on the work by von Braun, 1994, this stage is taken as latent since this process is difficult to define especially based on the cropping type since cash crops may not be necessarily commercialized and staple foods can be commercialized. As such, using the categories of cash crops and food crops to analyze commercialization and requires one to look at the intent of growing the particular crop. However, since the data in this study is cross-sectional in nature, it is impossible to analyze the intent of the smallholder farmer in adopting the particular crop. Furthermore, research shows that, smallholder farmers generally transition progressively from subsistence to commercial agriculture rather than a change to cash crops whereby the farmers start by producing surplus staple commodities for the market then moving to mixed staple and cash crop production before moving to cash crop production systems (Pingali et al. 2005; Gebre-ab 2006).

The approaches to take in the commercialization process will depend on whether there is a leading agent or a primary driver which further determines the activities and partnerships involved. The measurements elements in the case will be the smallholder farmer's enterprise decisions and participation in the output markets. The production purpose and orientation is taken as a latent variable in this study. The measurement process then informs as to whether the farmer is commercialized or not. The non-commercialized farmers are the ones who do not engage with the output market while the commercialized farmers are the ones who engage with the output market. It is put forward that the intensity of commercialization is also influenced by the external and internal factors. After the determination of commercialized and non-commercialized farmers, the analysis further looked

into the effects of commercialization on household dietary diversity, farm income, non-farm income and assets. Figure 2 shows the interrelationships between these variables.

Figure 2: Conceptual Framework



Source: Modified from Zhou et. al., 2013

3.2 Model specification

3.2.1 Factors Influencing Commercialization and the Level of Commercialization- Heckman Two-Stage Model

The nature of this study necessitated the use of a two-step selectivity model (see studies by Goetz, 1992, Bellamere and Barrett, 2006; Alene *et al.,* 2008; Mathenge at al., 2010; Bahta and Bauer, 2012 and Muricho, 2015). This is opposed to the studies that have used tobit model to investigate the intensity of market participation (Omiti *et al.,* 2009 and Macharia *et al.,* 2014).

The use of tobit model assumes simultaneity of the decision to commercialize and amount of produce sold, thus the factors that affect these two aspects would be the same. This premise creates a limitation since factors that determine the likelihood to commercialize and the level of commercialization are not necessarily the same (Tobin, 1958). The tobit model also assume that if no products are sold,

it is because the farmer has made a rational choice not to sell which in the case this assumption may underestimate the intercept and overestimate the slope of the regression (Komarek, 2010; Sigei, 2014). In addition, a study by Makhura (2001) shows that the tobit model obscures some details through merging the direct and partial effects of the independent variables on the dependent variables. Based on these limitations, the study used a two-step selectivity model approach which relaxes the Tobit regression's assumptions thus allowing for a distinction between the choice to commercialize as well as the level of commercialization.

The two-step selectivity model approach can utilize either the Craig's double-hurdle model or the Heckman two-stage model. The Craig's double-hurdle (Craig, 1971) comprises of a probit regression in the initial step and a truncated regression in the preceding stage. This model was reckoned as inappropriate for this study since in the case of incidental truncation, some part of the explanatory variable is not observed (Sigei, 2014). Instead the Heckman two-stage model was chosen over Craig's double-hurdle since it does not require exclusion restrictions and the same set of regressors can be used in each stage without making parameter identification difficult (Newman *et al.,* 2003: Bushway *et al.,* 2007). The Heckman two-stage model (Heckman, 1979) has been extensively applied to remedy for biases from sample selection thus providing plausible and asymptotically competent approximation for all the factors (Heckman, 1979; Maddala, 1983; Amemiya, 1985).

Commercialization for the smallholder farmer is binary in nature in that a farmer is either commercialized (interacting with the market on the input or output side) or not. Therefore, the model involves the use of two equations where the first equation's dependent variable is binary in nature as to whether the smallholder farmer was commercialized or not while the second one measures the extent to which the commercialized farmers were commercialized. Through this, the model corrects the sample selectivity bias (Hoffman and Kassouf, 2005).

The first equation will therefore be a probit model that will predict the probability that a farmer is commercialized or not that is specified as:

$$pr\,(Z_i = 0, 1 | w_i\,\alpha) = \Phi\,[h(w_i,\alpha)] + \varepsilon_i \quad \text{..... Equation 10}$$

Where Z_i is an indicator variable equal to one for commercialized smallholder farmers and zero otherwise, Φ is the coefficient, w_i is the standard normal cumulative distribution function, is a vector of factors influencing the decision to commercialise, α is a vector of coefficients to be estimated, and ε_i is the error term assumed to be distributed normally with a mean of zero and a variance of one. The indicator variable Z_i is therefore dependent on a latent variable Z_i* such that:

$$Z_i^* = \alpha w_i + u_i \quad \text{..... Equation 11}$$

Where Z_i^* is the commercialization status the smallholder farmers obtain from commercialization and u_i is the error term N (0, 1). Therefore:

$$Z_i = 1 \text{ if } Z_i^* > 0 \quad \text{..... Equation 12}$$

$$Z_i = 0 \text{ if } Z_i^* \leq 0 \quad \text{..... Equation 13}$$

Thus the equation 13 measures the probability of the farmer commercializing where Z_i^* is the farmers' commercialization status (0 or 1), α is the parameter to be estimated, w_i are vector of coefficients to be estimated and u_i is the error term that is normally distributed with a mean of zero and variance of one. The binary choice then becomes:

$$y^* = 0, \text{ if } y = 0 \quad \text{..... Equation 14}$$

$$y^* = 1, \text{ if } 0 < y \leq \mu_1 \quad \text{..... Equation 15}$$

Where y^* is equal to Z_i^* and μ's are unknown parameters to be estimated. The probability of a farmer commercializing then can be defined as:

$$Prob\ (y = 0 | W) = F\ (-\alpha' W) \quad \text{..... Equation 16}$$

$$Prob\ (y = 1 \mid W) = F\ (\mu_o - \alpha' W) - F\ (-\alpha' W) \quad \text{..... Equation 17}$$

Where $F(.)$ is the cumulative probability distribution written as:

$$P_i = F\ (\alpha' X) = [1/\sqrt{2\pi}] \int_{-\infty}^{(\alpha' X)} e^{(-z^2/2)}\ dz, [z \sim N(0,1)] \quad \text{..... Equation 18}$$

With the binary probit utilizing the maximum likelihood estimation in estimating α and u_i above, the probabilities can be reduced to:

$$Prob\ (y = n) = \Phi\ (\mu_n - \alpha' X) - \Phi\ (\mu_{(n-1)} - \alpha' X),\ n = 0,1 \quad \text{..... Equation 19}$$

Where Φ is the cumulative distribution function, $\mu_o = 0$ and $\mu_4 = +\infty$ and μ_o and μ_1 are the thresholds between choices of commercialization estimated with a maximum likelihood function. But the estimated coefficients do not represent the effect of an individual variable on the farmer choice to commercialize, hence

the marginal effects will be calculated to establish the effect (Greene, 2003). The marginal effect is calculated as:

$$[\partial Prob\ (y=n)]/\partial X = -[\Phi(\mu_n - \alpha'X) - \Phi\ (\mu_{(n-1)} - \alpha'X)]\ \alpha,\ n = 0,1 \ldots\ldots\ldots \text{Equation 20}$$

The goodness of fit is calculated as:

$$p^2 = 1 - [(\ln L_b)/(\ln L_o)] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 21}$$

Where L_b is the log likelihood at convergence and L_o is the log likelihood computed at zero and $0 \leq p^2 < 1$. If all the coefficients are zero, the goodness of fit is zero. The goodness of fit cannot be equal to one but a value close to one indicates a very good fit (Duncan *et al.*, 1998).

The model estimated is thus specified as:

$$COM = \alpha_1\ AGEHH + \alpha_2\ AGEHHSQURE + \alpha_3\ AGRICRDT + \alpha_4\ AGRIGRPMEM + \alpha_5\ AGRINS + \alpha_6\ AGRISAV + \alpha_7\ ASSCORE + \alpha_8\ DFEM + \alpha_9\ EXT + \alpha_{10}\ FINC + \alpha_{11}\ HDDS + \alpha_{12}\ HHEDUC + \alpha_{13}\ HUMSUBHUM + \alpha_{14}\ LACC + \alpha_{15}\ LOWN + \alpha_{16}\ MACUSE + \alpha_{17}\ MKTINFOACC + \alpha_{18}\ NONFINC + \alpha_{19}\ SEMHUMSEMARD + \alpha_{20}\ SHH + \alpha_{21}\ TPROD + \alpha_{22}\ TSOLD + u \ldots\ldots\ldots\ldots\ldots \text{Equation 22}$$

Where commercialization is the dependent variable, $\alpha_1, \alpha_2 \ldots \alpha_n$ are the parameters to be determined and u is the error term.

In the second step of the Heckman two-stage model, the aim is to look at factors that influence the level of commercialization. In order to achieve this, an additional regressor, Inverse Mills Ratio (IMR), will be added to correct for selection model. The Inverse Mills Ratio (IMR) is specified as:

$$\varphi\ [h\ (w_i, \dot{\alpha})] / [\varphi(w_i, \dot{\alpha})] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 23}$$

Where φ is the normal probability density is function and $\dot{\alpha}$ is the standard normal cumulative distribution function.

Therefore, the second stage equation is given by:

$$E = (Y_i \mid Z_i=1) = f\ (x_i, \beta) + \lambda\ \{\varphi\ [h(w_i, \dot{\alpha})] / \varphi(w_i, \dot{\alpha})\} \ldots\ldots\ldots\ldots\ldots \text{Equation 24}$$

Where E is the expectation operator, Y_i is the proportion of commercialization, x_i is a vector of independent variables affecting commercialization, β is the vector of the corresponding coefficients to be estimated and λ is the coefficient of the IMR. Y_i can be defined as a factor of Y_i^* defined as:

$$Y_i^* = \beta' x_i + \gamma\lambda_i + u_i \quad \text{..... Equation 25}$$

Such that is only observed for those farmers who are commercialized therefore.

The equation above is operationalized as:

$$HCI = \alpha_1 AGEHH + \alpha_2 AGEHHSQURE + \alpha_3 AGRICRDT + \alpha_4 AGRIGRPMEM + \alpha_5 AGRINS + \alpha_6 AGRISAV + \alpha 7\, A_S SCORE + \alpha_8 DFEM + \alpha_9 EXT + \alpha_{10} FINC + \alpha_{11} HDDS + \alpha_{12} HHEDUC + \alpha_{13} HUMSUBHUM + \alpha_{14} LACC + \alpha_{15} LOWN + \alpha_{16} MACUSE + \alpha_{17} MKTINFOACC + \alpha_{18} NONFINC + \alpha_{19} SEMHUMSEMARD + \alpha_{20} SHH + \alpha_{21} TPROD + \alpha_{22} TSOLD + u \quad \text{..... Equation 26}$$

Table 2 shows the variables description, variable type and the expected sign of the variables in relation to the dependent variables included in the first and second stage of the model.

3.2.2 Effect of Commercialization on Farmers' Welfare- The Propensity-Score Matching (PSM) Approach

The analytical framework underlying the estimation the effect of commercialization on the farmer's welfare is grounded on the work by Wooldridge (2004). As discussed earlier, commercialization indicator is binary in nature where:

$C = 1$ *if the farmer is commercialized* ..... *Equation 27*

$C = 0$ *if the farmer is not commercialized* ..... *Equation 28*

If we define the outcome for commercializing as y_1 and for not commercializing as y_0, then in estimating the average treatment effect (ATE) which is the causal effect of commercializing, the study estimates the difference between the two outcomes defined as:

$$ATE = E(y_1 - y_0) \quad \text{..... Equation 29}$$

The equation above thus gives effect of commercialization on the entire population as opposed to the farmers who had commercialized. However, rather than investigate the causal effect represented by the difference in the equation above, our interest is on the effect of commercialization on the individuals who have commercialized which is the average treatment effect on the treated (ATT) which can be represented as:

$$ATT = E\,(y_1 - y_0 \mid C = 1) \quad \text{..... Equation 30}$$

But since the difference is actually in the averages, the equation can be expanded to:

$$ATT = E\,[(y_1 \mid C = 1) - (y_0 \mid C = 1)] \quad \text{..... Equation 31}$$

The challenge then arises of how to estimate the second term since it if the mean effect of a farmer who had not commercialized if they had commercialized. Choosing the farmers that have not commercialized and comparing them with those who had commercialized would give the following difference:

$$\Delta = E\,[(y_1 \mid C = 1) - (y_0 \mid C = 0)] \quad \text{..... Equation 32}$$

But $\Delta \neq ATT$

This can be demonstrated by subtracting the second term of the ATT to the equation above thus giving the following equation:

$$\Delta = E\,[\{(y_1 \mid C = 1) - (y_0 \mid C = 1)\} - \{(y_0 \mid C = 0) - (y_0 \mid C = 1)\}] \quad \text{..... Equation 33}$$

$$\Delta = ATT + E\,(y_0 \mid C = 0) - E\,(y_0 \mid C = 1)\}] \quad \text{..... Equation 34}$$

If we assign the second part as π such that:

$$\pi = E\,(y_0 \mid C = 0) - E\,(y_0 \mid C = 1) \quad \text{..... Equation 35}$$

then,

$$\Delta = ATT - \pi \quad \text{..... Equation 36}$$

The term π thus makes Δ a biased estimator of ATT. The term π represents the bias brought about by difference between the commercialized farmers and the non-commercialized farmers. Thus in an ideal situation, we would assume that π is equal to zero. However, the term π is almost operationally impossible to be zero due to unobservable characteristics that may make the farmer to commercialize such as entrepreneurial mindset and risk behaviour, and thus the difference in means (ATE) will be a biased estimator of ATT. This is the main challenge of evaluation in trying to make the selection bias be equal to zero.

But, this means that we can overcome this situation by making sure that the commercialized farmers underwent commercialization randomly and without

any association to their characteristics. This would thus make commercialization uncorrelated with any observable and unobservable factor thus making it statistically autonomous of the commercialization as advocated by Winters *et al.*, (2010). As such, the characteristics of commercialized and non-commercialized farmers statistically equal). As such the commercialized and non-commercialized farmer would be indistinguishable except for the commercialization hence:

$$E(Y_o \mid D = 1) = E(Y_o \mid D = 0) \quad \text{..... Equation 37}$$

Thus, making it possible to replace the counterfactual with the term and therefore:

$$ATT = E[(y_1 \mid C = 1) - (y_o \mid C = 0)] \quad \text{..... Equation 38}$$

In order to achieve this, the propensity score matching approach was used to estimate the effect of commercialization on smallholder farmers' household dietary diversity, farm income, non-farm income and assets. The approach assumes those farmers who commercialize and those who do not differ not only in commercialization aspect but also in characteristics that affect commercialization and the outcome of commercialization. It thus seeks non-commercialized farmers who have the same characteristics to the commercialized farmers and matching them using "propensity scores" and thus creating a "quasi-experiment" such that non-commercialized farmers and commercialized farmers are statistically equivalent to commercialized farmers (Winter *et al.*, 2010).

In order to satisfy this statistical condition and ensure the plausibility of the results, two assumptions have to be fulfilled; the conditional independence assumption and the common support condition (Becker and Ichino, 2002). The conditional independence assumption or the unconfoundedness assumption in this case affirms that the prospective outcomes are independent of the commercialization status. Therefore, this makes the commercialization status be as good a random selection assignment thus ensuring that, even though the commercialized and non-commercialized farmers are in reality different, the differences may be accounted for thus reducing the bias. Consequently, the non-commercialized farmers can be used to construct a counterfactual. On the other hand, the common support condition necessitates the ability to have a satisfactory overlie in the distinctiveness of the commercialized and non-commercialized units in order to have sufficient matches. These two conditions must be satisfied for the propensity score matching method results to be valid.

Thus, the propensity scores to estimate the probability of receiving treatment $(P_i = 1)$ given observed characteristics (X) is equal to:

$$Pr(P_i) = Pr(P_i = 1|X) \quad \text{..... Equation 39}$$

However, since $0 < P_i < 1$, the conditional probability of commercialization (propensity score) was estimated using a probit model where the dependent variable is a dummy variable equal to one if the farmer commercialized and zero if they did not (Wooldridge, 2002). The independent variable in this analysis that determined the propensity scores was the age of the household head. The outcome of the scores was used as suggested by Rosenbaum and Rubin (1983), to match the scores of those who were treated and those who were not treated. The outcome is the measure of the impact attributable to commercialization (Gertler *et al.*, 2011) defined as:

$$ATT = E[(Y_1 \mid C = 1) - (Y_0 \mid C = 0)] \quad \text{..... Equation 40}$$

Where Y_1 is the welfare outcome for commercialized farmers, Y_0 is the welfare outcome for non-commercialized farmers, $C = 1$ represents commercialization and $C = 0$ represents non-commercialization.

3.3 Variable Description

This section discusses the various definitions used to define the variables used in the analysis. The summary of the variables is presented on Table 2.

3.3.1 Household Commercialization Index

Though in literature there is no agreed consensus to the best index to use in the measurement of commercialization, the unit of analysis determines the index to use. With the household being the unit of analysis, this study employed the index developed by Govereh *et al.*, (1999) and Strasberg *et al.*, (1999). The choice of this index as opposed to the indexes developed by von Braun *et al.*, (1994) and Gabre-Madhin *et al.*, (2007) is because of its ability to incorporate all the crops in the farm as opposed to a partial HCI that was based on one crop of a food group, this index incorporates all the crops in the farm.

The index is computed by taking the gross value of crop sales as a proportion of the gross value of crop production. The index is therefore specified as:

$$HCI_{household} = (\text{Gross Value of Crop Sales}) / (\text{Gross Value of Crop Production}) \quad \text{..... Equation 41}$$

Therefore, a household with a value of zero signified total subsistence farming, whilst as a value approaches one indicated higher degrees of commercialization meaning that a greater proportion of crops produced were sold.

As Leavy and Poulton (2007) observe, this index attracts some criticism. One of it is on the proportion of amount of produced and amount sold such that for instance a farmer who produces just 5 bags and sells 5 bags would be more commercialized than one growing 100 bags of maize who sells 40 bags. However, this limitation is overcome by the fact that, often, small farms tend not to sell all their products while larger farms sell more of their products.

3.3.2 Estimation of Household Welfare

This study uses food security, income and assets as a measure of smallholder farmers' welfare. Food security has over the years evolved to be a global, national, household and individual indicator of well-being (Monroe *et al.*, 1999; Bickel et al., 2000). Food insecurity is not only undesirable, but it is often a precursor to both present and future health and developmental problems. The importance of food security in the Kenyan context has seen it included in the Constitution of Kenya in Article 43(1) (c) as an economic and social right stating that "every person has the right to be free from hunger, and to have adequate food of acceptable quality" (Page 31).

The use of income as a measure of household welfare is generally accepted by economists (Boulding, 1949; David, 1959; Morgan and Smith, 1969). This has been attributed to its direct comparison with other variables thus being undemanding to use in analysis and to interpret (Moser and Felton, 2007). This measure has also been applied to the predominantly rural population who engage in agriculture (Davis *et al.*, 2010). In addition, income is a reliable measure of welfare since it is a determinant of both the household expenditure and consumption.

Assets have been increasingly advocated for as a measure of welfare (Filmer and Pritchett 2001; Carter and May 2001). This is brought about by the need to complement other income and consumption grounded welfare measures. Studies have thus shown that assets are a predicator of welfare measures such as poverty, health, nutrition and long-term wealth (Sahn and Stifel 2003)

Household Dietary Diversity Score: In the calculation of the household dietary diversity score, guidelines by the Food and Agriculture Organization of the United Nations (2007) were utilized. The household dietary diversity score comprises of different foods consumed within a specified period (in this case one week). Information on the different foods consumed in a week was aggregated into 12 food groups as shown on Table 1.

Table 1: Aggregation of Food Groups to create Household Dietary Diversity Score

Number	Food Group
1	Cereals
2	White roots and tubers
3	Vegetables
4	Fruits
5	Meat
6	Eggs
7	Fish and other seafood
8	Legumes, nuts and seeds
9	Milk and milk products
10	Oils and fats
11	Sweets
12	Spices, condiments and beverages

Source: Food and Agriculture Organization (FAO), 2007

Every food group was given a value of 1. With the odds of consuming each food group per day for seven days, the maximum score per household was 84. The choice of this score was based on the findings that even though the score primarily depicts the different diets consumed by a household, evidence shows that there is a correlation between dietary diversity and per capita consumption which is a proxy for income and energy availability (Hoddinot and Yohannes, 2002; Ruel, 2004). Furthermore, the score has been found to be a pointer of the households' economic access to food (FAO, 2007). Thus, this makes this score a useful indicator for the households' wellbeing.

Farm and Non-Farm Income: Most of the farmer's incomes in the rural areas comprises of incomes from farming activities and from activities carried out outside farm activities such as labour. Evidence has consistently shown a variation in the response of economic variables to farm and non-farm income as opposed to pooling both incomes together especially as relates to welfare (Senadza, 2011; Mat et al., 2012; Scharf and Rahut, 2014). As such, this study disaggregated the incomes of smallholder farmers into farm and non-farm income in measuring the welfare effect of commercialization.

Household Asset Score: Inclusion of asset value as an independent variable posed some statistical challenges. This is due to the differences in the value of an asset due to differences in cultures and distance from the source. For instance, while the ownership of a mortar and pestle in some communities indicates poverty (inability to access a mill), in some cultures it is a valuable asset due the cultural

cuisine that uses ingredients prepared using one. In addition the time variances have an impact in the value of assets due to inflation and changes in the value of currencies. In order to mitigate for these factors, in this study, a household asset score (Morris *et al.*, 2000) was derived. The asset score is specified as:

$$Asset\ Score = \sum_{(g-1)}^{G} f_g\, w_g \quad \text{..... Equation 42}$$

Where g is the listing of assets, w is the weight equal to the reciprocal of the proportion of the households who owned one or more of the asset and f is the quantity of item of asset the household owns.

Table 2: Description of Variables used in the Analysis

Notation	Variable	Variable Description	Variable Type	Expected Sign
Dependent variable				
COM	Commercialization	Commercialization status of the smallholder farmer (Non-Commercialized=0, Commercialized =1)	Dummy	N/A
HCI	Household commercialization index (HCI)	A measure of the level of commercialization. $0 \leq HCI \leq 1$	Continuous	N/A
Independent variable				
AGEHH	Age of household head	Age of household head in years	Continuous	+
AGEHHSQUARE	Age of household head (Square)	Square of the age of household head in years	Continuous	+
AGRICRDT	Agricultural credit	Access to agricultural credit (Obtained =1, No obtainment = 0)	Dummy	+
AGRIGRPMEM	Agricultural group membership	Membership to an agricultural group/ association (Member = 1, Non-Member = 0)	Dummy	+
AGRINS	Agricultural insurance	access any agricultural insurance services against crop loss (Access = 1, No access = 0)	Dummy	+
AGRISAV	Agricultural savings	Access formal saving services (Have = 1, Don't have =0)	Dummy	+
ASSCORE	Asset score	A score to measure the household assets (as specified in section 3.3.3)	Continuous	+/-
DFEM	Decision female	The sex of the person who makes the crop production decisions (Female =1, Male=0)	Dummy	-

EXT	Extension	Access to extension services on crop production (Accessed = 1, No access = 0)	Dummy	+
FINC	Farm income (Logarithm)	The logarithm of the total farm income (Kenya shillings)	Continuous	+
HDDS	Household's dietary diversity score	Household's dietary diversity score (as specified in section 3.3.1)	Continuous	+/-
HHEDUC	Household head education continuous	Years of schooling of the household head	Continuous	+
HUMSUBHUM	Humid and sub-humid	Areas in the humid and sub-humid agro-ecological zones ±	Dummy	+
LACC	Land accessed	Total size of all the land accessed by the household (in acres)	Continuous	+
LOWN	Land owned	Total size of all the land owned by the household (in acres)	Continuous	+
MACUSE	Machinery use	Use of machinery for farm activities (Used =1, Not used = 0)	Dummy	+
MKTINFOACC	Market information access	Access to marketing information systems (Access =1, No access = 0)	Dummy	+
NONFINC	Non-farm income (Logarithm)	The logarithm of the total non-farm income (Kenya shillings)	Continuous	-
SEMHUMSEMARD	Semi-Humid and Semi-Humid to Semi-Arid	Areas in the semi-humid and semi-humid to semi-arid agro-ecological zones ±	Dummy	+
SHH	Sex of household head being female	Sex of the household head (Female =1, Male=0)	Dummy	-
TPROD	Total produced	Total quantity harvested (in respective units)	Continuous	-
TSOLD	Total sold	Quantity of output sold (in respective units)	Continuous	+

± The pooling of the seven agro-climatic zones (Sombroek et al., 1982; Orodho, 1999) in the country was done in a similar manner as works by Bukania et al., (2014) and Waswa et al., (2014).

N/A means not applicable

Source: Author's Composition

3.4 Data and Data Sources

In executing this study, data from the 2013 Agricultural Household Survey collected by the Agricultural Sector Development Support Programme (ASDSP) was used. The data is cross-sectional in nature and was collected at the household level via a structured questionnaire. Some of the data variables that were used in the study were the household's socio-economic characteristics, farm characteristics, level of production, agricultural technologies, inputs, farm labour, and quantities of commodities consumed and marketed, on-farm income and off-farm income, food and nutrition security, asset ownership and access to financial services.

4. Results and Discussion

4.1 Descriptive Statistics

4.1.1 Descriptive Statistics for variables in the Heckman Two-Stage Model

The summary of the age, schooling years, income and land characteristics of sampled households are presented on Table 3 and Table 4. The mean age of the total sample was 49.36 years. The mean age of the commercialized smallholder farmers was found to be 48.62 years while that of the non-commercialized farmers was found to be 49.65 years. The difference in years between the commercialized and non-commercialized farmers was found to be significantly different at 99 per cent level of confidence meaning that non-commercialized smallholder farmers were significantly older than commercialized smallholder farmers. With the statistics showing that Kenya has a bulging youthful population (KIPPRA, 2016), this shows that the proportion of the youth involved in agriculture is still low.

The household heads' average years of schooling for the sample was 7.35 years with the commercialized smallholder farmers having a higher number of years of schooling at 8.28 years as compared to the non-commercialized smallholder farmers' mean of 6.98 years. This difference in years of schooling between commercialized and non-commercialized farmers was found to be significant at 1 per cent confidence level showing that commercialized farmers have a higher education level. Therefore, this may point out that education increases commercialization as found by Tufa *et al*., (2014).

The average size of land owned by the sampled farmers was 2.07 acres. The commercialized smallholder farmers owned larger land at 2.36 acres as compared to non-commercialized smallholder farmers' landholding of 1.95 acres. This difference in landholding between the commercialized and non-commercialized smallholder farmers was found to be significantly difference at 99 per cent level of confidence. This shows that commercialization increases with land size and is in line with the findings of Carletto *et al.,* (2016) who found that commercialization increases with farm size. On the other hand, land accessed by farmers, including owned and rented in land, averaged 17.60 acres, 19.48 acres and 16.85 acres for the pooled sample, commercialized smallholder farmers and non-commercialized smallholder farmers respectively. However, there was no significant difference in land accessed between the two groups of farmers.

On income, the mean farm income and non-farm income for the sampled smallholder farmers was Ksh 60,237.73 per year and Ksh 44, 728.15 per year respectively. Commercialized smallholder farmers had a significantly higher farm income at 99 per cent level of confidence of Ksh 84,889.45 per year as compared to Ksh 50388.24 per year for non-commercialized smallholder farmers. Contrastingly, non-commercialized farmers had a higher non-farm income of Ksh 44, 965.35 per year in comparison to Ksh 44,134.46 per year for the commercialized farmers.

Female headed households comprised of 18.27 per cent of the population while the male headed households were 81.73 per cent. Among the female headed households, 24.94 per cent had commercialized their farm while 75.06 per cent had not commercialized their farms. About 29.31 per cent of the male headed households had commercialized their farm while 70.69 per cent had not commercialized their farms. The Pearson's Chi statistic showed that there was a significant relationship between the sex of the household head being a female and commercialization.

Out of the sampled households, 39.07 per cent of the crop production decisions were made by a female while 60.93 per cent of the crop production decisions were made by a male. This shows that the proportion of females who make crop production decisions was higher that the proportion of female headed households. This is congruent to the findings that even in male headed households, persons of the female sex are the ones involved in agriculture (Fletcher and Kubik, 2016).

Of the households where crop production decisions are made by a female, 28.54 per cent were commercialized while 71.46 per cent were not while 28.55 per cent of the households where the crop production decisions were made by males were commercialized and 71.45 per cent were not commercialized. The Pearson's Chi statistic showed that there was no relationship between the sex of the person who makes crop production decision being female and commercialization.

Approximately 30.23 per cent of the sampled households used machinery for farm activities of which 63.21 per cent had commercialized farms and 36.79 per cent did not have commercialized farms. On the other hand, 69.77 per cent of the sampled households did not use machinery for farm activities. Of the proportion that did not use machinery for farm activities, 75.02 per cent had commercialized and 24.98 per cent had not commercialized. There was a significant relationship between use of machinery for farm activities and commercialization at 99 per cent level of confidence.

About 86.53 per cent of the sampled farmers were not members of any agricultural group or association. Out of this proportion, 12.30 per cent of the farmers had commercialized their farming activities while 87.70 per cent had not commercialized. Only 13.48 per cent of the sampled smallholder farmers were members of agricultural

groups or associations of which 16.44 per cent had commercialized farms against 83.56 who had not commercialized their farms. The Pearson's Chi statistic showed that there was a significant relationship between membership to an agricultural group or association and commercialization at 1 per cent confidence level.

Access to agricultural extension was low among the sampled smallholder farmers with only 18.49 per cent of the smallholder farmers having accessed agricultural extension while 81.50 per cent had not. Out of the proportion that had accessed agricultural extension services, 34.81 per cent had commercialized and 65.19 had not. On the other hand, out of the proportion that had not accessed agricultural extension, 27.13 per cent had commercialized and 72.86 had had commercialized.

Evidence from the sampled farmers' shows that access to agricultural credit is still very low. Only 5.26 per cent of the sampled farmers accessed agricultural credit. This shows that even though access to credit in the country has improved (Allen et al., 2014) a very low proportion of the credit is directed towards agriculture (Kalunda, 2014; Wainaina *et al.,* 2016). The relationship between agricultural credit and commercialization was found to be significant at 99 per cent level of confidence.

Approximately 31.90 per cent of the sampled smallholder farmers had accessed market information while 68.10 had not. About 34.29 per cent of the farmers that had accessed market information had commercialized their crop production while 65.71 per cent had not while 25.86 per cent of the famers who had not accessed market information had commercialized and 74.14 per cent had not commercialized. The study found a significant relationship at 99 per cent level of confidence between market information access and commercialization.

On agricultural savings, the study found a significant relationship between agricultural savings and commercialization at 1 per cent confidence level. Approximately 23.89 per cent of the sampled smallholder farmers had agricultural savings of which 42.04 per cent had commercialized and 57.96 per cent had not commercialized. The proportion of smallholder farmers who did not have agricultural savings was 76.11 per cent of which 24.31 per cent had commercialized and 75.69 per cent had not commercialized.

Agricultural insurance uptake was low with only 0.46 per cent of the sampled farmers having accessed agricultural insurance against 99.54 per cent who did not access agricultural insurance. About 37.78 per cent of smallholder farmers who accessed agricultural insurance had commercialized and 62.22 per cent had not while 28.51 per cent of smallholder farmers who did not have agricultural insurance had commercialized their crop production and 71.49 per cent had not. The study found a significant relationship between agricultural insurance and commercialization.

Table 3: Summary Statistics for Characteristics of Sampled Households Continuous Variables

Variable	Mean N= 9864			t-value
	Pooled data	Commercialized n=2816	Non-Commercialized n=7048	
Age of the household head	49.36 (14.6090)	48.62 (14.0860)	49.65 (14.8040)	-3.175***
Schooling years of the household head	7.35 (4.9870)	8.28 (4.593)	6.98 (5.0900)	11.721***
Land owned	2.0651 (1.3933)	2.3606 (1.4128)	1.9471 (1.3679	13.434***
Land accessed	17.60 (182.2310)	19.48 (233.0290)	16.85 (157.4310)	0.649
Farm income	60237.73 (232770.3630)	84889.45 (184058.0580)	50388.24 (248919.2310)	6.663***
Non-farm income	44728.15 (321269.8060)	44134.46 (105793.6370)	44965.35 (374149.587)	-0.116

*Note: Figures in parenthesis are the standard deviations associated with the means. ***P<0.01, **P<0.05 and *P<0.10 mean significant at 1 per cent, 5 per cent and 10 per cent respectively*

Source: Author's computation using ASDSP 2013 data

Table 4: Summary Statistics for Characteristics of Sampled Households Dummy Variables

Variable		Mean N= 9864			χ2
		Pooled data	Commercialized n=2816	Non-Commercialized n=7048	
Sex of household head being female	Female	18.27	24.94	75.06	13.2467***
	Male	81.73	29.31	70.69	
Machinery use	Used	30.23	63.21	36.79	142.2384***
	Not used	69.77	75.02	24.98	
Agricultural group membership	Member	13.48	16.44	83.56	29.5687***
	Non-Member	86.52	12.30	87.70	
Extension	Accessed	18.49	34.81	65.19	43.4252***
	No access	81.50			
Agricultural credit	Obtained	5.26	34.30	65.70	8.8747**
	No obtainment	94.74	28.23	71.77	

Market information access	Access	31.90	34.29	65.71	74.6034***
	No access	68.10	25.86	74.14	
Agricultural savings	Have	23.89	42.04	57.96	276.5732***
	Don't have	76.11	24.31	75.69	
Agricultural insurance	Access	0.46	37.78	62.22	1.8878***
	No access	99.54	28.51	71.49	
Sex of the person who makes the crop production decisions being female	Female	39.07	28.54	71.46	0.0001
	Male	60.93	28.55	71.45	

*Note: Figures in parenthesis are the standard deviations associated with the means. ***P<0.01, **P<0.05 and *P<0.10 mean significant at 1 per cent, 5 per cent and 10 per cent respectively*

Source: Author's computation using ASDSP 2013 data

4.1.2 Descriptive Statistics for variables in the Propensity-Score Matching (PSM) Approach

The mean household commercialization index for the country was 0.18. The score shows that as relates to smallholder farmers commercialization of annual crops, the country's level is still low. The semi-humid and semi-humid to semi-arid agro-climatic zones had the highest level of commercialization index at 0.21 followed closely by humid and semi-humid zones. The low commercialization index in the humid and sub-humid zones as compared to the semi-humid and semi-humid to semi-arid zones can be attributed to the growing of perennial crops such as tea and coffee and dairy keeping rather than annual crops that were the crops of study in this paper. Similarly, farmers in semi-arid and very arid zones practice livestock keeping rather than crop farming hence the zone was not included in the study. The distribution in the household commercialization index is presented in Table 5.

Table 5: Distribution in the Household Commercialization Index across Agro-Climatic Zones

Variable	Agro-Climatic Zones	Mean	F
Household commercialization index	Countrywide	0.18	142.4403***
	Humid and Sub-Humid	0.20	
	Semi-Humid and Semi-Humid to Semi-Arid	0.21	

Source: Author's computation using ASDSP 2013 data

The average total income for the sampled households was found to be Ksh 104,965.88 per annum with Ksh 60.237.73 being the mean farm income and Ksh 44,728.15 being the mean non-farm income. This shows that for most of the smallholder farmers, farm income still forms the greater proportion of their income. The humid and semi-humid zones had the highest income per year with a mean farm income of Ksh 76,895.99 and a mean non-farm income of Ksh 56,421. On the other hand, the semi-humid and semi-humid to semi-arid agro-climatic zones had a mean farm income and non-farm income of Ksh 47,015.51 and Ksh 33,863.68 respectively.

On the household dietary diversity score, the mean dietary diversity score for the sampled smallholder farmer households was 30.04. With the possible dietary diversity score is 120, this shows a very low diversity in diets across the country. The household dietary diversity score across the different agro-climatic zones was 32.11 and 27.41 for the humid and semi-humid, semi-humid and semi-humid to semi-arid agro-climatic zones respectively. The mean household asset score for the country was 0.0060 with the humid and semi-humid having the highest asset score at 0.0072. This was followed by the semi-humid and semi-humid to semi-arid agro-climatic zones at a score of 0.0049.

To analyze whether there was any significance difference in the means of these key variables of interest across the pooled agro-climatic zones, an analysis of variance was carried out. A summary of the results is shown on Table 6. The analysis showed that there was significant difference in the means across the pooled agro-climatic zones at 99 per cent level of confidence for the household commercialization index, farm income, household dietary diversity score and household asset score and at 95 per cent level of confidence for non-farm income.

Table 6: Analysis of Variance across the Pooled Agro-Climatic Zones

Variable	Agro-Climatic Zones	Mean	F
Household dietary diversity score	Countrywide	30.04	219.0347***
	Humid and Sub-Humid	32.11	
	Semi-Humid and Semi-Humid to Semi-Arid	27.41	
Farm income	Countrywide	60237.73	30.47455***
	Humid and Sub-Humid	76895.99	
	Semi-Humid and Semi-Humid to Semi-Arid	47015.51	
Non-farm income	Countrywide	44728.15	7.550055**
	Humid and Sub-Humid	56421.40	
	Semi-Humid and Semi-Humid to Semi-Arid	33863.68	

Asset score	Countrywide	0.0060	9.423502***
	Humid and Sub-Humid	0.0072	
	Semi-Humid and Semi-Humid to Semi-Arid	0.0049	

*Note: Figures in parenthesis are the standard deviations associated with the means. ***P<0.01, **P<0.05 and *P<0.10 mean significant at 1 per cent, 5 per cent and 10 per cent respectively*

Source: Author's computation using ASDSP 2013 data

4.2 Factors that influence Commercialization among Smallholder Farmers

Before econometric analysis was done, tests for multicollinearity were done so as to ensure that the statistical tests of significance are valid. To test for multicollinearity in dummy variables, the variance-covariance estimator (VCE) was used to check for correlation between the independent variables. The closer the value are to +1 or -1, the more correlated they are (Taylor, 1990). The absolute values obtained are shown in the appendices and it showed that there was no evidence of strong multicollinearity. The Variance Inflation Factor (VIF) was used to test for multicollinearity in the continuous variables (Gujarati, 2004). If the Variable Inflation Factor is above 10, then there is multicollinearity. But the values obtained showed no obvious presence of multicollinearity as shown in the appendices.

4.2.1 Factors that Influence Smallholder Commercialization

The estimated results of the Heckman selection model estimation is shown in Table 7. The Wald test statistic was 6702.75 and it was significant at 99 per cent level of confidence while the probability of getting the log likelihood ration test statistic was less than 0.05 meaning that the model was a good fit thus failing to accept the null hypothesis since at least one of the coefficients is not equal to zero. The sigma value is 0.1498 is the adjusted standard error for the equation regression while the correlation coefficient between the unobservable variables that determine selection into commercialization and the level of commercialization is given by the rho which was 0.0895. The product of the rho and sigma gives the lambda whose value was 0.0131. With the rho being positive, the lambda also was positive meaning the unobservable variables are positively correlated and thus the selection bias of the population is that the farmers would self-select themselves into commercialization. The analysis involved 9,864 households in the first stage of the model and in the second stage 7,048 households were censored.

Table 7: Heckman selection model two-step estimates

Number of observations						9864
Censored observations						7048
Uncensored observations						2816
Wald chi2(20)						6702.75
Prob > chi2						0.0000
	Coef.	**Std. Err.**	**z**	**P>z**	**[95% Conf. Interval]**	
Lambda	0.0134	0.0056	2.3800	0.0170	0.0024	0.0244
Rho	0.0895					
Sigma	0.1498					

Source: Author's computation using ASDSP 2013 data

The summary results of the first stage analysis of the Heckman estimation is shown in Table 8. The household being headed by a female reduces the commercialization by 12.59 per cent. This is plausible due to women having limited access to resources as compared to their male counterparts (Odeny, 2013). On the other hand, a one unit change in the person making crop production decision being female was found to increase commercialization by 21.01 per cent. However, decision making by females in agriculture remains low despite their involvement in agriculture (Chayal *et al.*, 2013), with less than half of the production decisions are made by females in this study.

A one unit increase in the land owned was also found to increase commercialization by 6.66 per cent. Research has shown that land tenure security encourages investment in land improvements (Gebremedhin *et al.*, 2003) therefore, with an increase in the land owned, the farmers can invest more resources in commercialization. A unit increase is in farm income increases the probability to commercialize by 2.41 per cent while a unit increase in non-farm income increases the probability to commercialize by 0.98 per cent. Income (farm or non-farm), provides resources needed for commercialization and thus influence commercialization positively.

A unit increase in agricultural credit reduces the probability to commercialize by 18.29 per cent. This can be attributed to the disparity in demand and supply of credit facilities especially among smallholder farmers in the country, such that very few farmers have access to credit facilities (Atieno, 2001). The results also showed that a unit increase in access to market information increases the probability to commercialize by 10.67 per cent. This is in line with precious research that shows that market information stimulates market participation (Alene *et al.*, 2008) which is an integral part of commercialization.

A unit increase in the household dietary diversity score increases the probability of smallholder farmers' commercialization by 0.63 per cent. This might be explained by the positive influence of market access to nutrition with research showing that market access improves nutrition (Sibhatu et al., 2015). In addition, a unit increase in the amount of produce sold increases the probability to commercialize by 191.91 per cent. With the amount of produce sold being a determinant to whether the farmer commercializes, the more the produce sells to the market, the more motivated they will be to commercialize.

Being in the humid and sub-humid agro-ecological zone and semi-humid and semi-humid to semi-arid agro-ecological zone increases the probability to commercialize by 54.94 per cent and 35.93 per cent respectively. This is [plausible since these agro-ecological zones are the ones that practice crop commercialization with the other zones being predominantly livestock keeping areas.

Table 8: Marginal Effects of the Factors that Influence Commercialization after First Stage Heckman Estimation

Variable	dy/dx	Std Error	z	P>z	95% Confidence Interval	
Sex of household head female	-0.1259	0.0638	-1.9700	0.0480	-0.2509	-0.0009
Decision female	0.2101	0.0487	4.3100	0.0000	0.1146	0.3055
Household head education continuous	0.0026	0.0050	0.5200	0.6040	-0.0072	0.0124
Age of household head	0.0015	0.0012	1.2900	0.1980	-0.0008	0.0039
Age of household head square	0.0000	0.0000	-1.4300	0.1530	0.0000	0.0000
Land owned	0.0666	0.0164	4.0600	0.0000	0.0344	0.0987
Land accessed	-0.0004	0.0003	-1.5200	0.1290	-0.0010	0.0001
Log farm income	0.0241	0.0046	5.2000	0.0000	0.0150	0.0332
Log non-farm income	0.0098	0.0041	2.4000	0.0160	0.0018	0.0177
Machinery use	0.0097	0.0497	0.2000	0.8450	-0.0877	0.1071
Agricultural group membership	-0.0705	0.0650	-1.0800	0.2780	-0.1979	0.0569
Extension	0.0219	0.0570	0.3900	0.7000	-0.0897	0.1336
Agricultural credit	-0.1829	0.0996	-1.8400	0.0660	-0.3780	0.0122
Market information access	0.1067	0.0470	2.2700	0.0230	0.0146	0.1987
Agricultural savings	0.0395	0.0535	0.7400	0.4610	-0.0654	0.1444
Agricultural insurance	0.2060	0.2814	0.7300	0.4640	-0.3455	0.7574
Household Dietary Diversity Score	0.0063	0.0021	2.9500	0.0030	0.0021	0.0105
Asset score	-0.5125	0.9082	-0.5600	0.5730	-2.2926	1.2676
Log total produced	0.0110	0.0122	0.9100	0.3650	-0.0128	0.0349
Log sold	1.9191	0.0434	44.2400	0.0000	1.8341	2.0042
Humid and sub- humid	0.5492	0.0704	7.8000	0.0000	0.4112	0.6872
Semi-Humid and Semi-Humid to Semi-Arid	0.3593	0.0767	4.6800	0.0000	0.2089	0.5097

Source: Author's computation using ASDSP 2013 data

4.2.2 Factors Effect of the Level of Commercialization

The results of the second stage Heckman estimation are presented on Table 9. The results showed that the decision on crop production being made by a person of the female sex, years of schooling of the household head, farm and non-farm income, extension services, agricultural savings, agricultural insurance, asset score, amount of product produced and amount of product sold significantly influence the level of commercialization.

The analysis show that a unit increase in the decisions on crop production being made by a person of the female sex reduces the level of commercialization by 1.42 per cent. This may due to persistent gender disparities between men and women in accessing productive resources such as land as found by Fischer and Qaim (2012). Therefore, when a female member of the household is responsible for the decisions on crop production, they do so in an environment that is limited hence limiting their capability to make decisions (Kimani, 2017) such as on commercialization. In addition, commercialization in associated with an increase in household workload (Spring, 2000; Garcia *et al.,* 2006), therefore this may be a deterrent to intensifying commercialization since as the level of commercialization at the farm increases the workload for women as compared to men increases (Doss *et al.*, 2011).

The study also found that a unit increase in farm income increases the level of commercialization by 0.17 per cent while a unit increase in non-farm income decreases the level of commercialization by 0.16 per cent. While increased farm income is a motivator to engage more in farming activities, income earned from non-farm activities by smallholder farmers is an opportunity cost to income that could have been earned in the farm thus giving a reciprocal relationship between non-farm income and commercialization.

In addition, the results show that a unit increase in agricultural insurance and amount produced decreases the level of commercialization by 10.90 per cent and 25.46 per cent. On the other hand a unit increase in asset score and amount product sold increases the level of commercialization by 32.37 and 26.67 per cent respectively. With assets being a key factor in making investments in the farm possible, assets encourage smallholder farmers to invest in farm activities. In contrast, having agricultural insurance is an additional cost to the resource poor farmers hence it acts as deterrence to commercialization as well as uptake by smallholder farmers hence the low penetration of agricultural insurance in

the sample. Lastly, commercialization is employed as a way of increasing profit, therefore, with the farmer having commercialized, the amount sold rather than produced encourages the level of commercialization.

The humid and sub- humid, semi-humid and semi-humid to semi-arid agro-ecological zones were also found to increase the level of commercialization. A one unit increase in being in the humid and sub- humid zone was found to increase commercialization by 5.96 per cent while a unit increase in being in the semi-humid and semi-humid to semi-arid agro-ecological zones was found to increase commercialization by 2.84 per cent.

Table 9: Regression Analysis of the Second Stage Heckman Estimation on the Factors that Influence the Level of Commercialization

Variable	Coef.	Std Error	z	P>z	95% Confidence Interval	
Sex of household head female	0.0138	0.0089	1.5600	0.1200	-0.0036	0.0312
Decision female	-0.0142	0.0066	-2.1600	0.0310	-0.0271	-0.0013
Household head education continuous	0.0007	0.0007	1.0400	0.2980	-0.0006	0.0021
Age of household head	0.0015	0.0012	1.2900	0.1980	-0.0008	0.0039
Age of household head square	0.0000	0.0000	-1.4300	0.1530	0.0000	0.0000
Land owned	-0.0001	0.0021	-0.0500	0.9560	-0.0043	0.0041
Land accessed	0.0000	0.0000	-1.1500	0.2490	-0.0001	0.0000
Log farm income	0.0017	0.0007	2.5100	0.0120	0.0004	0.0030
Log non-farm income	-0.0016	0.0005	-2.9800	0.0030	-0.0027	-0.0006
Machinery use	-0.0035	0.0061	-0.5700	0.5650	-0.0155	0.0085
Agricultural group membership	0.0008	0.0082	0.1000	0.9220	-0.0153	0.0169
Extension	-0.0100	0.0071	-1.4200	0.1570	-0.0239	0.0039
Agricultural credit	0.0142	0.0122	1.1700	0.2430	-0.0096	0.0381
Market information access	-0.0034	0.0062	-0.5500	0.5850	-0.0155	0.0087
Agricultural savings	0.0070	0.0064	1.0900	0.2770	-0.0056	0.0196
Agricultural insurance	-0.1090	0.0366	-2.9800	0.0030	-0.1809	-0.0372
HDDS	-0.0001	0.0003	-0.5000	0.6200	-0.0007	0.0004
Asset score	0.3237	0.1932	1.6800	0.0940	-0.0550	0.7023
Log total produced	-0.2546	0.0033	-76.9100	0.0000	-0.2610	-0.2481
Log sold	0.2667	0.0035	76.1000	0.0000	0.2598	0.2736
Humid and sub-humid	0.0596	0.0104	5.7500	0.0000	0.0393	0.0799
Semi-Humid and Semi-Humid to Semi-Arid	0.0284	0.0107	2.6500	0.0080	0.0074	0.0494
Constant	0.6782	0.0343	19.7700	0.0000	0.6109	0.7454

Source: Author's computation using ASDSP 2013 data

4.3 Effect of Commercialization on Smallholder Farmers' Welfare

4.3.1 Algorithm to Estimate the Propensity Score

The results of the probit model were used to generate the propensity scores where commercialization variable was regressed against the age of the household head. The number of farmers was 9,864 with 2,816 farmers having commercialized their farms and 7,048 famers being non-commercialized farmers. The likelihood ratio (LR) Chi-square test was 10.18 showing that none of the variables' coefficient was equal to zero. The probability of getting the likelihood ratio (LR) test statistic (Prob > chi^2) as extreme than the null hypothesis was 0.0014. Thus, the analysis does not to accept the null hypothesis that all the regression coefficients in the model are equal to zero thus showing that the model was a good fit and that at least one of the coefficients is not equal to zero. The McFadden's pseudo R-squared (Pseudo R^2) was 0.0009. The log likelihood was -5894.1442 hence illustrating that the model converged. However, it is important to note that though these analyses are of importance, the aim of the model is to solely produce the propensity score that ranges between 0 and 1. The results are shown in Table 10.

The common support region was found to be from 0.2369 and 0.3195 and the mean propensity score was 0.2855. This means that the uppermost propensity score was 0.3976 while the least was 0.0092 and the average probability for a respondent in the sample to be in the commercialized was 28.55%. The estimated propensity scores and the regions of common support are shown in Table 11.

Table 10: Probit Results for estimation of the Propensity Scores

	Coef.	Std. Error	z	P>z	[95% Conf. Interval]	
Age of household head	-0.0029	0.0009	-3.19	0.001	-0.0048	-0.0011
Constant	-0.4219	0.0473	-8.93	0.000	-0.51145	-0.3293
Number of observations						9864
Likelihood ratio Chi Square test						10.18
Prob>Chi²						0.0014
McFadden's pseudo R-squared						0.0009
Log Likelihood						-5894.1442

Source: Author's computation using ASDSP 2013 data

Table 11: Description of the Estimated Propensity Score in Region of Common Support

Percent	Percentiles	Propensity Scores
		Smallest
1	0.2508	0.2369
5	0.2602	0.2369
10	0.2650	0.2379
25	0.2748	0.2388
50	0.2857	
		Largest
75	0.2968	0.3195
90	0.3039	0.3195
95	0.3070	0.3195
99	0.3111	0.3195
Observations	9860	
Sum of Weight	9860	
Mean	0.2855	
Std. Dev.	0.0145	
Variance	0.0002	
Skewness	-0.3420	
Kurtosis	2.6068	

Source: Author's computation using ASDSP 2013 data

The results of the analysis above were matched using the stratification matching approach. The stratification method divides the common support of the propensity score into stratas. It then calculates the effect of commercialization within each individual stratum. This is accomplished by taking the average variation in outcomes between commercialized and non-commercialized farmers.

The number of blocks estimated was eight thus ending up with eight strata. The eight strata are of great significance since research shows that any stratas above five are sufficient for removing any bias associated with the covariates (Cochrane and Chambers, 1965; Imbens, 2004). The strata were also used in balancing in order to satisfy the balancing property of propensity score.

4.3.2 *Effects of Commercialization on Household Dietary Diversity Score, Farm Income, Non-Farm Income and Asset Score*

The summary statistics for the propensity score matching estimation for the effect of commercialization on household dietary diversity score, farm income, non-farm income and asset score are shown on Table 12. After matching, the t-statistics analysis showed that based on the observable characteristics, there was a not significant difference between the commercialized and non-commercialized farmers' thus showing that the match was a good fit.

The countrywide analysis on the impact of commercialization on household dietary diversity score showed that commercialized smallholder farmers had a more diverse diet by 1.806 than non-commercialized smallholder farmers. Similarly, commercialized farmers were also found to have a higher farm income and asset score than non-commercialized farmers by Ksh 20,553.32 per annum and 0.001 asset score respectively. The results are in line with the findings of Coates and Galante (2016) that suggested that smallholder agricultural commercialization may improve household diet through increased income. However, commercialized smallholder farmers had a lower non-farm income than non-commercialized smallholder farmers by Ksh 34,400 per year.

A comparison based on pooled agro-climatic zones showed that in the humid and semi-humid zones commercialized smallholder farmers had a higher dietary diversity score, farm income and asset score by 3.709, Ksh 35,754.34 and 0.004 respectively and a lower non-farm income of Ksh 55,700 as compared to non-commercialized smallholder farmers. In the semi-humid and semi-humid to semi-arid zones commercialized smallholder farmers had a higher farm and non-farm income as compared to non-commercialized smallholder farmers by Ksh 26927.81 and Ksh 33482.81 respectively. However, commercialized smallholder farmers in this zone have a lower household dietary diversity score and asset score by 3.508 and 0.005. Commercialized smallholder farmers in the semi-humid and semi-humid to semi-arid zones had a more diverse diet by 1.385 than non-commercialized smallholder farmers and a higher asset score than non-commercialized smallholder farmers. On the contrary, commercialized farmers were also found to have a lower farm income and non-farm income than non-commercialized farmers by Ksh 42,900 and Ksh 15,900 per annum.

Table 12: Average Treatment Effect on the Treated for Household Dietary Diversity Score, Farm Income, Non-Farm Income and Asset Score

Region	Variable	Commercialized	Non-Commercialized	Average Treatment Effect on the Treated	Standard Error	t
Countrywide	Household dietary diversity score	1101	8756	1.806	3.343	0.540
	Farm income	1101	8756	20553.316	12444.628	1.652
	Non-farm income	1101	8756	-34400	37603.306	-0.914
	Asset Score	1101	8756	0.001	0.002	0.367
Humid and Semi-Humid Zones	Household dietary diversity score	640	4578	3.709	1.870	1.983
	Farm income	640	4578	35754.336	24519.802	1.458
	Non-farm income	640	4578	-55700	56653.771	-0.984
	Asset Score	640	4578	0.004	0.001	7.241
Semi-Humid and Semi-Humid to Semi-Arid Zones	Household dietary diversity score	246	2394	-3.508	3.508	-1.000
	Farm income	246	2394	26927.809	28617.213	0.941
	Non-farm income	246	2394	33482.805	9600.333	3.488
	Asset Score	246	2394	-0.005	0.034	-0.138

Note: Figures in parenthesis are the standard deviations associated with the means.

****P<0.01, **P<0.05 and *P<0.10 mean significant at 1 per cent, 5 per cent and 10 per cent respectively*

Source: Author's computation using ASDSP 2013 data

5. Conclusions and Policy Recommendations

5.1 Conclusions

The level of commercialization for annual crops in the country is still low and varies across agro-climatic zones. On the factors that influence smallholder commercialization, the study also found that the sex of the person making the decision on crop production being female, land owned, farm and non-farm income, access to market information, household dietary diversity score, amount of produce sold and being in the humid and sub-humid agro-ecological zones and semi-humid and semi-humid to semi-arid agro-ecological zones influences the probability to commercialize positively. On the other hand, the sex of the person household head being female and access to agricultural credit influences the probability to commercialize negatively.

In addition, for the smallholder farmers that have commercialized, several factors were found to influence the level of commercialization. These factors include, the decision on crop production being made by a person of the female sex, non-farm income, agricultural insurance and amount of product produced influences the level of commercialization negatively while farm income, amount of annual crop product sold and being in the humid and sub-humid agro-ecological zones and semi-humid and semi-humid to semi-arid agro-ecological zones influences the level of commercialization positively.

Though the study found a general improvement in country on the household diversity score, asset holding and farm income for commercialized farmers as opposed to non-commercialized farmers, there are disparities as relates to agro-climatic zones. The household dietary diversity score for the humid and semi-humid zones had been impacted positively by commercialization of annual crops while in the semi-humid and semi-humid to semi-arid zones the impact was negative. On asset holding, though there a significant improvement in asset holding for the farmers who had commercialized annual crops in humid and semi-humid zones while in the humid and semi-humid zones, the effect was negative.

5.2 Policy Recommendations

Based on the findings of this study, the following policy recommendation can be made:

1. There is need to invest more resources in the promotion of smallholder commercialization by the National and County Governments in order to raise the level of commercialization in the country.

2. Given the diverse agricultural activities across agro-climatic zones, crop specific commercialization policy will be more effective rather than a blanket policy covering the entire country.

3. The Ministry of Agriculture, Livestock and Fisheries and the County Governments need to review on the rendering of agricultural credit and agricultural insurance services since it is not only a deterrent to smallholder commercialization.

4. There is need for the government to empower women especially as regards decision making in the farm through trainings and capacity building programmes especially by the County Governments who have the functions and powers over agriculture.

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7. Appendices

Variance-Covariance Estimator (VCE) Analysis

e(V)	SEX_~EMALE	DECISION~E	MACHINER~E	AGRICULT~P	EXTENSION	AGRICULT~T	MARKET_I~S	AGRICULT~S
SEX_OF~EMALE	.00008642							
DECISION_F~E	-.00003244	.00005286						
MACHINERY_~E	9.586e-07	1.911e-06	.00004836					
AGRICULTUR~P	1.861e-06	-1.365e-06	-2.215e-06	.00008971				
EXTENSION	1.069e-06	9.093e-07	-3.307e-06	-.00001029	.00006754			
AGRICULTUR~T	2.099e-06	-3.671e-07	-1.320e-06	-.00001969	-7.842e-06	.00020568		
MARKET_INF~S	9.757e-07	2.895e-08	-3.171e-06	-5.574e-06	-6.324e-06	-5.366e-06	.0000478	
AGRICULTUR~S	1.036e-06	-2.183e-07	-3.084e-06	-8.161e-06	-5.000e-06	-.00001304	-8.741e-06	.00005991
AGRICULTUR~E	-1.670e-06	5.066e-06	-8.560e-08	-9.970e-07	-3.075e-06	-.00003853	-9.458e-06	-9.530e-06
HUMID_AND_~D	2.360e-06	-7.337e-06	-9.443e-09	-1.758e-06	2.412e-06	-4.030e-06	-1.462e-06	-.00001151
SEMI_HUMID~D	-7.832e-07	-4.497e-06	-.00001091	2.189e-06	5.036e-07	-2.204e-07	7.591e-07	-8.182e-06
_cons	-4.800e-06	-.00001044	-9.875e-06	-4.197e-06	-8.433e-06	6.618e-07	-9.565e-06	3.667e-07

e(V)	AGRICULT~E	HUMID_AN~D	SEMI_HUM~D	_cons
AGRICULTUR~E	.0021086			
HUMID_AND_~D	-4.644e-06	.00006908		
SEMI_HUMID~D	-5.139e-06	.00004968	.00008688	
_cons	5.833e-07	-.00004425	-.00004308	.00005747

Variance Inflation Factor (VIF) Analysis

Variable	VIF	1/VIF
Age of household head	34.83	0.028708
Age of household head squared	34.54	0.028956
Log sold	1.82	0.549564
Log total produced	1.78	0.562451
Household head education continuous	1.14	0.877383
Log farm income	1.09	0.916865
Household Dietary Diversity Score	1.06	0.946392
Land owned	1.05	0.955854
Log non-farm income	1.02	0.976778
Asset Score	1.01	0.987721
Land accessed	1.01	0.990693
Mean VIF	7.3	