AN ASSESSMENT OF THE EFFECT OF SUBSIDIZED FERTILIZER ON FARMER PARTICIPATION IN COMMERCIAL FERTILIZER MARKETS IN NORTH RIFT REGION OF KENYA

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DECLARATION

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

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DEDICATION

I dedicate this thesis to my family and friends for their inspiration and moral support throughout the study period. May our gracious Lord bless you abundantly.

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ABBREVIATIONS AND ACRONYMS

AEZs	Agro-ecological zones
AHM	Agricultural Household Model
APE	Average Partial Effects
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Programme
CMAAE	Collaborative Masters in Agricultural and Applied Economics
CRE	Correlation Random Effects
EPSEM	Equal Probability Selection Method
ERA	Economic Review of Agriculture
FAO	Food and Agricultural Organization
FISP	Farmer Input Subsidy Program
GoK	Government of Kenya
IFDC	International Fertilizer Development Centre
IMR	Inverse Mills Ratio
Kg	Kilogram
Kg /ha	Kilograms per hectare
KIHBS	Kenya Integrated Household Budget Survey
KNBS	Kenya National Bureau of Statistics
KShs	Kenya shillings
KTDA	Kenya Tea Development Agency
LR	Likelihood Ratio
MDG	Millennium Development Goal

MoAL&F	Ministry of Agriculture, Livestock and Fisheries
MoS	Measure of Size
MT	Metric Tons
NAAIAP	National Accelerated Agricultural Inputs Access Program
NASSEP	National Sample Survey and Evaluation Programme
NCPB	National Cereals and Produce Board
NEPAD	New Partnership for Africa's Development
ROK	Republic of Kenya
TAPRA	Tegemeo Agricultural and Policy Research Analysis
TIP	Target Input Program
SAPs	Structural Adjustment Policies
SDGs	Sustainable Development goals
SPS	Starter Pack Scheme
SSA	Sub-Saharan Africa

ABSTRACT

One of the most outstanding economic issues concerning input subsidies in many third world countries is their effect on commercial fertilizer purchases. This is particularly so in countries like Kenya where subsidized fertilizer distribution exists side-by-side with commercial market outlets. The objective of the national fertilizer program designed in 2009 in Kenya was mainly to encourage fertilizer use through public support to local fertilizer manufacturers and strengthening local fertilizer distribution channels. However, the effect of the subsidy program on commercial fertilizer market outlets in general is not known.

This study assessed the level of displacement of commercial fertilizer sales by subsidized fertilizer as well as the factors affecting the quantity of subsidized fertilizer received by households in the North Rift region of Kenya. A structured questionnaire was used to collect primary data from 1,023 households. Descriptive statistics were used to characterize the fertilizer market in the North Rift of Kenya. A double-hurdle model was employed to assess the effect of subsidized fertilizer on farmer participation in commercial fertilizer market outlets.

Results show that most of the subsidized fertilizer went to the wealthier, male-headed, more educated households with more land and higher non-farm incomes. This means that the beneficiaries of the national fertilizer subsidy were households with the resources to purchase fertilizer from commercial sources in the absence of a subsidy. Reducing the quantity of subsidized fertilizer to the bare minimum is likely to make wealthy households shy away from the subsidized fertilizer thereby allowing poorer households to acquire the subsidized fertilizer.

In addition, households with strong social networks with the chair of the village fertilizer subsidy vetting committee received significantly more subsidized fertilizer. This is an indication that the process of identifying the beneficiaries of Kenya's national fertilizer is prone to substantial capture by social elites through rent-seeking and exclusivity.

Access to subsidized fertilizer reduced households' probability to participate in commercial fertilizer market in the North Rift of Kenya by 29 percent. This indicates that the national fertilizer subsidy is suppressing commercial fertilizer outlets. On average, an extra kilogram (kg) of subsidized fertilizer displaced 0.22 kg of commercial fertilizer, *ceteris paribus*, indicating that the national fertilizer subsidy has a potential to crowd out commercial fertilizer. This may not augur well in a liberalizing economy such as Kenya's.

The study recommends that the government of Kenya should consider strengthening the current National Accelerated Agricultural Inputs Access Program (NAAIAP). A program targeted to resource-poor households where farmers access fertilizers through vouchers that can be redeemed from the agro-dealers like in Nigeria. This will enhance the transparency, equity and inclusiveness of the subsidy program which the current one does not.

CHAPTER ONE

INTRODUCTION

1.1 Background

Governments in sub-Saharan Africa (SSA) are increasingly intervening in agricultural input markets in an effort to correct market failure in pursuit of a more inclusive pro-poor agriculture-led economic growth strategy (Dorward, 2009; 2006). Poor output price incentives, high fertilizer prices, lack of credit, poor infrastructure, and information asymmetry are some of the constraints that hinder farmers in SSA from improving agricultural production and productivity (Druilhe and Barreiro-Hurlé, 2012). Therefore, both agricultural growth and growth of agricultural labor productivity in SSA continue to lag behind that of 1960s (Badiane et al., 2015). Thus, the much anticipated agriculture-led economic transformation in SSA remains a pipe dream.

Fertilizer is one of the most important farm inputs that has received considerable government support in SSA (Baltzer and Hansen, 2012). Such interventions have included import and price controls, institutionalization of fertilizer subsidies, and establishment of state-owned fertilizer production distribution systems (Ariga and Jayne, 2010). Fertilizer use in SSA lags far behind the rest of the world this has led to low farm productivity (Sheahan et al., 2016). Therefore, subsidies are expected to induce farmers to adopt the use of modern inputs including fertilizer to increase agricultural productivity to feed a bourgeoning population (Baltzer and Hansen, 2012).

In the last two decades, many SSA countries have re-introduced fertilizer subsidy programs under the “smart subsidy” Africa-wide clarion attributed to the celebrated success of the Malawian Agricultural Input Subsidy Program (Liverpool-Tasie, 2012). The primary objective of the resurgence of these subsidies was to promote agricultural production, improve food security and stimulate the growth of the private input sector (NEPAD, 2006; FMARD, 2011). For instance, the Malawian government pioneered the return of fertilizer subsidies in 1998 having discontinued related programs in early 1990s (Kelly et al., 2011). Other countries that re-introduced fertilizer subsidies were Nigeria (1999), Zambia (2000), Tanzania (2002), Kenya (2006) and Ghana (2008) (ibid.).

In the past, fertilizer subsidy and promotion programs were implemented as direct budgetary support payments to lower farm-gate prices of fertilizer (Gregory, 2006). These, however, suffered from high unsustainable costs, administrative inefficiencies and rent-seeking (ibid.). Therefore, subsidized input programs in SSA have generally been expensive, unsuccessful and rarely equitable, with benefits accruing mainly to large-scale farmers (Gregory, 2006).

Government intervention in fertilizer markets coupled with poor investment in infrastructure to facilitate a competitive commercial fertilizer distribution channel has been shown to deter agricultural development in SSA countries (Takeshima and Lee, 2012). In most cases, commercial fertilizer markets have been negatively affected by publicly-managed fertilizer distribution especially where public and private distribution channels exist concurrently (Ricker-Gilbert et al., 2011).

However, the level of market distortion is dependent on the level of administrative efficiency, targeting, size of the program and timeliness of fertilizer distribution (Liverpool-Tasie, 2014). As such, the effect of government intervention in commercial sector participation in fertilizer markets is not obvious (Liverpool-Tasie 2014). Lack of knowledge on the effect of fertilizer subsidy on commercial markets may lead to inefficiencies associated with poor program policy design.

Kenya introduced its input subsidy program, dubbed the "National Accelerated Agricultural Inputs Access Program" (NAAIAP), in 2006. This was a program designed as a safety-net for farmers who lacked financial resources to purchase farm inputs (Megan et al., 2014). The aim was to address the then Millennium Development Goal (MDG) number one of eradicating extreme poverty and hunger (ibid.). Moreover, the program was a response by the Kenya Government to the Abuja Declaration of 2006 on "Fertilizer for African Green Revolution" in which the African Union (AU) member states resolved to increase fertilizer use from 8 to 50 kgs per hectare by 2015 (Bunde et al., 2014).

To enhance fertilizer use, AU member countries were expected to increase their budgetary allocation to fertilizer purchases, introduce "smart" fertilizer subsidies, and remove all taxes and tariffs on fertilizer and fertilizer raw materials to improve fertilizer financing by importers and agro-dealers (NEPAD, 2006). At the same time, member countries were to develop and implement fertilizer policy and regulatory frameworks by which the fertilizer sub-sector would be regulated and quality-controlled (ibid.).

In 2009, the Government of Kenya (GoK) introduced its national fertilizer subsidy program in line with Vision 2030 (GoK, 2007). The subsidy program, which is still operational, is being implemented by the Ministry of Agriculture, Livestock and Fisheries (MoAL&F) as a three-tier fertilizer cost reduction strategy called the "Fertilizer Cost-Reduction Initiative" or simply, "the national fertilizer subsidy" (IFDC, 2012). The program was started as an emergency response to high fertilizer prices in 2008 (Nzuma, 2013). The aim was to encourage fertilizer use through (a) reduction of fertilizer cost and effective fertilizer supply chain (Tier 1), (b) blending of fertilizers (Tier 2), and (c) support to local fertilizer manufacturing (Tier 3) (Ndung'u et al., 2009).

In an attempt to address Tier 1, the GoK procures and distributes fertilizer at subsidized prices to farmers across the country through the National Cereals and Produce Board (NCPB) depots (IFDC, 2012). Table 1.1 presents a summary of the quantity and cost of subsidized fertilizer procured by the Kenyan Government since inception of national fertilizer subsidy in 2009. A total of 444,805 metric tons (MT) of subsidized fertilizer were procured between 2009 and 2014. This has contributed approximately 23 percent of the total inorganic fertilizer demand at a cost of Kenya shillings (KShs) 14.1 billion which is approximately 30 percent of the treasury allocation for the agriculture sector (MoAL&F, 2015). Elsewhere in Africa, fertilizer subsidies absorb a significant part of total public expenditure in agriculture; for example, 60 percent in Malawi, up to 50 percent in Tanzania and 40 percent in Zambia (Druilhe and Barreiro-Hurlé, 2012).

Table 1.1: Quantity and cost of inorganic fertilizer procured by the GoK under the fertilizer cost-reduction initiative in Kenya (2009-2014)

Financial year	Total fertilizer requirement (MT)	Quantity of organic fertilizer required (MT)	Percentage of organic fertilizer procured	Quantity subsidized (MT)	Percent of organic fertilizer subsidized	Treasury allocation for subsidized fertilizer (KShs M)
2009/2010	503,784	384,406	76.3	16,624	4.3	758
2010/2011	505,489	365,561	72.3	96,000	26.3	2,995
2011/2012	539,910	387,401	71.8	94,155	24.3	3,320
2012/2013	542,780	379,946	70.0	66,276	17.4	3,150
2013/2014	568,000	431,680	76.0	171,750	39.8	3,900
Total	**2,659,963**	**1,948,994**	**73.3**	**444,805**	**22.8**	**14,123**

Source: MoAL&F, (2015).

In Kenya, fertilizer is distributed by the NCPB through four main channels C-1 to C-4 in Figure 1.1. The diagram focuses on domestic participants and does not include international fertilizer actors (manufacturers, shippers and others). In channel C-1, commercial importers buy the fertilizer directly from international suppliers and deliver it to wholesale points or to other firms in the chain, who then transmit the product to agro-dealers from whom farmers purchase at full market prices (IFDC, 2012).

In the second channel, C-2, importers purchase fertilizer directly from international suppliers and deliver it to their own distribution or wholesale points or to agro-dealers from whom farmers purchase at subsidized prices through the voucher system under the NAAIAP (ibid.). The third supply channel, C-3, captures specific high-value crops (mainly tea, coffee, sugar) in which procurement is made directly from international sources or through local importers by a collective crop agency on behalf of all farmers (ibid.).

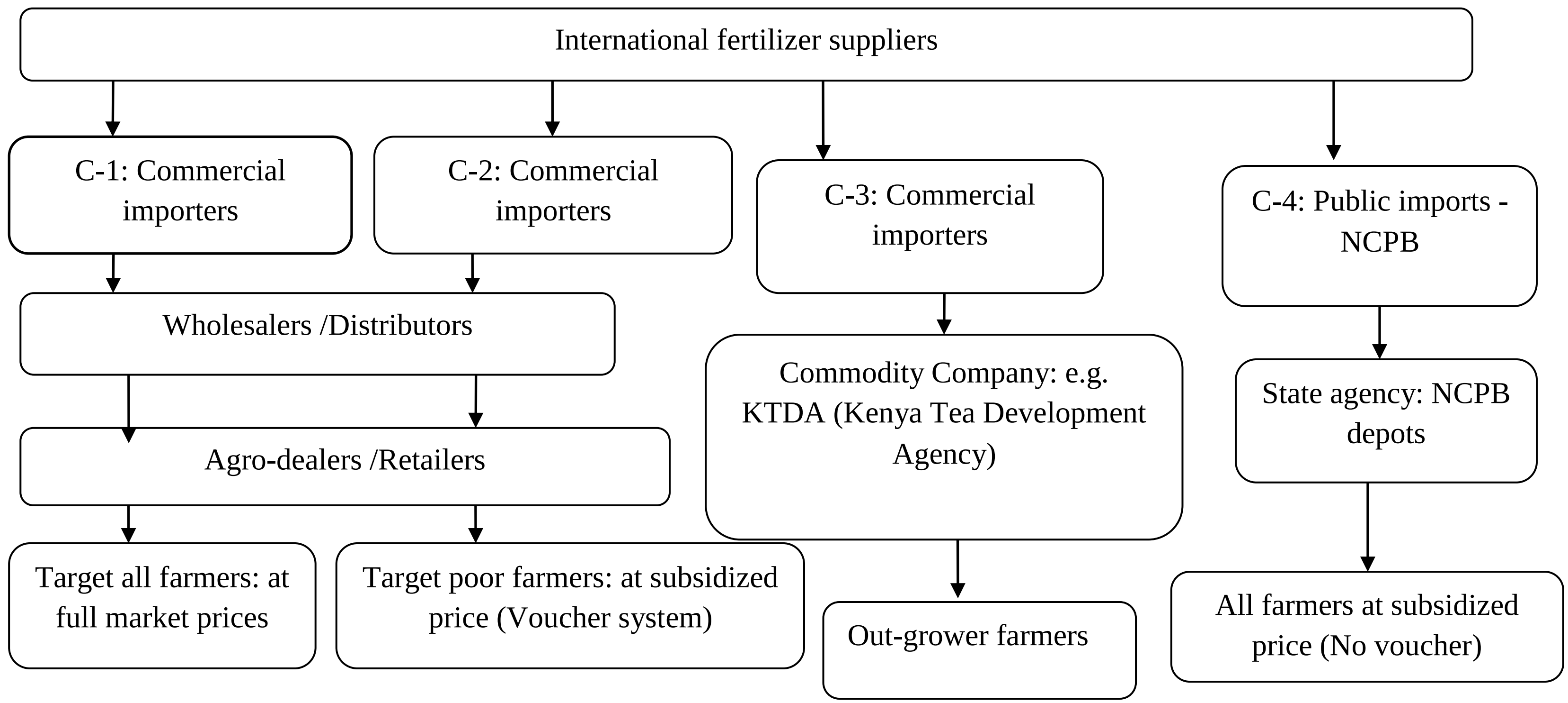

Figure 1.1: Major fertilizer distribution channels in Kenya

Source: Modified from IFDC (2012)

The fourth supply chain, C-4, is state-led and it involves procurement by tender and distribution through the NCPB network of depots across the country at subsidized prices (ibid.). It is worth noting that C-4 differs from C-2 in that in the latter, the vouchers issued to beneficiaries are redeemable from accredited dealers who in turn redeem them from the government (IFDC, 2012).

According to the MoAL&F (2014), the following are procedures for accessing subsidized fertilizer by the farmers (i) a farmer must be vetted by Location Subsidy Fertilizer Vetting Committee and be registered, (ii) a farmer obtains an official form showing the crops and quantity of fertilizer required based on size of land prepared for planting, (iii) the form is signed by the chief /assistant chief and the ward extension officer and the farmer can access a maximum of 40 bags, (iv) the original copy is taken to the nearest NCPB depot and upon receiving dully filled and authorized form the NCPB official advices the farmer to pay for and collect the fertilizer.

1.2 Statement of the problem

Fertilizer supply through the NCPB started in 2009 as an attempt to stabilize fertilizer prices in Kenya by strengthening respective distribution channels in order to boost productivity (GoK, 2007). This has created a dual fertilizer market in which both the government and commercial sellers participate in fertilizer procurement and distribution. According to the International Fertilizer Development Corporation (IFDC), such a parallel fertilizer marketing system creates uncertainty for the commercial sellers because the public sector rarely has a clear exit strategy (IFDC, 2012).

Although government intervention in the fertilizer market is principally aimed at correcting market failure in distribution, it has the potential of crowding out commercial players when implemented in a market where the private sector is operating well (Krausova and Banful, 2010).

Previous studies on the effect of fertilizer subsidies on commercial outlets in SSA have concentrated on targeted subsidies whereby the fertilizer is channeled to certain intended beneficiaries, for example, Ricker-Gilbert et al. (2011); Mason (2011); Xu et al. (2009) and Liverpool-Tasie (2012; 2014) in Malawi, Zambia and Nigeria. Although these studies have shed some the light on the circumstances under which fertilizer subsidies may promote or suppress private fertilizer markets, they have not examined the effect of non-targeted fertilizer subsidy programs on farmer participation in commercial markets. Consequently, the existing literature is unable to inform policy makers on the effect of non-targeted fertilizer subsidy programs on farmer participation in privately-operated fertilizer distribution channels, which would otherwise suppress the commercial fertilizer markets.

In particular, there is no study that has explicitly evaluated the effect of the fertilizer subsidy program on farmer participation in commercial fertilizer markets in the North Rift region of Kenya. Additionally, no study has attempted to identify the determinants of the quantity of subsidized fertilizer acquired by farmers in North Rift region of Kenya in order to understand who the national fertilizer subsidy beneficiaries are. This study aimed to fill these gaps in knowledge by providing evidence on whether the input subsidy suppresses or promotes the commercial fertilizer markets in North Rift region of Kenya.

1.3 Objectives of the study

The overall objective of this study was to assess the effect of subsidized fertilizer on farmer participation in commercial fertilizer outlets in the North Rift region of Kenya. The specific objectives of the study were:

1. To describe the socio-economic characteristics of households in North Rift region of Kenya by source of fertilizer used.
2. To identify the determinants of the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya.
3. To assess the effect of subsidized fertilizer on farmer participation and level of participation in commercial fertilizer outlets in North Rift region of Kenya.

1.4 Hypotheses tested

The following hypotheses were tested in this study:

1. There is no difference in the socio-economic characteristics of households who access fertilizer from different sources in North Rift region of Kenya.
2. Socio-economic, institutional and market factors have no effect on the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya.
3. The quantity of subsidized fertilizer acquired by a household has no effect on farmers' decision as well as the level of participation in commercial fertilizer outlets in the North Rift region of Kenya.

1.5 Justification of the study

Effective and efficient use of fertilizers is embedded in strategies from global, continental and local policies. To be precise, countries that prescribed to MDGs, now Sustainable Development goals (SDGs), and the Comprehensive Africa Development Programme (CAADP) have tried to promote and encourage the use of fertilizers. At the local level, Vision 2030's economic pillar includes agriculture as a major sector, and in which fertilizer use is significant. In addition, the Africa Fertilizer Summit brought forth the Abuja declaration on fertilizer for the African Green Revolution and resolved to introduce smart subsidies (Lunduka et al., 2013; FAO, 2014). However, the perceived benefits and costs of these subsidy programs continue to stir heated debate. Literature reveals that the most contentious issues surrounding fertilizer subsidies programs in SSA countries are poor targeting, patronage, crowding out of commercial inputs and fiscal sustainability (Sharma and Thaker, 2010; Druilhe and Barreiro-Hurlé, 2012; Ricker-Gilbert et al., 2011). To add to this literature, there is need to understand the effect of subsidized fertilizer on commercial fertilizer markets in Kenya.

Therefore, by assessing the effect of national fertilizer subsidy on farmer participation in commercial markets, this study provides policy makers, the private sector, development partners and researchers with information on the magnitude of the existing displacement of commercial by subsidized fertilizer in Kenya, which is currently unknown. This will help to shed some light on who benefits from the national program and aid in re-examining the effectiveness of the program. Additionally, it will contribute to the current debate on general county-level fertilizer subsidy program design and implementation.

This study also provides information on fertilizer use patterns and the factors influencing the quantity of subsidized fertilizer acquired by households in the North Rift of Kenya. This information can be used by the government to re-examine how to implement fertilizer subsidy programs in other areas so as to strengthen the fertilizer supply chain.

This study contributes to existing stock of scientific knowledge through the application of a double-hurdle model in exploring the effect of non-targeted fertilizer subsidy on commercial fertilizer markets. The model has been applied in assessing the factors affecting farmer decision to participate in commercial fertilizer outlets and the extent of participation in Nigeria, Malawi and Zambia.

1.6 Scope and limitation of the study

The main objective of this study was to assess the effect of subsidized fertilizer on farmer participation in commercial fertilizer outlets in the North Rift region of Kenya. Focus was on smallholder farmers in Uasin Gishu, Trans-Nzoia, Elgeyo Marakwet, Baringo, Nandi, Samburu, Turkana and West Pokot counties where farmers were picked to respond to the questionnaires designed (refer to Annex 1). One major limitation of data used in this study is collection of reliable fertilizer quantity and off-farm income data. Most respondents kept sketchy or no records and the study relied mostly on recall ability. In addition, some farmers could not remember the prices at which they bought their fertilizer. Authors had to rely on official prices given at the NCPB depot for the subsidized fertilizer since it was controlled by the government.

CHAPTER TWO

LITERATURE REVIEW

2.1 Defining “fertilizer subsidy”

A subsidy is defined as a payment made from public resources to allow a household, sector or industry face a lower market price of a commodity or service (Takeshima and Lee, 2012). According to Bates (1981), fertilizer subsidies, constitute government intervention in fertilizer supply to maintain stable and low prices for the benefit of both resource-poor farmers and urban consumers through lower food prices.

2.2 Fertilizer subsidies and input vouchers

After several fertilizer subsidy programs were discontinued in 1990’s, lessons learnt led re-designing of smart subsidy programs (Druilhe and Barreiro-Hurlé, 2012). Smart subsidy programs aimed at promoting fertilizer market development and improve agricultural production and productivity for resource-poor households (Sibande, 2016). Supply of fertilizer through commercial markets targeting the poor can be considered as smart subsidy (Minot and Benson, 2009). These subsidies are phased out once the market infrastructure is developed and markets are operating well. Provision of input vouchers is one of approach to designing smart subsidies for fertilizer (Dorward, 2009). In this approach the beneficiaries are identified and issued with vouchers that are redeemable at commercial input suppliers (Mangisoni, 2007).

The cost of the fertilizer to the farmer is reduced by the value of the voucher. The supplier, having provided fertilizer to the farmer in exchange for the voucher takes the voucher to a designated agency and is reimbursed for its value plus a handling fee (Minot and Benson, 2009). The voucher is an income transfer through private sector suppliers to farmers (Dorward, 2009;

Minot and Benson, 2009; Druilhe and Barreiro-Hurlé, 2012). Vouchers are a way to guarantee demand for fertilizer supplied and enable commercial sellers to benefit from economies. Input vouchers help strengthen commercial-sector distribution network, build exit strategies by reducing the value of the voucher over time, provide an opportunity to train farmers and input suppliers on efficient and profitable use of fertilizer and in emergency response situations, vouchers can replace food aid as medium-term support to those affected.

2.3 Rationale of a fertilizer subsidy

In a world of imperfect markets, subsidies are socially justifiable because they combat market inequities (Aloyce et al., 2014; DeBow, 1991). Imperfect markets are predominant in SSA where economic market does not meet the rigorous standards of a hypothetical perfectly competitive market (Krugman, 1997). With regard to fertilizer, many farmers in SSA do not to use recommended rates partly because they cannot afford large quantities of fertilizer and partly due to lack of appreciation of the benefits of adequate fertilizer use.

Theoretically, the introduction of fertilizer subsidies in an agricultural production process increases fertilizer use as farmers are able to purchase the input whose price has fallen (Debertin, 1986; Varian, 1992; Ricker-Gilbert and Jayne, 2008). The net effect of the fertilizer subsidy is a reduction in production cost at the farm level, an increase in commodity supply (from Q to Q^*) and a fall in commodity prices (from P to P^*) in Figure 2.1.

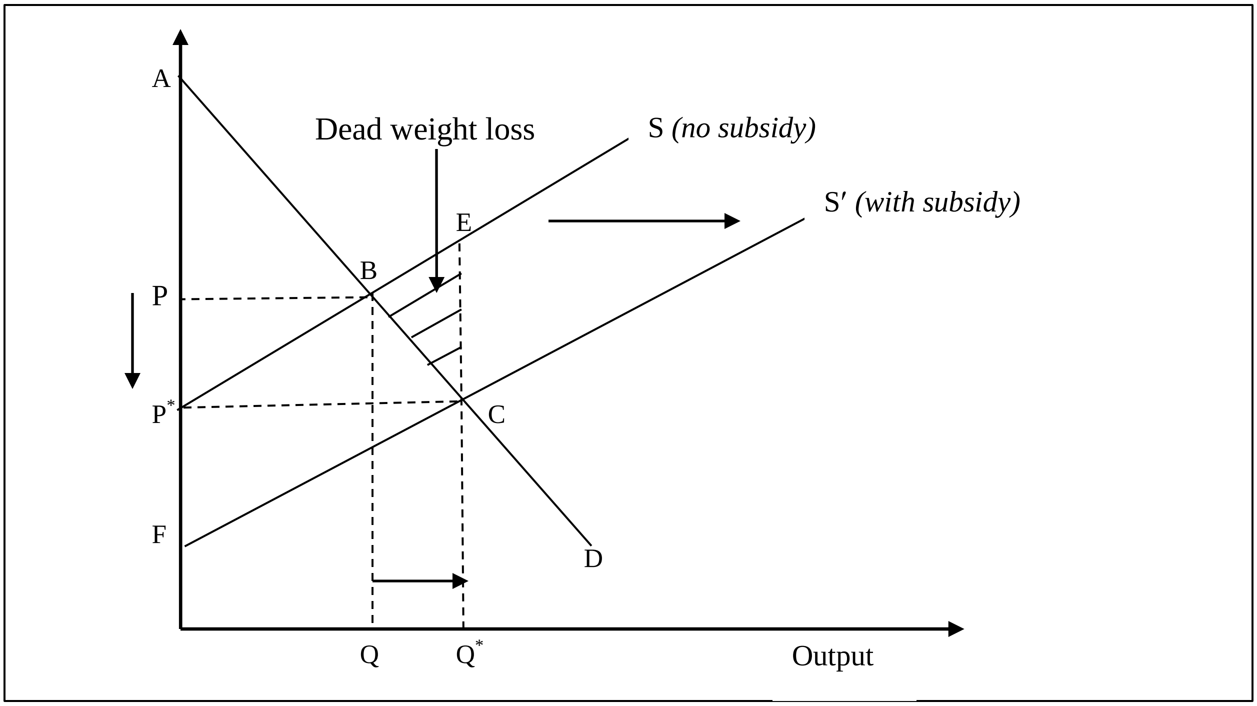

Figure 2.1: Effect of fertilizer subsidy on commodity supply

Source: Varian (1992)

However, this only happens in an environment where farmers are faced with intractable market failure (Druilhe and Barreiro-Hurlé, 2012). In analyzing fertilizer use in SSA, information asymmetry and poor fertilizer market development are the two main sources of market failure (Tuteja, 2003). Market failure presents a *prima facie* case for government intervention in fertilizer markets, albeit with the consequence of dead weight loss to society (see Figure 2.1) (Alston and Hurd, 1990). Despite the deadweight loss, fertilizer subsidies are often justified on social welfare grounds such as equity (Dorward, 2009).

2.4 History of fertilizer subsidy programs in Kenya

As in many SSA countries, Kenya implemented “universal” subsidy programs from independence in 1963 to the early 1980s when the largely donor-funded projects came to an abrupt end following the adoption of structural adjustment policies (SAPs) (Dorward, 2009; Minot, 2009). These programs were state-led and succeeded in raising agricultural productivity through use of modern inputs including fertilizer (Badiane et al., 2015). However, they were phased out largely because they tended to benefit the well-off in the society (Druilhe and Barreiro-Hurlé, 2012). Additionally, the fertilizer subsidy programs were inefficient due to high administrative costs, government monopoly and political influence (Banful, 2010).

In 1980s and 90s, input markets in Kenya were liberalized following the adoption of SAPs. As a result, fertilizer use declined due to increase in price from KSh 4 in 1990 to KSh 24 per kilogram in 2001 (Karanja and Nyoro (2002); Kelly et al., 2011). By the end of the 1990s subsidy programs re-emerged in several SSA countries including Kenya, principally to forestall the dismal performance of the agricultural sector due to the negative effects of SAPs (NEPAD, 2013). Through the donor-driven Poverty Reduction Strategy Papers (PRSPs), many SSA countries started implementing “smart subsidies” to raise agricultural productivity (Bindraban et al., 2008). The Abuja Declaration of 2006 provided the continental policy framework for the implementation of “smart subsidies’’ in Africa (Bunde et al., 2014). Smart subsidy programs were designed to address the weaknesses of the universal subsidies (Minde et al., 2008; Tiba, 2009).

In SSA, Malawi pioneered the return of input subsidies through the Starter Pack Scheme (SPS) in 1998, followed by the Target Input Program (TIP) in 2000 and the Farmer Input Subsidy Program (FISP) in 2005 (Bunde et al., 2014). According to Levy and Barahona (2002), SPS succeeded in promoting national food security and lowering maize prices from US$ 0.25 per kilogram before the subsidy program to US$ 0.18 per kilogram following subsidy implementation. However, these subsidies crowded out commercial operators by 0.13 kg in Zambia and 0.22 kg in Malawi (Mason and Jayne, 2012; Ricker-Gilbert et al., 2011). Therefore, despite the visible benefits of the SPS, most donors supporting Malawi were unwilling to support the subsidy program claiming it was undermining the growth of commercial fertilizer sellers and creating a dependence syndrome among farmers (Harrigan, 2008).

In Kenya, the return of the fertilizer subsidy program in 2006 under NAAIAP (Kiratu et al., 2014). This program begun with a component called "Kilimo Plus", which was pro-poor and aimed at increasing food production to enhance food security. The beneficiaries in this program were given starter kits comprising of 10 kg of certified maize seed, 50 kg of base fertilizer, and 50 kg of top dressing fertilizer (Megan et al., 2014). The kit was supposed to aid the farmers to cultivate 0.4 hectare of land which was said to be enough to provide food to an average household of five people at an annual maize consumption of 125 kg per capita (Kiratu et al., 2014). The grant was administered through a voucher issued to the farmer (ibid.).

Following the 2008 global financial crisis, the GoK initiated the National Fertilizer Subsidy Program in 2009 designed to increase fertilizer use among poor households as well as to cushion them against high fertilizer prices (Tegemeo, 2010). This program was supported by bulk procurement of fertilizer by the MoAL&F which was then distributed as subsidized fertilizer to farmers (Nzuma, 2013).

In this program, the government procured subsidized fertilizers through the NCPB which was distributed to farmers through its depots countrywide after being vetted by the Location Subsidy Fertilizer Vetting Committee.

Table 2.1 shows the price comparison between commercial and subsidized fertilizers in 2012 and 2013. Generally, the level of subsidy differs from year to year and across different types of fertilizer and region in Kenya. The national subsidy program has lowered and somewhat stabilized fertilizer prices. From the Table, the amount of subsidized fertilizer is substantial, which means it has a potential displace effect to commercial outlets.

Table 2.1: Price comparison between commercial and subsidized fertilizers in Kenya

	Commercial fertilizer prices (KShs)		**National Cereals and Produce Board Prices (KShs)**		**Subsidy level (%)**	
Type Fertilizer	**2013**	**2014**	**2013**	**2014**	**2013**	**2014**
DAP	3,760	2,000	2,480	1,800	36	10
CAN	2,600	2,300	1,600	1,500	37	44
NPK	3,360	3,100	2,500	2,000	24	32

Source: Author (Survey data)

Although Kenya's fertilizer subsidy programs have had a positive effect on crop yield, household income and poverty reduction (Mason et al., 2015), studies show that they are fraught with problems associated with poor targeting, rent-seeking, smuggling and diversion to commercial markets (Gregory, 2006; Kamoni and Rotich, 2013). The supply of fertilizer subsidy in Kenya has raised public concerns due to its chronic lateness in delivery, which has led to low fertilizer application rates (ibid.). Both the intention and the practice of the fertilizer subsidy program may have affected participation in commercial outlets.

2.5 Theoretical review

2.5.1 A review of theories underpinning farmer participation in fertilizer markets

Three theoretical constructs underpin the motivation of a farmer participating in an input markets. These are (i) theory of the firm, (ii) random utility model, and (iii) agricultural household model. The particulars of each model are described below.

2.5.1.1 Theory of the firm

In the neoclassical theory of the firm, the main objective of a business firm is profit maximization. Thus, with this major motive, any firm will supply an output that maximizes the profits for all the individual firms. Maximum profits refer to pure profits which are a surplus above total costs of production. It is the amount left with the entrepreneur after he has made payments to all factors of production, including his wages of management.

According to Varian (1992), profit maximizing condition can be expressed as:

$$\text{Maximize } \pi(Q) = R(Q) - C(Q) \qquad (2.1)$$

subject to a cash constraint.

where $\pi(Q)$ is profit, $R(Q)$ is total revenue, $C(Q)$ are total costs, and Q is the output produced.

The assumptions underlying this theory are; the objective of the firm is to maximize profits, the entrepreneur is the sole owner of the firm, tastes and habits of consumers are stable, and techniques of production are given (Mendola, 2007). There is however profound market imperfection in Africa that is characterized by lack of credit, inefficient labor and land rental markets, tenure rights, marketing constraints, or various combinations of these (Boucher et al., 2005). Therefore, households in SSA aim to maximize utility rather than profits (Mendola, 2007).

Profit maximization cannot be used to anchor the current study because of the existence of trade-offs between profit maximization and other household goals, and the role of uncertainty and risk in farm household production decisions as in the case of fertilizer use in the north rift of Kenya. In addition, this theory overlooks the aspect of consumption in household decision processes.

2.5.1.2 Random utility model

Households are often faced with a range of options from which to make choices. Whether one item is preferable to another depends on how much satisfaction it yields relative to its alternatives utility (Case and Fair, 2007). Neoclassical random utility theory assumes that an individual has perfect discriminatory power, access to information and rank alternative choices in a well-defined and consistent manner (Kjær, 2005). Therefore, the individual can thus determine his or her best choice and will repeat this choice under identical circumstances (Anderson et al., 1992).

The utility derived from a given choice can be expressed as the linear sum of a deterministic part that captures the observable components of the utility function and a random error term that captures unobservable components of the function.

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

According to Hanemann (1984), U_{ij} is the latent utility derived by an individual household i from choosing to buy fertilizer form source j, V_i is the observable systematic component of utility, and ε_i is the stochastic error term unobservable to the researcher and treated as a random component. This random component is inherently stochastic and an individual's preferences cannot be understood perfectly. In addition, individual's utility function cannot be observed. Therefore, random utility framework was not adopted for this study.

2.5.1.3 Agricultural household model

Among peasant households, the neoclassical agricultural household model (AHM) has been used to explain the behavior of farm households in simultaneous decision making about consuming own-produced and market-purchased goods. By consuming all or part of its own output, which could alternatively be sold at a given market price, the household implicitly purchases goods from itself. On the other hand, by households allocating it's time to leisure or to household production activities, the household implicitly buys time, valued at the market wage, from itself. Therefore, small-holder farmers have this dual character.

The interaction of consumption and production within the household causes a unique form of decision making which sets smallholder farmers apart from any other kind of production unit under capitalism. According to Singh et al. (1986), the AHM typically incorporates the notion of full household income and conceives of the household as a production unit that converts purchased goods and services as well as its own resources into use values or utilities when consumed. Hence, the household maximizes utility through the consumption of all available commodities (home-produced goods, market-purchased goods, and leisure), subject to income constraints.

The model shows that if all markets exist and all goods are tradable, prices are exogenous and production decisions are taken independently of consumption decision. It is however noted that markets do not exist in all cases and hence not all goods are tradable. Hence, it is not possible to separate consumption from production (ibid.).

In reality, households operating in developing countries are likely to face more than one market imperfection leading to transactions and investments that are sub-optimal (Dillon and Barret, 2014). Hence, the logical option is for the household's objective to maximize utility from a list of consumption goods. Subsequently, utility maximization approach within the AHM is more suitable than the profit maximization approach for assessing farm household behavior. This model has been used by Ricker-Gilbert et al. (2011) and Liverpool-Tasie (2012) to study participation in fertilizer markets in Malawi and Nigeria respectively.

2.5.2 Review of methods used to evaluate farmer participation in fertilizer markets

Past studies have treated household decision to participate in fertilizer markets as a two-step process (Ricker-Gilbert et al., 2011; Liverpool-Tasie, 2012; Liverpool-Tasie, 2014). The first step entails a household making the decision on whether or not to participate in the fertilizer market while the second step involves deciding how much fertilizer to purchase conditional upon the participation decision (Goetz, 1992; Key et al., 2000; Holloway et al., 2001; Bellmare and Barrett, 2006). These studies have typically used the Heckman (1979), the Tobin (1958), double-hurdle (Omiti et al., 2009; Ricker-Gilbert et al., 2011; Jayne et al., 2013; Liverpool-Tasie, 2014) and triple-hurdle models (Burke, 2009). The choice of the model to use depends on the objective of the study, the nature of underlying econometric issues at hand such as inferences based on normal distributions when distributions are not normally distributed, parametric inference where the economist's theoretical knowledge is limited to directions of change, classical and Bayesian inferential procedures when samples from a population are limited in size, unique, and non-repeatable except at very high cost and tractability of results (Kmenta & Ramsey, 1980).

The Heckman model is a two-stage technique that corrects for selection bias arising from non-randomness of the sampling units associated with non-experimental survey design (Olwande and Mathenge, 2012). The correction for selection bias is achieved by generating an inverse Mill's ratio (IMR) in first stage and using it as an explanatory variable in the second stage (Heckman, 1979). Some studies that used Heckman model in analyzing market participation include Siziba et al., (2011); Jagwe (2011); Sebatta et al. (2012); Moono, 2015). However, the model is designed for incidental truncation where the zeros arising from decision not to participate in a certain market are considered to be unobserved values rather than logical economic decisions leading to loss of valuable information in the dataset (Ricker-Gilbert et al., 2011). Therefore, the Heckman model could not be applied in the current study.

The Tobit model has been the widely used in data that have zeros, yielding a censored dependent variable (Tobin, 1958). Although it can be used to model farmer participation in fertilizer markets, its major drawback is that it requires that the decision to participate and how much to buy be determined by the same process, which is restrictive (Wooldridge 2003; Ricker-Gilbert et al., 2011). The Tobit model allows the partial effect of a particular regressor on the probability of participation as well as the level of participation to have the same signs (Wooldridge, 2008; Reyes et al., 2012).

Due to the shortcomings of the Tobit model mentioned above, this study did not use it to assess the effect of national fertilizer subsidy on farmer participation and the level of participation in commercial market outlets. However, Tobit model was used to evaluate the determinants of the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya. This is because the study considered households who benefited from subsidized fertilizer.

In empirical instances where zeros in the outcome variable reflect a household's optimal choice rather unobserved characteristics, the double-hurdle model is normally used (Cragg, 1971). This model is more flexible than the Tobit because it allows for the possibility that the factors influencing the decision to participate in the market be different from factors affecting the decision of how much to buy (Komarek, 2010). For this reason, the double-hurdle model was adopted for use in the third objective of this study. The first hurdle comprised the household deciding whether or not to participate in commercial fertilizer market while the second hurdle assessed how much fertilizer to buy conditional upon the participation decision (Goetz, 1992; Key et al., 2000; Holloway et al., 2001; Bellmare and Barrett, 2006).

The choice of which model to use depends on the underlying distribution of the dependent variable. For example, if the dependent variable is normally distributed, the ordinary least squares (OLS) technique is used (Wooldridge, 2002). If it is continuous but limited within some range, the Tobit model is used (Baum, 2006). If the dependent variable involves count data, then the Poisson model is used (Crawley, 2005). In this study, the probit model was used for in the first hurdle because that hurdle involved a binary choice of whether or not to participate in commercial fertilizer market outlets. Truncated regression was then used in the second hurdle to assess the factors influencing how much fertilizer to buy from commercial sources contingent upon the participation decision.

2.6 Empirical review

Several studies have been undertaken in many countries to evaluate the effect of fertilizer input vouchers on commercial fertilizer sales. For example, Xu et al. (2009) using double hurdle model, examined the impact of government input programs on crowding out the private sector in Zambia using a double-hurdle model. The study found that in areas where the private sector was fairly active and the average wealth was high, input subsidies substantially crowded out the private sector. On the other hand, in poorer areas where the private sector was relatively inactive, subsidies helped to generate demand and crowd in the private sector.

Like Xu et al. (2009), the current study recognizes two parallel fertilizer distribution channels. However, the current study differs from Xu et al. (2009) in that once the national subsidized fertilizer is paid for farmers can only get it through NCPB depots but not from the private markets.

Ricker-Gilbert et al. (2011) used a double-hurdle model to evaluate whether subsidies crowd out commercial fertilizer sales in Malawi. The study found that on average, crowded out 0.22 kg of commercial fertilizer. In addition, one kilogram of subsidized fertilizer increased fertilizer use by 0.18 kg among the poorest farmers and 0.30 kilogram among relatively non-poor farmers. This meant that fertilizer subsidies targeted to the rural poor increased total fertilizer use albeit also distorting the market. Ricker-Gilbert and colleagues' study is useful to the current one in terms of econometric modeling regarding how to control for potential endogeneity caused by the non-random targeting of fertilizer subsidy in the North Rift of Kenya.

Mason and Jayne (2012) used a double-hurdle model to assess the effect of fertilizer subsidies in crowding out the commercial fertilizer outlets in Zambia.

The study found that each additional kg of subsidized fertilizer received by a household decreased the quantity of fertilizer purchased from commercial retailers by 0.13 kg. In addition, the displacement effect was 0.23 kg in areas where the private sector was operating well. Moreover, the displacement rate was higher among households that cultivated two or more acres of land than among those that cultivated smaller areas. The authors also found that the displacement rates were higher among male-headed households (0.15) than among female-headed ones (0.09). The study used the double hurdle model which informed the current study on the considerations for various methodological approaches.

Jayne et al. (2013) used a double-hurdle model to evaluate the effect of fertilizer subsidy programs on commercial outlets in Kenya, Malawi and Zambia. The authors found that fertilizer subsidies crowded out commercial fertilizer outlets in all the three countries. An additional kilogram of subsidized fertilizer distributed in Malawi, Zambia, and Kenya crowded out 0.18 kg, 0.13 kg and 0.43 kg of commercial fertilizer respectively. In addition, the crowding out was higher for subsidized fertilizer distributed to households with large land sizes. In all the three countries, an additional ton of subsidized fertilizer allocated to households with large farm sizes doubled the magnitude of crowding out. In Malawi, for instance, 251 kg of commercial sales were displaced compared to 27 kg if the subsidized fertilizer were allocated to households with small land sizes. According to Jayne et al (2013), the crowding out effect was lower in areas with low commercial fertilizer demand. The study informed the current one on important background information on the determinants of the quantity of subsidized fertilizer acquired by households.

Mason and Ricker-Gilbert (2013) used a combination of correlated random effects (CRE) Tobit estimation with a control function to test and control for endogeneity in assessing the effect of input subsidies on commercial seed outlets in Malawi and Zambia.

The study found that an additional kilogram of subsidized maize seed crowded out 0.58 and 0.49 kg of commercial improved maize seed in Malawi and Zambia respectively. The authors also found that acquiring subsidized fertilizer had no effect on commercial seed purchases in both countries. In addition, the study found that on average, an additional hectare of land owned by the household led to 11.30 and 0.19 more kgs of subsidized fertilizer purchased by households in Malawi and Zambia respectively.

Although Mason and Ricker-Gilbert (2013) examined the effects of maize seed subsidy on commercial seed markets, it is informative to the current study in terms of providing some of the important variables to include in the estimation the double-hurdle model and the use of the control function to control for potential endogeneity.

Liverpool-Tasie (2014) used a double-hurdle model to assess the effect of fertilizer voucher system on farmer participation in private fertilizer markets in Nigeria. The study found that the farmers that received subsidized fertilizer had a higher probability of participating in the private fertilizer markets in subsequent years than those who did not because the fertilizer was distributed through private markets. The study concluded that fertilizer subsidies enhanced the commercial fertilizer market. In the Nigerian case, the farmers were given fertilizer vouchers redeemable from commercial dealers. This practice differs from that in Kenya where no such vouchers are issued in Tier 1 (see Figure 1.1). However, the beneficiaries vetted at the village level redeem their stamped forms with the NCPB. Although Liverpool-Tasie (2014) focused on the effect of targeted fertilizer on farmer participation in commercial markets, the relevance of this study to the current one is that it provides useful information for identification of regressors to include in the empirical models. Additionally, the current study used a similar methodological approach especially in regard to the formulation of double-hurdle model.

2.7 Summary

The literature reviewed in the fore-going sections shows that fertilizer subsidies can either crowd-in or crowd-out commercial fertilizer markets. In addition, the effect of subsidy programs in commercial outlets is dependent on the level of administrative efficiency, the size of the subsidy program, targeting, and timeliness of fertilizer distribution. Various models have been suggested in the literature to assess the effect of subsidies on farmer participation and the level of participation in commercial fertilizer markets.

This study used the double-hurdle model because of its ability to address corner solution challenges with estimating input demand. It also allows for the possibility that the factors influencing the likelihood of market participation be different from those influencing the level of participation contingent upon the participation decision. From the literature reviewed, only Xu et al. (2009) explicitly modeled farmers' fertilizer purchase behavior where subsidy programs parallels the commercial ones. Even then, according to Xu et al. (2009), in Zambia, private firms had been contracted to distribute fertilizer on behalf of government to the targeted households. This departs from the Kenya's national subsidy program in that it is non-targeted.

The next chapter describes the methodology applied in this study.

CHAPTER THREE

METHODS AND DATA

3.1 Theoretical framework

This study is anchored on the Agricultural Household Model (AHM). Agricultural households in developing countries are faced with challenges that influence their livelihood and livelihood strategies (Ellis, 1993; Carney, 1998). According to Singh et al. (1986), the AHM recognizes that farmers consume the agricultural output they produce. The model assumes that farm output is consumed by producing households, with the surplus being marketed, a reality for most farm households in developing countries (ibid). At the core of household models is the concept of separability. Separability means that production, consumption and labor supply decisions in a household are independent of each other. According to Taylor and Adelman (2003), consumption and production decisions in developing countries are jointly determined.

According to Singh et al. (1986), the AHM assumes that households maximize utility derived from the proceeds of production and family labor subject to a set of constraints. In any production cycle, the *i*th household is assumed to maximize the following utility function (ibid.):

$$U_i = U_i(X_{a,} X_{m,} X_l) \qquad (3.1)$$

where X_a is an agricultural staple, X_m is a market-purchased good, and X_l is leisure subject to a cash income constraint:

$$p_m X_m = p_a(Q - X_a) - w(L - F) + E \qquad (3.2)$$

where p_m is price of the market-purchased commodity, p_a is price of the staple, Q is household production of the staple, Q-X_a is the marketed surplus, w is market wage, L is total labour, F is family labor input [so that if L-F>0, then the household hires labor; if L-F<0 then the household supplies off-farm labor], and E is any non-labor non-farm income (ibid.).

The household also faces a time constraint. This is because it cannot allocate more time to leisure, on-farm production or off-farm employment than the total time available. Therefore,

$$T = X_l + F \tag{3.3}$$

where T is the total household time. It also faces a production technology constraint that depicts the relationship between inputs and farm output:

$$Q_a = Q_a(L, A, K) \tag{3.4}$$

where A is the household's fixed quantity of land and K is its fixed stock of capital.

The three constraints on household behavior can be collapsed into a single one (Singh et al., 1986) by substituting the production constraint into the cash income constraint for Q_a and substituting the time constraint into the cash income constraint for F yields:

$$p_m X_m + p_a X_a + p_l X_l = p_l T + \pi + E \tag{3.5}$$

where $\pi = p_a Q(L, A, K) - wL$ is a measure of farm profits.

In equation (3.5), the left-hand side ($p_m X_m + p_a X_a + wX_l$) shows the total household expenditure on the market-purchased commodity, the household's purchase of its own output and time in form of leisure. The right-hand side is a development of Becker's concept of full income, in which the value of the stock of time owned by the household is explicitly recorded as labor income (Becker, 1965). The extension of the AHM is the inclusion of a measure of farm profits (Taylor and Adelman, 2002):

$$p_a Q_a - wL \tag{3.6}$$

In this case, all labor is valued at the market wage. Equations 3.1 to 3.5 show that the household can choose different levels of consumption for the agricultural staple, market-purchased good and leisure. Maximizing utility subject to the single constraint in equation 3.5 yields the following first order conditions (Singh et al., 1986):

$$\partial U/\partial X_m = \lambda p_m \quad (3.7)$$

$$\partial U/\partial X_a = \lambda p_a \quad (3.8)$$

$$\partial U/\partial X_l = \lambda w \quad (3.9)$$

The first-order conditions on the production side can be solved for optimal input demand (L^*) and output supply (Q^*) in terms of prices, wage rate, land and capital:

$$L^* = L^*(P_{m,}P_a, w) \quad (3.10)$$

$$Q^* = L^*(P_{m,}P_a, w) \quad (3.11)$$

In this study, equation 3.10 took the following general form:

$$Qprivatei = f(Qsubsidy, fertpric\ Maizepric, K, A, Z) \quad (3.12)$$

where $Qprivatei$ is the quantity of commercial fertilizer purchased at market price by the i^{th} farmer, $Qsubsidy$ is quantity of subsidized fertilizer received, $fertpric$ is average price of all commercial inorganic fertilizers purchased by the household with an exception of foliar feed; $maizepric$ is price of output (maize in this case), K, A and Z represent access to credit, land size and household socio-economic characteristics that affect the demand for fertilizer. The estimation of equation 3.12 uses standard econometric techniques associated with compensated input demand functions (Debertin, 1986).

In equation 3.12 following Roy (1951); Cameron and Trivedi (2005, 2009), $Q_{privatei}$= 0 is determined by the density f1(.)such that $P(Q_{privatei})$ = 0 = f1(0) and $P(Q_{privatei})$ > 0 is determined by $f2(Q_{privatei}|Q_{privatei} > 0) = f2(Q_{privatei})|1 - f2(0)$. The associated likelihood function whose log is maximized can be expressed as:

$$L = \prod_{i|\mathrm{Q_{privatei=0}}}\{f1(0)\}\prod_{i|\mathrm{Q_{privatei\neq 0}}}\{\frac{1-f1(0)}{1-f2(0)}f2(Q_{privatei})\} \qquad 3.12$$

3.2 Empirical framework

3.2.1 Assessing factors influencing the quantity of subsidized fertilizer acquired by a household in North Rift region of Kenya

To assess the factors influencing the quantity of subsidized fertilizer acquired by the *i*th farmer, a Tobit model was fitted into the data:

$$Q_{SUBSIDY_i} = \beta_0 + \beta_1\mathrm{AGE} + \beta_2\mathrm{GENDER} + \beta_3\mathrm{EDUC} + \beta_4\mathrm{LANDSIZE} + \beta_5\mathrm{HHSIZE} + \beta_6\mathrm{NONINCM} + \beta_7\mathrm{TLU} + \beta_8\mathrm{WEALTHCAT} + \beta_9\mathrm{CRD} + \beta_{10}\mathrm{NCPB} + \beta_{11}\mathrm{MOBILE} + \beta_{12}\mathrm{TRANSPORT} + \beta_{13}\mathrm{MAIZEPRIC} + \beta_{14}\mathrm{FERTPRIC} + \beta_{15}\mathrm{LEADERSHIP} + \varepsilon_i \qquad (3.13)$$

This equation was used to generate Tobit model residuals (Ω_i) that were then used in the second stage of the double-hurdle model to test and control for endogeneity.

Table 3.1 presents a summary of variables in equation (3.13) that were hypothesized to affect quantity of subsidized fertilizer acquired by households in North Rif region and their expected signs.

Table 3.1: Description of variables hypothesized to influence quantity of subsidized acquired by fertilizer in the North Rift of Kenya

Variable	Description	Measurement	Hypothesized signs
Dependent variables:			
$Q_{SUBSIDY_i}$	Quantity of subsidized fertilizer purchased in 2013 /2014	Kg	
Independent variables:			
AGE	Age of household head	Years	+
GENDER	Gender of household head	Dummy (1 =Male, 0= Female)	+
EDUC	Years of formal schooling of household head	Years	+
LANDSIZE	Total farm size	Acres	-
HHSIZE	Household size	Number	+
NONINCM	Non-farm income per year	KShs	-
TLU	Total Livestock Units	Number	-
WEALTHCAT	Household wealth category based on PCA	Categorical (1 = "Poor", 2 = "Middle class", 3="Rich")	-
CRD	Access to credit facilities in 2013/2014 cropping season	Dummy (1 = Yes, 0 = No)	+
NCPB	Distance to nearest NCPB depot	Kilometers	-
MOBILE	Ownership of mobile phone	Dummy (1 = Yes, 0 = No)	+
TRANSPORT	Ownership of a transport equipment	Dummy (1 = Yes, 0 = No)	+
MAIZEPRIC	Price of output/90kg bag	KShs	+
FERTPRIC	Price of fertilizer/kg	KShs	+
LEADERSHIP	If a member of the household belong to the same family, or belong to a group or are in any way connected to government officials in the fertilizer subsidy vetting committee.	Dummy (1 = Yes, 0 = No)	+

Source: Author (Survey data)

3.2.2 Justification for inclusion of regressors in the Tobit Model

The following factors were hypothesized to influence the quantity of subsidized fertilizer acquired by a household.

(a) Socio-economic factors

AGE: This was measured in years representing the age of the household head. It was a continuous variable. According to Frank (1995), older individuals are able to assess the utility of new agricultural technologies by relating their perception of the practice to their experience and interpreting the value of that practice to their needs. If that experience suggests that the potential rewards to be gained adopting the new practice is greater than the expected effort or cost, the individual is likely to adopt it (Rogers, 1962). In this study, older household heads could have enabled farmers to establish social capital and networks with village chiefs who were responsible for approving the fertilizer subsidy forms. Therefore, older farmers would acquire more subsidized fertilizer than younger ones. Therefore, AGE was hypothesized to be positively associated with the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya. According to Xu et al. (2009), age of the household head increased the quantity of subsidized fertilizer acquired by households in Zambia by 4.41 kg.

GENDER: This was a dummy variable one and zero representing male- and female-head of household respectively. Being a male-headed household was expected to be positively related with the quantity of subsidized fertilizer acquired by the household. This is because male-headed households tend to In Kenya, Foeken et al. (2002) found that women-headed households were using less chemical fertilizer than their male-headed counterparts. This is because female-headed households lack the resources to purchase chemical fertilizer. In Uganda, Okoboi and

Barungi (2012) found that female-headed households were less likely to use chemical fertilizers compared to their male-headed counterparts. The authors attributed to this to dominance of male extension workers in Uganda who focused their services mostly to fellow men. In this study, GENDER was hypothesized to be positively related to the quantity of subsidized fertilizer acquired by households.

EDUC: This variable represented the number of years of household head in formal school. Generally, more educated farmers are able to get and make use of information on input and output markets at reduced transaction costs than less educated ones (Sigei et al., 2014). Additionally, education has a positive effect on the likelihood of a household accessing financial assets or being more attractive to financial services providers to enable them acquire the necessary farm inputs (Diagne and Zeller 1998; Tu et al., 2015). Such households are more likely to participate in product and factor markets (Obisesan et al., 2013). Additionally, more educated farmers are often more enlightened than uneducated ones on the benefits of using modern inputs such as fertilizer (ibid.). In this study, EDUC was expected to be positively related with the quantity of subsidized fertilizer acquired by the household.

LANDSIZE: This was a continuous variable representing the total land area cultivated by the household. It was derived from summing up the total land owned and rented. Larger land sizes increase the demand for inputs purchased by a household (Sall et al., 2000; Adegbola and Gardebroek, 2007). Additionally, land can be used as collateral for credit hence increasing household's purchasing power of farm inputs (Abeykoon et al., 2013). However, Feder et al. (1985) report that in developing countries, farm size may be negatively correlated with the demand for fertilizer as households with smaller land sizes use fertilizer more intensely to improve productivity than their counterparts.

In this study, therefore, LANDSIZE was hypothesized to have a negative relationship with the quantity of subsidized fertilizer acquired by the household in the North Rift of Kenya. This is because households with larger landholdings would have the resources to purchase fertilizer from commercial sources. They are also attractive to financial service providers for credit that would enable them purchase modern inputs such as fertilizer.

HHSIZE: This was a continuous variable representing the number of household members living and eating together. Fertilizer demand is derived from demand for food where in this study demand for fertilizer occurs as a result the demand for food crops (Tura, 2010). Consequently, households with more members would need to use more fertilizer to produce more food compared to their counterparts. In this study therefore, HHSIZE was expected to have a positive effect on the quantity of subsidized fertilizer acquired by a household. Imoru and Ayamga (2015) found that household size increased the quantity of subsidized fertilizer received in Ghana.

NONINCM: This was a continuous variable representing non-farm household income. Non-farm employment offers an opportunity to diversify sources of income (Irungu et al., 1998). It therefore increases farmer's effective demand for goods and services that are not available on the farm including fertilizer. In this study, NONINCM was hypothesized to be negatively associated with the quantity of subsidized fertilizer acquired by the household in the North Rift of Kenya. This is because the Kenya's national subsidized fertilizer is usually delivered late, hence households with high non-farm incomes have the ability to purchase commercial fertilizer rather than wait for the subsidized one and plant and or top-dress late. Imoru and Ayamga (2015) found that non-farm incomes lowered the quantity of subsidized fertilizer acquired by households in Ghana.

TLU: This was coded as a continuous variable representing the number of tropical livestock units (TLUs) owned by the household. The TLU was obtained by multiplying the number of livestock owned by the household with the corresponding conversion factor for each species: cattle = 0.7, sheep = 0.1, goats = 0.1, pigs = 0.2, chicken = 0.01 based on Food and Agricultural Organization (FAO, 2004). In this study, TLU was used as a proxy for the quantity of own-produced manure accessible to the household. According to Ali et al. (2012), manure can be used as a substitute for inorganic fertilizer thereby reducing the demand for fertilizer. Therefore, TLU was hypothesized to have a negative relationship with the quantity of subsidized fertilizer acquired by a household in the North Rift of Kenya. This is because the higher the number of animals kept the higher the likelihood that the farmer will have access to more manure for his/her crop production and therefore less need for inorganic fertilizer.

WEALTHCAT: This was coded as a categorical variable where 1 = "Poor", 2= "Middle class" and 3="Rich" household respectively. WEALTHCAT was derived from Principal Component Analysis (PCA) which aggregates assets owned by the household to generate a household wealth index (Moser and Felton, 2007; Córdova, 2009). To compute the principal components, asset ownership was coded as a dummy where one and zero represented ownership and non-ownership respectively. Following Moser and Felton (2007), the eigen values generated by the PCA were used as weights for the positive response. Finally, the factor scores from the PCA were multiplied by number of assets owned as below:

$$WWHH_i = \sum_{i=1}^{n} w_j^i \, a_j^i \qquad (3.14)$$

where $WWHH_i$ is the household wealth index for the *i*th household, w_i is the factor score or PCA weight of asset *j* owned by the *i*th household, and a_j^i is the *j*th asset owned by the *i*th household.

On the basis of the values of the asset index the consumers were classified into “Rich” that were the top 20 % which was followed by “Middle” 40% and “poor” 40%.

Studies show that poor households face entry barriers in access to markets due to low levels of physical and financial assets (Ellis, 2000; Holloway et al., 2001 and Khatun and Roy, 2012). This means subsidizing fertilizer is an incentive for the poor households to acquire more fertilizer. Using the rich as the base category, this study hypothesized a negative relationship between WEALTHCAT and the quantity of subsidized fertilizer acquired by a household in North Rift of Kenya. According to Imoru and Ayamga (2015), the richer in n Ghana received disproportionately more fertilizer than the poor.

LEADERSHIP: This variable was coded as a dummy with one representing a social relationship with officials of the village fertilizer subsidy vetting committee and zero otherwise.

Liverpool-Tasie (2014) found that being a relative of one of the farm group leaders in Nigeria increased the number of bags subsidized fertilizer received by households due to social capital. In the current study, LEADERSHIP was hypothesized to be positively related to the quantity of subsidized fertilizer acquired by the household. This is because fertilizer subsidy beneficiaries are vetted by the local leaders. In Ghana, Imoru and Ayamga (2015) found that community leadership positively influence quantity of subsidized fertilized acquired by household. The authors attributed the positive relation with the fact that the input subsidy program in Ghana was channeled through village leader.

(b) Institutional factors

CRD: This variable was coded as a dummy with one and zero representing household access to agricultural credit.

Access to credit has been shown to increase farmers' purchasing power thus enabling them to procure farm inputs and cover operating costs (Guirkinger and Boucher, 2005; Eswaran and Kotwal, 1990; Komicha and Öhlmer, 2007). In Peruvian agriculture, Guirkinger and Boucher (2005) found that credit obtained from informal lenders increased household access to inputs. In this study, therefore, CRD was hypothesized to have a positive association with the quantity of subsidized fertilizer acquired by a household in North Rift region of Kenya.

(c) Infrastructural factors

NCPB: This variable was continuous representing distance to the nearest fertilizer seller. This variable was to assess whether location of NCPB depots has an influence on the quantity of subsidized fertilizer acquired by a household. NCPB is a government marketing board which procures and sells maize and fertilizer at administratively determined prices (Jayne et al., 2008).
Studies show that distance to input markets is a major constraint to the quantity of input purchased by farm households (Goetz, 1992; Montshwe, 2006; Bahta and Bauer, 2007; Omiti et al., 2009). In this study, NCPB was hypothesized to be negatively related with the quantity of subsidized fertilizer acquired by households in the North Rift of Kenya.

MOBILE: Ownership of a mobile phone was coded as a dummy variable with one representing ownership and zero otherwise. In this study, ownership of mobile phone was hypothesized to have a positive effect on the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya. This is because a mobile phone increases farmer access to agricultural information (Sigei, 2014; Nyamba and Mlozi 2012).

According to Fafchamp and Hill (2005), poor access to market information results in information-related problems, namely moral hazard and adverse selection, which in turn increase transaction costs. This discourages some farmers from accessing farm inputs.

TRANSPORT: This variable represented household ownership of transport equipment. It was coded as a dummy with one denoting ownership and zero otherwise. According to Key et al. (2000), ownership of a means of transport such as bicycle, motorcycle, car and truck has increases the quantity of fertilizer purchased by a household. This is because fertilizer is a bulk commodity and ownership of a means of transport enables the household to haul large quantities of the input to reduce transportation cost. In this study, therefore, TRANSPORT was hypothesized to have a positive association with the quantity of subsidized fertilizer acquired by a household in North Rift region of Kenya. This is because ownership of a transport equipment reduce transaction costs as subsidized fertilizer is distributed via NCPB depots located at major towns

(d) Market factors

MAIZEPRIC: This was coded as a continuous variable representing the market price (in Kenya shillings) of a kilogram of maize reported by sample households during the season just prior to the survey 2013. In Kenya, Alene et al. (2008) found the price of maize to be positively related with the quantity of subsidized fertilizer acquired by a household. This was because high output price acted as an incentive for sellers to supply more in the market where they enjoyed greater margins due to the fertilizer subsidy. In Nigeria, Liverpool-Tasie (2012) found that price of maize was positively correlated with the quantity of fertilizer received.

Therefore, in this study, MAIZEPRIC was hypothesized to be positively associated with the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya.

FERTPRIC: This variable was a continuous one representing the median price of a kilogram of fertilizer in Kenya shillings as reported by households. In this study the price of fertilizer was hypothesized to have a negative effect on quantity of subsidized fertilizer acquired by households in North Rift region of Kenya, This means that the higher the price of fertilizer, the less likely farmers are to purchase it.

3.2.3 Assessing the effect of subsidized fertilizer on household participation and level of participation in commercial fertilizer outlets in North Rift region of Kenya

To achieve this objective, a choice had to be made between using a double-hurdle, a Heckman or a Tobit model, all of which have potential for use in a two-step decision making process as in the case of this study. The traditional approach to deal with datasets that have zeros arising from non-response is the use of Tobit model (Tobin, 1958). However, according to Burke (2015), the Tobit model is too restrictive as it assumes that the same set of variables determine both the probability of engaging in a behavior as well as the extent of engaging in that behavior.

The double-hurdle model overcomes the restriction of the Tobit model by allowing different mechanisms to determine the discrete probability of participation as well as the level of participation (Cragg, 1971). The Heckman and double-hurdle models are similar in identifying the rules governing the discrete (zero or positive) outcomes. Both models recognize that outcomes are determined by the participation in the first step and level of participation in the second step. They also permit the possibility of estimating the first and second stage equations using different sets of explanatory variables.

However, the Heckman, as opposed to the double-hurdle model, assumes that there are no zero observations in the second stage once the first-stage selection is passed (Tura, 2010).

To choose between the three models, the study used the Vuong (1989) test. The test involves the computation of a likelihood ratio (LR) in which the log-likelihood of each model is estimated separately and the test statistic is estimated as:

$$D = -2ln\{likelihood\ for\ null\ model | likelihood\ for\ alternative\ model\} - 2\ln(likelihood\ for\ null\ model) + 2\ln(likelihood\ for\ alternative\ model) \quad (3.15)$$

where D is the test statistic. The test statistic has a chi-square distribution with degrees of freedom equal to the difference between number of free parameters of the alternative and the null model (Satorra and Bentler, 2001). Table 3.2 summarizes the LR test statistics to choose between a double-hurdle, a Heckman and a Tobit model for use in the third objective of this study. The null hypothesis was that either Tobit or Heckman is superior to the double-hurdle model. As shown in Table 3.2, the two null hypotheses were rejected confirming that the double-hurdle model was best suited for use in this study.

Table 3.2: Summary of likelihood ratio tests for choosing between double-hurdle, Tobit and Heckman models

Model	**Chi-square**	**p-value**	**Decision**
Tobit vs double-hurdle	767.11	0.000	Reject Tobit
Heckman vs double-hurdle	5.5962	0.017	Reject Heckman
Tobit vs Heckman	762.2095	0.000	Reject Tobit

Source: Author (Survey data)

Based on these results, a double-hurdle model was used. In the first step (or hurdle), the factors influencing the probability of a household participating in commercial fertilizer markets were evaluated. The second step involved assessing the level of household participation in commercial fertilizer markets contingent upon the participation decision.

The double-hurdle model assumed that the zeros in the dataset arose from a rational choice by the household rather than missing observations (Burke, 2009).

Sample selection bias was suspected from the underlying random tendency of human subjects to self-allocate among one treatment group or another in non-experimental research designs (Heckman, 1979). If uncorrected, self-selection bias can lead to inconsistent β estimates due to self-selection (ibid.). In order to correct for selection bias, the IMR, λ_i, was computed in the first stage probit model following Wooldridge (2010) as follows:

$$\lambda_i = \frac{\phi\ (Z_i)}{1-\phi\ (Z_i)} \tag{3.16}$$

where ϕ and ϕ are, respectively, the density and distribution function for standard normal variable, and

$$Z_i = \frac{X_i \beta_i}{\sigma^2} \tag{3.17}$$

where X_i is a vector of explanatory variables hypothesized to influence household demand for commercial fertilizer including household demographic and socio-economic characteristics while β_i are unknown parameters to be estimated and σ^2 is the variance.

In the second hurdle, the IMR obtained in the first hurdle was used as one of the regressors to control for self-selection bias. The average partial effects (APEs) were obtained at the means of the dependent variables from the *MARGINS* command in Stata (StataCorp, 2005).

The coefficients in the first hurdle constituted the participation APEs while those in the second hurdle were the conditional APEs.

3.2.3.1 Assessing the determinants of households participation in commercial fertilizer outlets in North Rift region of Kenya

A double-hurdle model was used for this objective. The first stage of the model determined the likelihood of a household participating in commercial fertilizer outlets using the following probit model:

$$\mathrm{PART_i} = \beta_0 + \beta_1\mathrm{AGE} + \beta_2\mathrm{GENDER} + \beta_3\mathrm{EDUC} + \beta_4\mathrm{LANDSIZE} + \beta_5\mathrm{HHSIZE} + \beta_6\mathrm{NONINCM} + \beta_7\mathrm{TLU} + \beta_8\mathrm{WEALTHCAT} + \beta_9\mathrm{CRD} + \beta_{10}\mathrm{DISTFERT} + \beta_{11}\mathrm{MOBILE} + \beta_{12}\mathrm{TRANSPORT} + \beta_{13}\mathrm{MAIZEPRIC} + \beta_{14}\mathrm{FERTPRIC} + \beta_{15}\mathrm{QSUBSIDY} + \beta_{16}\mathrm{IMPROVEDSEED} + \mathrm{e_i} \quad (3.18)$$

Equation 3.18 was used to compute the IMR using equations 3.16 and 3.17.

3.2.3.2 Assessing the effect of subsidized fertilizer on the level of participation in commercial fertilizer outlets in North Rift region of Kenya

In the second stage of the double-hurdle model, the level of farmer participation in commercial fertilizer outlets was estimated using the quantity of fertilizer purchased by each household from those outlets as the dependent variable. The IMR computed in stage 1 (equation 3.18) was used as a regressor to account for sample selection bias.

Equation 3.19 was fitted to the data to assess the determinants of the quantity of fertilizer purchased by the sample households from the commercial market outlets:

$$\mathrm{PART}_2 = \beta_0 + \beta_1\mathrm{AGE} + \beta_2\mathrm{GENDER} + \beta_3\mathrm{EDUC} + \beta_4\mathrm{LANDSIZE} + \beta_5\mathrm{HHSIZE} + \beta_6\mathrm{NONINCM} + \beta_7\mathrm{TLU} + \beta_8\mathrm{WEALTHCAT} + \beta_9\mathrm{CRD} + \beta_{10}\mathrm{DISTFERT} + \beta_{11}\mathrm{MOBILE} + \beta_{12}\mathrm{TRANSPORT} + \beta_{13}\mathrm{MAIZEPRIC} + \beta_{14}\mathrm{FERTPRIC} + \beta_{15}\mathrm{QSUBSIDY} + \beta_{16}\mathrm{IMPROVEDSEED} + \beta_{17}\Omega + \beta_{18}\mathrm{IMR} + \varepsilon_i \quad (3.19)$$

Table 3.3 highlights the hypothesized variables and their expected signs for the double-hurdle model given in equations 3.18 and 3.19.

3.2.4 Justification for inclusion of regressors in the double-hurdle model

(a) Socio-economic factors

AGE: This was measured in years representing the age of the household head. Age of the household head was used as measure of risk attitude of the farmer (Mukundi, 2014; Sebatta et al., 2014). Studies show that older farmers have experience in fertilizer use and therefore understand its benefits and hence are more likely than younger farmers to participate in commercial fertilizer markets (Olwande and Mathenge, 2010). On the other hand, age can negatively influence a household's market participation decision. According to Kisaka-Lwayo et al. (2005), younger farmers are more likely to take risks and may be willing to take up new ideas such as participating in commercial fertilizer outlets. In this study, older farmers could have created huge social capital, accumulated over the years, with the Chiefs responsible for approving the fertilizer subsidy forms. Thus, they would be less willing to participate in commercial fertilizer outlets relative to younger farmers. There, AGE was hypothesized to be negatively related with the likelihood of farmer participation and level of participation in commercial fertilizer market in North Rift of Kenya.

Table 3.3: Description of variables in the double-hurdle model and their hypothesized signs

Variable	Description	Measurement	Hypothesized signs	
			Hurdle 1	Hurdle2
Dependent variables:				
$PART_1$	Participation in commercial fertilizer market outlets	Dummy (1 = Yes, 0 = No)		
$PART_2$	Quantity of commercial fertilizer purchased by a household	Kg		
Independent variables:				
AGE	Age of household head	Years	-	-
GENDER	Gender of household head	Dummy (1 =Male, 0= Female)	+	+
EDUC	Years of formal schooling of household head	Years	+	+
LANDSIZE	Total land size cultivated	Acres	+	+
HHSIZE	Household size	Number	+	+
NONINCM	Non-farm income	KShs	±	±
TLU	Total Livestock Units	Number	-	-
WEALTHCAT	Household wealth category	Categorical (1 = "Poor", 2 = "Middle class", 3="Rich")	-	-
CRD	Access to credit facilities in 2013/2014 cropping season	Dummy (1 = Yes, 0 = No)	+	+
DISTFERT	Distance to nearest fertilizer seller	Kilometers	-	-
MOBILE	Ownership of mobile phone	Dummy (1 = Yes, 0 = No)	+	+
TRANSPORT	Ownership of a transport equipment	Dummy (1 = Yes, 0 = No)	+	+
MAIZEPRIC	Price of output/90kg bag	KShs	+	+
FERTPRIC	Price of fertilizer/kg	KShs	-	-
$Q_{SUBSIDY}$	Quantity of subsidized fertilizer acquired	Kg	±	±
IMPROVED SEED	If a household used improved maize seed in 2013/2014 cropping season	Dummy (1 = Yes, 0 = No)	+	+

Source: Author (Survey data)

GENDER: This was coded as a dummy variable with one and zero representing male and female head of household respectively. The gender of the household head was hypothesized to influence market participation positively because male households might have more information on production technologies and input access than their female counterparts (Moono, 2015). Additionally, male-headed households could also be wealthier than their female-headed counter-parts and this could allow male-headed households to own more productive assets which increase the chances of producing a marketable surplus.

In SSA, female-headed households are more likely to be resource poor and hence less likely to participate in markets (Gebregziabher, 2010). Reyes et al. (2012) found that the gender of the household head positively influenced households' probability of market participation but had no effect on the intensity among potato producers in Mozambique. Siziba et al. (2010), found gender not to have significant influence on the probability and intensity of market participation among cereal producers in SSA. Further, Omiti et al. (2009) found the gender of the household head to positively influence intensity of market participation among kale producers in Kenya. In this study therefore, being male was hypothesized to be positively related with the probability and level of farmer participation in commercial fertilizer outlets in the North Rift of Kenya.

EDUC: This represented the number of years the household head took in formal school. Generally, more educated farmers are able to get and make use of information on input /output markets at reduced transaction costs than less educated ones (Sigei et al., 2014). Additionally, education has a larger impact on the likelihood of a household to access financial assets or be more attractive to financial services providers (Diagne and Zeller 1998; Tu et al., 2015). Such households are more likely to participate in product and/or factor markets (Obisesan et al., 2013).

This may be due to the fact that more educated farmers are enlightened on the benefits of using fertilizer in crop production (ibid.). In this study, EDUC was expected to be positively associated with the probability and level of household participation in commercial fertilizer outlets in the North Rift of Kenya.

LANDSIZE: This was a continuous variable representing the total land farmed by the household. It was derived from adding owned to rented land. Larger land sizes influence the size of marketable surplus and hence a higher probability to participate in input markets (Olwande and Mathenge, 2010; Sall et al., 2000; Adegbola and Gardebroek, 2007). Moreover, land can be used as collateral for credit hence increasing household's purchasing power of farm inputs (Abeykoon et al., 2013). Larger landholdings indicate that potentially high amounts of fertilizer are needed (Liverpool-Tasie, 2014). In this study, therefore, LANDSIZE was hypothesized to have a positive relationship with the probability and level of farmer participation in commercial fertilizer outlets.

HHSIZE: This was a continuous variable representing the members of the household living and eating together. *Ceteris paribus*, larger families have higher food demand compared to smaller ones. Because fertilizer demand is derived from the demand for food, large family sizes may need to use more fertilizer than smaller families in order to meet their food requirement (Tura, 2016). Thus, larger families would have a higher likelihood to participate in commercial fertilizer markets relative to smaller ones. Because the quantity of subsidized fertilizer acquired by the household from government depots is seldom enough, this study hypothesized a positive relationship between HHSIZE and the probability and level of household participation in commercial fertilizer outlets in the North Rift of Kenya.

NONINCM: This was a continuous variable representing non-farm income. Non-farm income increases household's participation in input markets particularly among households with no access to credit (Lamb, 2003). Conversely, households with high non-farm income save more and in turn are able to access credit for investment in agricultural production (Reardon et al., 2007). It has been observed that when the off-farm activity is lucrative, households shun away from farm activities and therefore participate less in agricultural markets (Bjornsen and Mishra, 2012). Based on these contrasting observations, the relationship between non-farm income and the probability and level of household participation in commercial fertilizer outlets was considered indeterminate.

TLU: This was a continuous variable representing the number of tropical livestock units (TLUs) owned by the household calculated as shown in Section 3.2.2. Households with many livestock (hence higher TLUs) were expected to have more manure than those with less. This is because manure is a substitute for commercial fertilizers, whose prices rose sharply in recent (Huang, 2009; MacDonald, 2009). Such households are expected to use less inorganic fertilizers and therefore less likely to participate in private fertilizer markets (Nambiro and Okoth, 2013). Therefore, in this study, TLU was hypothesized to have a negative effect on both the probability and the level household participation in commercial fertilizer outlets in the North Rift of Kenya.

WEALTHCAT: This was coded as a categorical variable where 1 = "Poor", 2='Middle class" and 3="Rich" household respectively as shown in Section 3.2.2. Using the rich as the base category, it was hypothesized that WEALTHCAT would be negatively associated with the probability and level of household participation in commercial fertilizer outlets in North Rift of Kenya. This is because the poor lack the resources needed to purchase fertilizer from the commercial outlets.

(a) Institutional factors

CRD: This variable was coded as a dummy with one and zero representing access to agricultural credit. Access to agricultural credit is an important factor influencing adoption of new technology such as high yielding varieties and fertilizers (Morris et al., 1999; Gemeda et al., 2001; Adesina and Zinnah, 1993; Langyintuo et al., 2005; Langyintuo and Mekuria, 2005). Therefore, households with access to credit are able to participate in markets. In this study, access to credit was hypothesized to have a positive relationship with the probability of as well as the extent of household participation in commercial fertilizer markets in the North Rift of Kenya.

(c) Infrastructural factors

DISTFERT: This was a continuous variable representing distance to the nearest fertilizer seller. This variable assessed as distance from the homestead to the nearest fertilizer seller in Kilometers. According to Ariga and Jayne (2010), households located 10 kilometers away from fertilizer selling points had 23 percent probability of not participating in input markets in Kenya. Sheahan (2011) found that distance to the nearest fertilizer selling point in Kenya was a major disincentive to fertilizer use although otherwise profitable. In this study, distance to the nearest fertilizer seller was hypothesized to be negatively related with the probability as well as the level of household participation in commercial fertilizer markets in North Rift region.

MOBILE: Mobile phone ownership was coded as a dummy where one and zero represented ownership and non-ownership. Mobile phones speed up ways in which farmers get information and are becoming increasingly crucial as an infrastructural device for improving efficiency of agriculture markets and improve participation in Tanzania (Nyamba and Mlozi 2012).

According to Key et al. (2000), ownership of communication equipment such as mobile phone and radio has a positive influence on farmer participation in product and factor markets. This is because it reduces transaction costs which in turn lower cost of production. In this study, ownership of a mobile phone was therefore hypothesized to have a positive effect on both the probability and extent of household participation in commercial fertilizer markets in North Rift region of Kenya.

TRANSPORT: Ownership of a means of transport was coded as a dummy where one represented ownership and zero otherwise. Ownership of a means of transport increases the chances of households participating in input markets as it reduces transportation costs (Jagwe, 2011). Mather et al. (2011) found that ownership of an ox-cart positively influenced both the probability and intensity of market participation among maize producers in Zambia. Reyes et al. (2012) found that ownership of a bicycle only influenced the intensity of market participation positively among potato producers in Mozambique. In this study, ownership of a means of transport was hypothesized to positively influence both the probability as well as intensity of market participation in commercial fertilizer markets in North Rift region of Kenya.

(d) Market factors

MAIZEPRIC: This variable was continuous representing the price in Kenya shillings of a kilogram of maize in North Rift region paid by households for the largest quantity of maize during the 2013 /2014 cropping season. Maize prices determine income and economic welfare of households which in turn influence production decision and consequently market participation (Benfica et al., 2006). Moono (2015) found that output price positively influenced farmer decision to enter and the extent of participation in the banana markets in Zambia.

Farm output prices impact positively on market participation as they act as an incentive for increased sales (Omiti et al., 2009; Enete and Igbokwe, 2009). According to Barnard et al. (2016), the demand for most agricultural goods is derived demand. Therefore, *ceteris paribus*, an increase in maize demand increases the demand for fertilizer and high maize prices encourage households to produce more (ibid.). In this study, the price of maize, the main crop grown in the North Rift region of Kenya was hypothesized to have a positive effect on the probability and level of market participation in commercial fertilizer outlets.

FERTPRIC: This variable was continuous representing the price of a kilogram of fertilizer (in Kenya shillings) paid by households during the 2013 2014 cropping season. In farm input market participation studies, price is used as a measure of consumers' sensitivity to price or the price elasticity of input demand (Anderson et al., 1997). Based on the law of demand, an increase in the price of a commodity reduces the quantity demanded (Varian, 1992). In this study, FERTPRIC was hypothesized to have a negative effect on the probability and level of household participation in commercial fertilizer outlets in the North Rift region of Kenya.

$Q_{SUBSIDY}$: This was a continuous variable representing the quantity of subsidized fertilizer acquired by households from the NCPB. Fertilizer subsidies have had mixed effect on farmer participation in commercial fertilizer markets.

Xu et al. (2009); Ricker-Gilbert et al. (2011) and Mason and Jayne (2012) found that when subsidized fertilizer is injected into the market, it reduces farmer participation in commercial fertilizer outlets. On the other hand, Liverpool-Tasie (2012; 2014) found that receiving subsidized fertilizer through a voucher redeemable through the private sector increased the probability and extent of farmer participation in the private fertilizer markets.

In this study, $Q_{SUBSIDY}$ was hypothesized to have a negative or a negative effect on the probability and level of household participation in commercial fertilizer outlets in the North Rift region of Kenya following the findings of Xu et al. (2009), Ricker-Gilbert et al. (2011) and Mason and Jayne (2012). This is because in the Kenyan case the subsidized fertilizer is likely to displace the commercial one.

IMPROVEDSEED: This variable was coded as a dummy to represent use of improved maize seed with one denoting use and zero otherwise. Use of improved seed increases the marketable surplus of the output therefore positively influencing household to participate in the market (Ferris et al., 2001). Studies indicate that farmers' failure to adopt improved inputs such as high yielding seed varieties, fertilizer, among others, leads to low productivity and therefore reduced marketable surplus, which ultimately, reduces the degree of market participation (Ferris et al., 2001; Nkonya and Kato, 2001; Aliguma et al., 2007). In this study, use of improved maize seeds was hypothesized to have a positive effect on the likelihood as well as the level of farmer participation in commercial fertilizer outlets in the North Rift of Kenya. This is because improved maize varieties require concomitant application of fertilizer to ensure high yields.

3.3 Data types and sources

This study used primary data collected by Tegemeo Institute of Agricultural Policy and Development, in North Rift region of Kenya in 2014 under Tegemeo Agricultural and Policy Research Analysis II project (TAPRAII). The survey covered two cropping seasons in 2012-2013 and 2013-2014. The primary data were collected using a semi-structured questionnaire to capture farmer information and socio-economic, institutional and market factors.

3.3.1 Sampling frame

This study used data collected within the fifth National Sample Survey and Evaluation Programme (NASSEP V) frame which is a household based sampling frame developed and maintained by Kenya National Bureau of Statistics (KNBS). It is based on the list of enumeration areas (EAs) from the 2009 Kenya Population and Housing Census. The sampling frame was stratified according to counties and further into rural and urban areas. During the 2009 population and housing census, each sub-location was subdivided into census enumeration areas. An enumeration area was defined as a small geographic unit with clearly defined boundaries (UN, 2000).

The primary sampling unit for the NASSEP V master sampling frame was a cluster, which constituted one or more EAs with an average of 100 households per cluster. The survey used a two-stage stratified cluster sampling procedure where the first stage selected the 55 clusters from NASSEP V using the equal probability selection method (EPSEM). The second stage randomly selected a uniform sample of 20 households in each cluster from a roster of households in the cluster using systematic random sampling method. Eventually, 1,100 households were selected for the study. To compensate for household that refuse to participate in the survey, the rule of thumb is to increase sample size by 10 percent. The sample size was calculated to give representative estimates of various indicators for the main Agro-Ecological Zones (AEZs) namely; Lower midlands (3-6), Upper midlands (2-6), Upper midlands (0-1), Lower highlands and Upper highlands covering North Rift region. The sample size was determined following Anderson et al. (2007) as:

$$n = \frac{\rho(1-\rho)Z^2}{E^2} \qquad 4.1$$

where;

n is the sample size, ρ is the proportion of population having the major interest, Z is the confidence interval and E is the margin of error. Since the proportion of the population in the study site was unknown, ρ = 0.5, Z = 1.96 and E = 0.0296. Thus, the sample size was determined as:

$$n = \frac{0.5(1-0.5)1.96^2}{0.0296^2} = 1{,}100 \qquad 4.2$$

Out of a sample size of 1,100 households, 77 did not take part in the survey while 313 did not use fertilizers in the 2013 /2014 cropping season.

3.3.2 Selection of Clusters

The clusters were selected using the EPSEM. The clusters were selected systematically from NASSEP V sampling frame with equal probability independently within the counties and rural strata. The EPSEM method was adopted since during the creation of the sampling frame, the clusters were standardized so that each could have one Measure of Size (MoS) defined as having an average of 100 households.

3.3.3 Selection of sample households

From each selected cluster, a uniform sample of 20 households was selected systematically with a random start. The systematic sampling method was adopted as it enables the distribution of the sample across the cluster evenly and yields good estimates for the population parameters. The sampling of households was done without replacement of non-responding households. Annex 1 summarizes number of households selected across agro-ecological zones and counties in the North Rift of Kenya.

3.4 Data collection

Primary data were collected through Computer Aided Personal Interviews using SurveyCTO software (SurveyCTO, 2014). The data were collected between July and September 2014 by trained graduates recruited through a competitive process. The interviews were conducted in Swahili and where possible in vernacular dialect.

3.4.1 Data capture and analysis

The data were downloaded from the surveyCTO server and cleaned using the Statistical Package for Social Sciences (SPSS). Descriptive statistical and econometric analyses were undertaken using STATA. The results were presented in tabular form.

3.5 Study area

According to MoAL&F (2014) as of 2014, Kenya had 30 active cereal depots with 43 percent of them being in the North Rift region that encompasses Uasin Gishu, Trans-Nzoia, Elgeyo Marakwet, Baringo, Nandi, Samburu, Turkana and West Pokot counties.

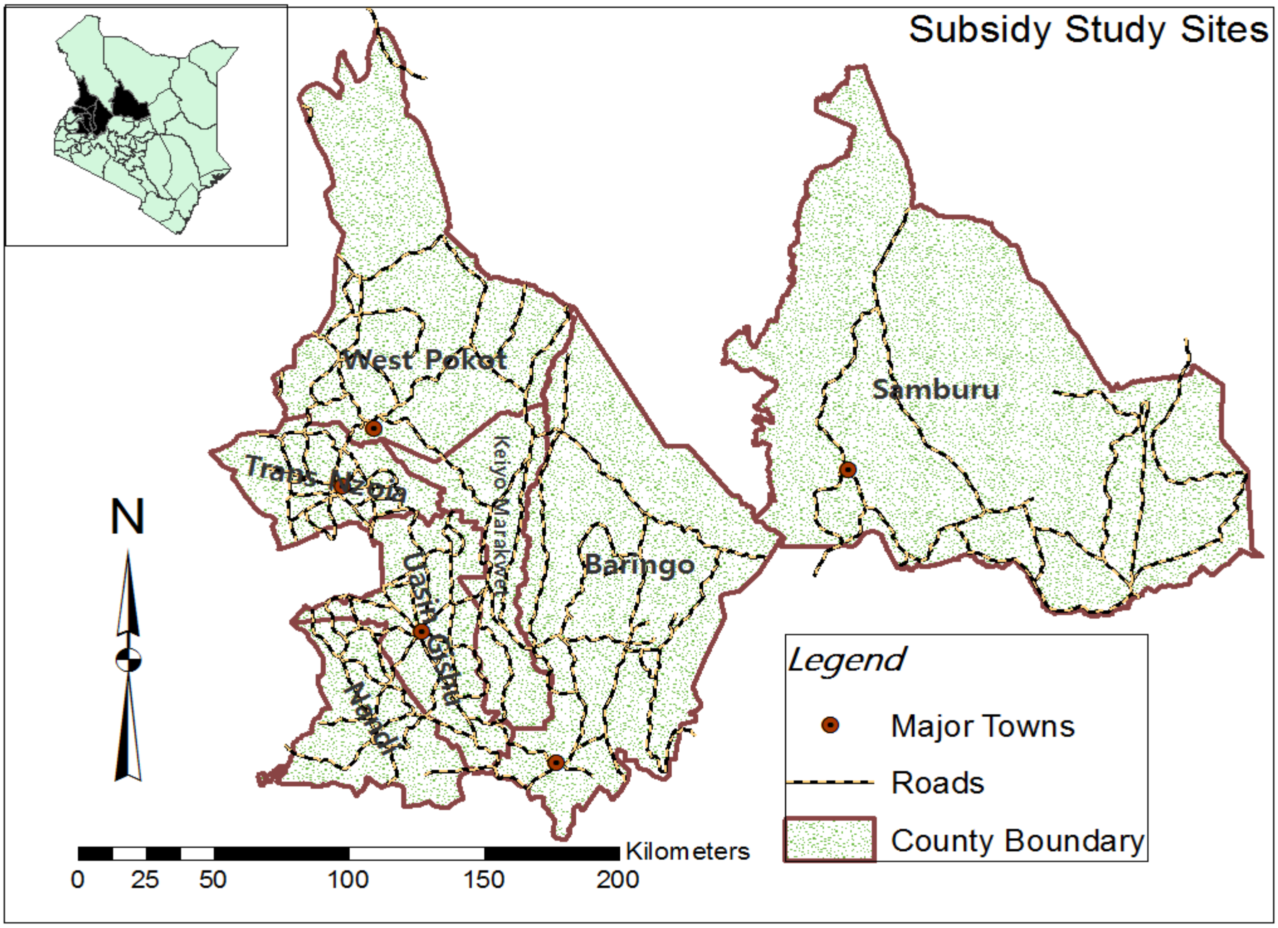

Figure 3.2: Map of North Rift region of Kenya

Source: www.arcgis.com

Table 3.4 presents the proportion of subsidized fertilizer distributed via NCPB depots across the country by region. The North Rift region consumes approximately one half of the national's subsidized fertilizer. Approximately 85 percent of small-scale farmers in the high-potential maize zones in the North Rift region of Kenya use fertilizer. The North Rift region alone uses 1.5 million bags of planting fertilizer yearly (Kamau et al., 2013). .This led to the choice of North Rift region as the study area.

Table 3.4: Percentage of subsidized fertilizer distributed by National Cereals and Produce Board in Kenya by region

Region	2010/2011	2011/2012	2012/2013	2013/2014	Average
North Rift	**56.7**	**50.9**	**41.2**	**45.4**	**48.6**
South Rift	22.4	19.8	27.2	19.7	22.2
Lake /Western	11.8	14.7	13.9	22.4	15.7
Northern	6.0	8.9	12.2	8.8	9.0
Nairobi /Eastern	2.9	5.3	5.2	3.4	4.2
Coast	0.2	0.3	0.3	0.4	0.3

Source: NCPB (Occasional reports)

3.6 Diagnostic tests

(a) Testing for multicollinearity

Multicollinearity refers to a case where one variable is a linear function of another (Wooldridge, 2002). Presence of multicollinearity leads to inefficient OLS estimates (Farrar and Glauber, 1967). It affects cross-section data such that there are wide confidence intervals leading Type 1 error (Wooldridge, 2009). According to Gujarati (2007), multicollinearity renders OLS estimates and standard errors sensitive to small changes in the dataset.

A number of methods are used to test for multicollinearity in regression analysis including pair-wise correlation analysis, Pearson correlation, and Variance Inflation Factor (VIF) (Weissfeld and Sereika, 1991; Curto and Pinto, 2007; Dormann et al., 2013). This study used both VIF and Pearson's pair-wise correlation matrix to test for multicollinearity. According to Kleinbaum et al. (1988), a VIF value greater than 10 indicates a problem of multicollinearity. The results of VIF presented in Annex 2 show that the VIF was less than 1.67, indicating absence of multicollinearity among the explanatory variables.

With regard to the pair-wise correlation, a statistically significant Pearson correlation coefficient between any two regressors that is greater or equal to 0.8 indicates existence of multicollinearity (Gujarati, 2007). Based on the results presented in Annex 3, none of the explanatory variable had a statistically significant pair-wise correlation above 0.4, which shows that the data had no multicollinearity.

(b) Testing for heteroscedasticity

Heteroscedasticity occurs when the variance of the error term is not consistent, leading to inefficient and invalid test of hypothesis (Wooldridge, 2002). If present in the data the estimates will not be the Best Linear Unbiased Estimates (BLUE) (Gujarati, 2007). In this study, the Breusch-Pagan/Cook-Weisberg test was used to test for heteroscedasticity under the null hypothesis of a constant variance (homoscedasticity).

According to Coenders and Saez (2000), a significant p-value of the Breusch-Pagan/Cook-Weisberg test leads to the rejection of the null hypothesis of homoscedasticity. As shown by the results in Annex 4, the Breusch-Pagan/Cook-Weisberg test was not statistically significant (p=0.512), we fail to reject the null hypothesis of homoscedasticity implying that heteroscedasticity was not a problem in the dataset.

(c) Testing for endogeneity

Endogeneity occurs when a regressor is correlated with the error term of a regressand (Hanchane and Mostafa, 2010). The presence of endogeneity leads to inconsistent parameter estimates because explanatory variable is correlated with the error term (Antonakis et al., 2014). In this study, endogeneity was tested using the two-step Durbin-Wu-Hausman test (Hausman, 1978).

In the first step, the variable suspected to be endogenous was regressed against other independent variables to obtain residuals (Wooldridge, 2009). In the second stage, the residuals were used to carry out the Hausman test. The null hypothesis for this study was that subsidized fertilizer is exogenous to the quantity of purchased from commercial outlets. Based on the Durbin-Wu-Hausman test results presented in Annex 5, we fail to reject the null of exogeneity. This shows that the quantity of subsidized fertilizer acquired by each household in the North Rift was indeed exogenous.

(d) Goodness-of-fit

A goodness-of-fit measure is a summary statistic showing the accuracy with which a model approximates the observed data. To measure the goodness-of-fit in qualitative models Greene (2003) suggests the use of the LR. The LR is also called McFadden R^2 or pseudo R^2 and is analogous to the R^2 in a regression (ibid.). A zero LR indicates a perfect lack of fit while an LR of value one indicates perfect fit. Empirical evidence suggests that LR usually lies between 0.2 and 0.4 for cross-section data such as in this study (Jarvis, 1990).

$$LR\ or\ Pseudo\ R^2 = 1 - \frac{lnL}{lnL_0} \qquad 3.21$$

where lnL is the log-likelihood function for the model with all the independent variables and lnL_0 is the log-likelihood computed with the constant term only. $Pseudo\ R^2$ and LR were used to measure goodness-of-it for the Tobit and double hurdle models respectively.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Household characteristics

4.1.1 Household categorization by source of fertilizer

The categorization of households by fertilizer source is as shown in Table 4.1. Out of a sample of 1,023 households, 30.6 percent did not use fertilizer. Of the 710 households that used fertilizer, 81.7 and 15.6 percent obtained theirs from commercial and subsidized sources respectively. The rest purchased their fertilizer from both commercial and subsidized sources. This study sought to determine the effect of fertilizer subsidy on commercial markets, the non-users were excluded; hence, the analysis was based on 710 households.

Table 4.1: Distribution of households by source of fertilizer in north Rift region of Kenya

Attribute	Number of households	Percentage of households Buying fertilizer from different sources
No fertilizer	313	30.6
Use fertilizer	710	69.4
Use commercial sources only	580	81.7
Use subsidized sources only	111	15.6
Use both sources	19	2.7
Total	1,023	100

Source: Author (Survey data)

Table 4.2 presents the mean quantity of fertilizer used per acre in the North Rift region of Kenya in the 2013/2014 cropping season. Those that purchased subsidized fertilizer used 183.2 kg/acre while those that used commercial fertilizer used 62.6 kg/acre. The difference was statistically significant (p=0.05).

Farmers using both commercial and subsidized fertilizer used a mean of 166.6 kg/acre which was statistically higher than that used by the households who only used commercial fertilizer (p=0.05). This implies fertilizer subsidy has substantially lowered fertilizer prices that lead to increased demand. On average, households that obtained their fertilizer from commercial sources used 62.6 kg/acre. These findings are consistent with Sheahan (2011) who found that in the high potential areas of Kenya, mono-cropped fields were fertilized at a rate between 50-91 kg/acre.

Table 4.2: Fertilizer application rates on maize among sample households in North Rift Kenya

Fertilizer source	Mean quantity kg /acre	Std Error	Range	
Commercial only	62.6^{a}	6.13	0.59	2020
Subsidized only	183.2^{b}	32.92	4.38	2222
Use both sources	166.6^{b}	36.43	10.88	801
Overall	82.35	7.01	.59	2222

Source: Author (Survey data)

^{a}, ^{b} Numbers with the same superscript are not significantly different (Tukey's HSD, $p < 0.05$).

4.1.2 Household socio-economic characteristics

Table 4.3 presents the socio-economic characteristics of fertilizer users in the North Rift of Kenya. Out of the 710 households who used fertilizer 81.8 percent were male-headed households. In addition, 84.1 percent used commercial fertilizer and 69.3 percent used subsidized fertilizer. These finding were different across the groups. Ogada et al. (2014) found that in Kenya 78 percent of the farm families were male-headed. This is lower than what the current study found. The difference may be due to the difference in study area.

The mean age of the household head was 48 years (range=21-94). This finding is close to that of Machio (2015) who found that the average age of a household in North Rift region was 47 years.

The average household size was six and did not vary significantly across the three fertilizer use groups which are nearly the same as that of Kenya's national mean of 5 members per household (CBS, 2005). However, this finding compare well with that of Machio (2015) who found that the average household size in North Rift region was 6 persons. The overall land size was 4.36 acres (range=0.09-50) and was statistically significant across the three sources ($p < 0.05$).This finding tallies with that of Unnevehr (2013) who found that the average land holding per household in the North Rift region of Kenya is 4 acres.

Table 4.3: Means and frequencies of socio-economic characteristics of fertilizer users in the North Rift region of Kenya

Variable	Commercial only	Subsidy only	Dual user	Overall
Frequencies				
GENDER	488(84.1)[a]	61 (69.3)[b]	19(73.1)[c]	568(81.8)
WEALTHCAT				
Poor	104 (17.9)[a]	8(9.1)[b]	6 (23.1)[c]	118 (17.0)
Middle	309 (53.3)	37 (42.0)	3 (11.5)	349 (50.3)
Rich	167 (28.8)[a]	43 (48.9)[b]	17 (65.4)[c]	227 (32.7)
CRD	75 (12.9)	8 (6.8)	5 (19.2)	86 (12.4)
MOBILE	507 (87.4)[a]	80 (90.9)[b]	26 (100)[c]	613 (88.3)
TRANSPORT	104 (17.9)[a]	17 (19.3)[b]	5 (19.2)[c]	126 (18.2)
IMPROVEDSEED	560 (96.6)[a]	85 (96.6)[b]	26 (100)[c]	671 (96.7)
Means:				
AGE	47 (0.6)	52.2 (1.8)	48.2 (2.4)	47.7 (0.6)
EDUC	7.58 (0.2)	7.6 (0.61)	9.42 (0.91)	7.65 (0.18)
LANDSIZE	3.74 (0.21) [a]	6.51 (0.81) [b]	10.87 (1.76) [a]	4.36 (0.22)
HHSIZE	5.96 (0.11)	6.1 (0.26)	6.08 (0.34)	5.98 (0.09)
NONINCM	54250 (5831) [a]	88781 (12063)[a]	221270 (5212) [b]	64886.2 (5594)
TLU	1.22 (0.03)	1.16 (0.08)	1.48 (0.15)	1.22 (0.03)
DISTFERT	5.13 (0.29)	4.9 (0.5)	4.39 (0.72)	5.07 (0.25)
MAIZEPRIC	2602 (109)	2445 (188)	2561 (665)	2580 (97)
FERTPRIC	74.0 (0.56) [a]	49.4 (1.31)[b]	73.2 (3.38)[a]	65.5 (2.26)
N	580	111	19	710

Source: Author (Survey data)

Numbers in brackets among frequencies and means represent percentages and standard errors respectively. [a],[b] Numbers with the same superscript are not significantly different from each other ($p < 0.05$).

Of the 710 households interviewed, 12.4 percent had accessed credit 12 months prior to the survey. Access to credit did not vary across the three sources. Another 88.3 percent and 27.7 percent had a mobile phone and an on-farm means of transport respectively. These findings were significantly different (χ^2=11.30).

When grouped in terms of wealth status, 17.0, 50.3 and 32.7 percent of the households were in the "poor," "middle class," and "rich" categories respectively. About 48.9 and 42.0 percent of households in the "rich" and "middle class" categories respectively received subsidized fertilizer. The proportion of respondents in each wealth category was significantly different across the three sources (χ^2=32.31; p =0.00). This is an indication that the national fertilizer subsidy was benefiting the better-off in North Rift region in Kenya. Place et al. (2004) found that wealth positively influence use of chemical fertilizer in Kenya. Hence, it can be inferred that it is only the well-off in terms of income that can effectively utilize the input provision programs whether subsidized or commercial.

4.2 Factors influencing the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya

Table 4.4 presents the determinants of the quantity of subsidized fertilizer that acquired by each household from the NCPB in the North Rift of Kenya. The pseudo R^2 of 0.694 shows a good fit indicating that the model fitted the data well. Out of the 15 variables evaluated, 11 were statistically significant. Of these, four and seven variables were, respectively, negatively and positively correlated with the quantity of subsidized fertilizer acquired by each household.

Table 4.4: Maximum likelihood estimates of factors influencing the quantity of subsidized fertilizer acquired by households in North Rift region of Kenya

Variable	Coefficient†	Std Error	t-value
AGE	0.13*	0.08	1.74
GENDER	0.67**	0.28	2.42
EDUC	0.0091*	0.02	0.39
LANDSIZE	0.04**	0.02	2.37
HHSIZE	-0.02	0.04	-0.43
NONINCM	0.00	0.00	1.52
TLU	-0.31**	0.14	-2.16
WEALTHCAT			
Poor	-1.17***	0.31	-3.76
Middle	-0.56**	0.25	-2.26
CRD	-0.78**	0.35	-2.22
DISTFERT	-0.03	0.02	-1.42
MOBILE	0.77*	0.45	1.73
TRANSPORT	0.56**	0.23	2.41
MAIZEPRIC	0.00	0.00	1.75
FERTPRIC	-0.00	0.01	-0.05
LEADERSHIP	0.20***	0.09	2.30
Log likelihood	-371.83		
Pseudo R^2	0.69		
Prob > Chi^2	0.00		

Source: Author (Survey data)

*, ** and *** represent statistical significance at 10%, 5% and 1% levels respectively.

As expected, the age of the household head had a positive influence on the quantity of subsidized fertilizer acquired by the household. An additional year in the age of the household head increased quantity of subsidized fertilizer acquired by the household by 0.1 kg. This could be due to the fact that elderly heads of household have greater social capital in terms of social networks, influence and relationships particularly with the Vetting Committee, which enabled them to acquire the subsidized fertilizer.

This finding tallies with that of Ricker-Gilbert et al. (2011) who reported that households with older heads had long term strong relationships and networks with government officials charged with vetting the beneficiaries of subsidized fertilizer in Malawi. In that study, each additional year lived in a village increased the quantity of subsidized fertilizer by 0.09 kg which compares well with the current study.

Male-headed household had a positive and significant effect on the quantity of subsidized fertilizer acquired. According to Chibwana (2010), female-headed households in Malawi acquired 6.1kg less than the male-headed households. This is because female-headed households face numerous challenges associated with agricultural production such as cultural discrimination, lack of access to job opportunities, low literacy and lack of regular income that could impact on program participation and fertilizer use. According to Peterman et al. (2014), female-headed households are more likely to be asset poor and subsistence oriented than their wealthier male counterparts who stand to benefit from technologies such as fertilizer subsidy in developing countries.

Ricker-Gilbert and Jayne (2009) found that female-headed households in Malawi received less subsidized fertilizer than their male counterparts. In this study, being in a male-headed household increased the quantity of subsidized fertilizer acquired by the household by 0.67kg. This is because female-headed households are more likely to have less social capital compared to male-headed households. In addition, the time taken to acquire fertilizer from NCPB depots is high and women have many other household chores to attend to.

The years in formal school of the household head had a positive influence on the quantity of subsidized fertilizer acquired by the household as expected a *priori*. This is because human capital represented by the head's formal education increases households' understanding of market dynamics hence influences their demand for modern inputs such as fertilizer. In addition, education may increase the household head's bargaining power with the subsidy vetting committee. This finding tallies with that of Wu (1977) who reported that in the short run, education increased the quantity of subsidized fertilizer acquired in Taiwan. The author attributed this to the likelihood that education improves farmer perceptions about inorganic as opposed to organic farming. In this study, an additional year of formal school by the household head increased the quantity of subsidized fertilizer acquired by 0.009 kg. Even though this quantity is quite low, it implies there is an element of elite capture in the distribution of the national fertilizer subsidy in the study area.

As expected *a priori*, the coefficient on land size was positive and statistically significant at 5 percent level. An additional acre of land owned by a household increased the quantity of subsidized fertilizer received by a household.. This means that large farm owner were more likely to benefit from the national fertilizer subsidy than their counterparts. Imoru et al. (2015) made a similar finding for Ghanaian farmers where an additional acre of land increased the quantity of subsidized fertilizer received by 0.05 kg.

The number of TLUs owned by a household had a negative but significant effect on the quantity of subsidized fertilizer acquired as expected *a priori*. This could be due to the fact that more livestock produce more manure, which is a substitute for fertilizer.

Therefore, households will demand less subsidized fertilizer as the number of livestock owned increases. Jaleta *et al*. (2009) found that a unit increase in the number of livestock owned reduced the quantity of fertilizer purchased by households in Ethiopia. This is because manure is a substitute for chemical fertilizers. On the other hand, Minot et al. (2000) found that each additional livestock owned by the household reduced the quantity of fertilizer used by one kilogram in Benin. In this study, one additional TLU reduced the amount of subsidized fertilizer acquired by the household by 0.3 kg. This means that farmers in the North Rift region of Kenya would substitute inorganic fertilizer for manure leading to better soils at less cost.

Compared to rich household, being in either a poor or middle wealth household had a negative and significant effect on the quantity of subsidized fertilizer acquired by a household in the study area as expected. This is because poor households use less fertilizer on their plots possibly due to low income. According to Shively and Ricker-Gilbert (2013), the demand for inorganic fertilizer was positively correlated with household wealth. In this study, a shift from being in a rich to a poor or middle income category would reduce the quantity of subsidized fertilizer received the household by 1.2 and 0.6 kg respectively.

This observation can be explained by two plausible reasons: one, poor households may not have the ability to purchase the subsidized fertilizer, and two, richer households may in addition have the social capital and persuasive power to engage the members of the village fertilizer subsidy vetting committee thereby benefiting enormously from the subsidy. This implies that the better-off in North Rift region of Kenya seem to benefit more from the national fertilizer subsidy.

While targeting based on poverty level was strictly not the objective of the national fertilizer subsidy, the significance of poor and middle income households receiving less quantities of subsidized fertilizer suggests that the beneficiaries of the subsidized fertilizer scheme included a good portion of wealthy households. Direct targeting of the poor household is necessary.

Contrary to expectation, access to credit had a negative but significant effect on the quantity of subsidized fertilizer acquired by the household. This means that households which did not have access to credit acquired 0.8 kg less than their counterparts. This was probably because farmers who accessed credit had the means to purchase commercial fertilizer from the market. Additionally, studies show that subsidized fertilizer in the North Rift is often delivered late so that farmers are often obliged to purchase from the market (Kamau et al., 2013; Kamoni, 2013). Liverpool-Tasie (2014) found that access to credit lower the quantity of subsidized fertilizer received by 0.07 kg in Nigeria. This means that access to credit does not change farmers' production decisions.

As expected, ownership of a mobile phone had a positive and significant effect on the quantity of subsidized fertilizer acquired by households in North Rift region. This could be attributed to the fact that a mobile phone can be used to provide market information, which lowers information acquisition costs to reduce information asymmetry. In this study, ownership of a mobile phone increased the quantity of subsidized fertilizer received by 0.8 kg. This means that use of mobile phones make it easier for farmers make optimal marketing by providing accurate and real-time information on (Deichmann et al., 2016). Kikulwe et al. (2014) found that ownership of a mobile phone significantly increased the quantity of inputs purchased as it reduced the transaction costs.

Ownership of a mode of transport had a positive influence on the quantity of fertilizer subsidized fertilizer acquired by households in North Rift region as expected *a priori*. This is because ownership of transport equipment reduces transport costs resulting in high profit margins. In addition, households owning transportation equipment would more likely use fertilizer since they would be in a better position to get it from the distribution center to the homestead.In this study, ownership of a farm transport increased the quantity of subsidized fertilizer acquired by 0.6kg. This result is consistent with that of Key et al. (2000) who found that ownership of a means of transport lowered the proportional transaction costs thereby enhancing the intensity of market participation in SSA.

As expected, the relationship between any household member and officials of the Location Subsidy Fertilizer Vetting Committee had a significant and positive effect on the quantity of subsidized fertilizer received by a household. This finding suggests that there is a possibility of the vetting process being undermined by such relationships. This could be in form of lobbying or rent-seeking by either interest groups or individuals, which ultimately adversely affects the distribution of subsidized fertilizer.

This finding tallies with that of Liverpool-Tasie (2014) who reported that households whose members were related to the farm group leadership received 1.6 kg more than their counterparts in Kano Nigeria. Shively and Ricker-Gilbert (2013) found that in Malawi, household heads that had lived in their villages for longer periods received 100kgs over households' heads that had lived for shorter period. The length of residency was influential in creating ties between the village heads and members of the Village Development Committees responsible for selecting the beneficiaries of fertilizer subsidy in Malawi.

In this study, having a relationship with officials of the fertilizer subsidy Vetting Committee increased the quantity of subsidized fertilizer received by a household by 0.2kg. Based on previous studies, this is relatively low.

4.3 Determinants of market participation and the extent of participation in commercial fertilizer markets in North Rift region of Kenya

4.3.1 Factors influencing household participation in commercial fertilizer outlets

Table 4.5 presents the maximum likelihood estimates of the determinants of farmer participation in commercial markets in the North Rift of Kenya. The likelihood ratio testing for the goodness-of-fit of the double-hurdle model was 0.79 indicating a good fit. Out of 18 variables, 6 were statistically significant. Half of these variables had a positive effect on the probability of a household participating in commercial fertilizer outlets while the other half had a negative effect.

As expected, the number of years of formal schooling of the household head had a positive and significant effect on the likelihood of a household participating in commercial fertilizer markets.This can be attributed to the fact that more educated heads of households are likely to be more aware and enlightened about the benefits of new technologies such as fertilizer relative to their non-educated counterparts. *Ceteris paribus*, an additional year of formal schooling of the household head increased the likelihood of a household participating in commercial fertilizer markets by 0.14 percent.

This finding is consistent with that of Martey et al. (2012) who reported that education is positively correlated with commercialization of smallholder agriculture in Ghana. According to Enete and Igbokwe (2009), education equipped households with better production and managerial skills in cassava production in Africa.

Lubungu et al. (2012) also found formal education to be an essential tool for utilization of market information dynamics in Zambia. In Ethiopia, Tura et al. (2010) found that the households that were headed by literate persons were more likely to adopt improved technologies compared to their non-educated counterparts.

Table 4.5: Maximum likelihood estimates of factors influencing farmer participation in commercial fertilizer markets in North Rift region of Kenya

Variable	Coefficient	Std error	t-value
AGE	-0.00	0.00	-0.44
GENDER	0.09	0.12	0.74
EDUC	0.01*	0.01	1.68
LANDSIZE	0.05	0.01	4.90
HHSIZE	0.03	0.02	1.74
NONINCM	0.02*	0.01	2.82
TLU	0.19	0.06	3.29
WEALTHCAT			
Poor	-0.36	0.31	-1.16
Middle	-0.26	0.24	-1.11
CRD	-0.00	0.00	-0.35
DISTFERT	-0.00*	0.00	1.76
MOBILE	0.11	0.13	0.87
TRANSPORT	0.00	0.01	0.03
MAIZEPRIC	0.00	0.00	1.53
FERTPRIC	-0.23***	0.10	2.16
QSUBSIDY	-0.29***	0.13	-2.32
IMPROVEDSEED	0.61***	0.27	2.28
Prob > Chi^2	0.0000		
lnL_0	-1305.1124		
lnL	-1305.1124		

Source: Author (Survey data)*, **, *** represent statistical significance at 10%, 5%, and 1% levels respectively.

Non-farm income had a positive and significant effect on the probability of a household participating in commercial fertilizer markets in the study area. This can be attributed to the fact that non-farm income contributes to the total household income, which, if large enough, enables households to purchase farm inputs (Reardon et al., 1988; 2007).

Thus, high income households are expected to be more likely to participate in the input markets compared to their low income counterparts. This finding is consistent with that of Martey et al. (2012) who reported that investment of non-farm income in farm technology increased production volumes and the marketable surplus thereby increasing the likelihood of the household participating in the market in Ghana. In the current study, a one shilling increase in non-farm income increased the probability of a household participating in commercial fertilizer markets by 0.02 percent. This increase was relatively low compared to previous studies.

Distance to the nearest fertilizer seller had a negative but significant effect on the probability of households participating in commercial fertilizer markets in the North Rift of Kenya. This is because longer distances raise both travel time and costs, which impact negatively on market participation (Kafle, 2010). This finding is consistent with that of Gebremedhin and Jaleta (2010) who reported that distance to nearest fertilizer seller had a one percent reduction in the likelihood of a household participating in bean markets in Ethiopia. Liverpool-Tasie (2014) also reported that distance to the main market lowered the probability of households participating in commercial outlets by 22 percent in Nigeria.

According to Ricker-Gilbert et al. (2011), distance to input markets reduced Malawian farmers' probability of participating in commercial fertilizer markets by 0.2 percent. Ariga and Jayne (2010) also found that households located 10 kilometers away from fertilizer sellers in the high potential areas in Kenya decreased their likelihood of participating in commercial fertilizer markets by 23 percent. In this study, an additional kilometer to the nearest fertilizer seller decreased the probability of households participating in commercial fertilizer markets in the North Rift by 0.42 percent. This reduction tallies with previous literature.

The price of commercial fertilizer had a negative but significant effect on the probability of a household participating in commercial fertilizer outlets in the North Rift of Kenya. This is attributable to the law of demand (Varian, 1992). Higher commodity prices diminish consumers' propensity to participate in markets in order to minimize expenditure (Beemanya, 1978). In this study, the negative effect of fertilizer price on the probability of households participating in commercial fertilizer outlets could be attributed to high fertilizer prices in Kenya in the recent past. This indicates that farmers in the North Rift are price sensitive.

Thus, a one percent increase in fertilizer price would reduce the propability of a household participating in commercial fertilizer outlets by 22 percent. Liverpool-Tasie (2014) and Ricker-Gilbert et al. (2009) independently found that the price of fertilizer had a negative effect on household participation in private fertilizer markets in Nigeria and Malawi respectively. The authors attributed their findings to the fact that farmers were rational and paid attention to input prices, which is similar to the current case.

The quantity of subsidized fertilizer acquired by the household had a negative but significant effect on the likelihood of farmers participating in commercial fertilizer outlets in North Rift as expected *a priori*. This finding can be attributed to the fact that the subsidized fertilizer is a cheaper substitute of commercial fertilizer. Thus, an additional kilogram of subsidized fertilizer would reduce the probability of households participating in commercial fertilizer outlets by 29 percent, which is somewhat huge. In a similar study in Malawi, Ricker-Gilbert et al. (2011) found that an extra kilogram of subsidized fertilizer decreased the likelihood of a household participating in commercial fertilizer outlets by 10 percent.

As expected *a priori*, the use of improved maize seed increased the probability of a household participating in commercial fertilizer markets in the North Rift region of Kenya by 60 percent. This can be attributed to the fact that the adoption of improved maize varieties requires concomitant adoption of production-enhancing technologies that include appropriate fertilizer. Bett et al. (2015) observed that the use of fertilizer increased the probability to use improved maize varieties by 28 percent in the moist transitional zone of eastern Kenya. Ricker-Gilbert (2013) also reported that in Malawi, the farmers who had planted improved maize varieties used approximately 50 kg more of fertilizer than those that had not.

The authors argued that high crop yield response is realized when improved seed, fertilizer and other soil fertility management technologies are combined. Liverpool-Tasie and Sheu (2013) found that the use of improved maize seed led to an increase in the likelihood of farmers participating in commercial fertilizer markets in Nigeria. Likewise in this study, use of improved maize seed increased the likelihood of households participating in commercial fertilizer outlets by 61 percent.

4.3.2 Factors influencing the level of household participation in commercial fertilizer outlets in North Rift region of Kenya

Table 4.6 shows the effect of the selected variables on the quantity of commercial fertilizer purchased conditional upon the participation decision. The residual, Ω, which measured the endogeneity of subsidized fertilizer was not statistically significant indicating that the quantity of subsidized fertilizer acquired by households was not endogenous (see the details in Section 3.2.1). The IMR was negative but statistically significant (t=0.026).

This implies that the self-selection bias suspected in the probit model (see Section 4.3.2) was present but successfully controlled by the inclusion of the IMR in equation (3.19). Six out of nine variables had a positive influence on the quantity of commercial fertilizer purchased while three variables had a negative effect.

Land size had a positive and significant effect on the quantity of commercial fertilizer purchased by a household as expected. This is because land sizes are associated with wealth that influences the ability to purchase fertilizer from commercial outlets. These results are consistent with the finding by Liverpool-Tasie (2014) who observed that larger landholdings potentially require larger quantity of fertilizer in Nigeria. Minot et al. (2009) found that each additional hectare was associated with an additional 170 kg of fertilizer used in Ghana. In the current study, an acre increase in land size increase the quantity of fertilizer purchased from commercial outlets by 0.45 kg.

As expected, the size of the household had a positive and significant effect on the quantity of fertilizer purchased from commercial outlets. This suggests that a large household is more likely to use fertilizer than a small one. This probably due to the fact a large family contributes to the labor required in the application of fertilizer. In addition, large families have a high demand for food.

This finding supports that of Deininger and Okidi (1999) who reported that large families may use fertilizer to fulfill higher food requirement in cases where expanding land holding is restricted by imperfect or missing land markets in Uganda. In this study, an additional member increased the quantity of fertilizer purchased from commercial outlets by 0.15 kg.

Table 4.6: Maximum likelihood estimates of factors influencing the level of participation in commercial fertilizer outlets in North Rift region of Kenya

Variable	Coefficient	Std error	t-value
AGE	-0.04	0.00	0.00
GENDER	0.14	0.13	0.02
EDUC	0.03	0.01	0.00
LANDSIZE	0.45***	0.17	2.59
HHSIZE	0.15*	0.08	1.92
NONINCM	0.01***	0.00	3.24
TLU	0.18***	0.06	3.08
WEALTHCAT			
Poor	-0.39	0.12	-0.05
Middle	-0.26	0.14	-0.04
CRD	0.04	0.16	0.01
DISTFERT	-0.12**	0.05	-2.31
MOBILE	1.23**	0.59	2.09
TRANSPORT	0.13**	0.12	0.02
MAIZEPRIC	0.00	0.00	0.00
FERTPRIC	-0.24***	0.05	-4.55
QSUBSIDY	-0.22***	0.08	-2.62
IMPROVEDSEED	0.63	0.26	0.16
Ώ	0.01	0.00	0.01
IMR	-0.05*	0.03	-1.88
Prob > Chi^2	0.0000		
lnL_0	-1305.1124		
lnL	-1305.1124		

Source: Author (Survey data)

*, **, *** represent statistical significance at 10%, 5%, and 1% levels respectively. The coefficients and p-values were obtained by the *MARGINS* command in STATA.

Non-farm income had a positive and significant effect on quantity of commercial fertilizer purchased. This implies that households in the North Rift were using some of their non-farm income to purchase fertilizer for production. The households which participated in non-farm activities purchased 0.01 kg more than those which did not. In Ethiopia, Nasir and Hundie (2014) found that, on average, households that participated in non-farm activities used 65 kg of urea and 91 kg of DAP to fertilizer their farms.

The authors attributed this positive effect to the fact that non-farm income increases rural incomes, which in turn increases agricultural productivity due to increased access to modern inputs.

Contrary to expectation, TLU had a positive and significant effect on the quantity of commercial fertilizer acquired by the household. Therefore, an additional TLU would increase the quantity of commercial fertilizer purchased by household by 0.2 kg. This is because TLU is a measure of income level and hence wealth status of the households. This improves households' purchasing power and their liquidity, hence buying this input. Ketema and Bauer (2011) found that livestock holding increased the quantity of fertilizer used in Ethiopia by 0.092 kg. This indicates that availability of manure is less important in determining its application.

Distance to the nearest fertilizer seller had a negative but significant effect on quantity of fertilizer purchased from commercial markets in the North Rift as expected. This means that households farther away from a fertilizer seller purchased smaller quantities of commercial fertilizer. This is because long distances to market increase both transport and transaction costs. According to Sadoulet and De Janvry (1995), costs incurred from poor infrastructure, long market distance, imperfect information and high marketing costs are major market constraints in agrarian households in developing countries. In this study, an additional kilometer in distance to a fertilizer seller would reduce the quantity of fertilizer purchased from commercial outlets by a 0.11 kg. In the North Rift region of Kenya, commercial fertilizer distribution channels are quite developed hence low negative marginal effect.

As expected, ownership of a mobile phone had a positive and significant effect on the quantity of fertilizer purchased by a household in the study area. In this study, ownership of a mobile phone increased the quantity of fertilizer purchased by each household from commercial outlets by 1.23 kg. This could be attributed to the fact that a mobile phone can be used to acquire information as well as making it easier and faster to carry out financial transactions and reduce barriers to fertilizer access. According to Lio and Liu (2006), ownership of mobile phone increases overall agricultural productivity because it facilitates the adoption of modern agricultural inputs such fertilizers. This means that use of mobile phones can increase use of modern inputs such as fertilizer as farmers can receive information and decide on where, to whom, and when to purchase inputs more easily than without mobile phones (Tadesse and Bahiigwa, 2015). According to Kijima (2016), ownership of a mobile phone increased quantity of subsidized fertilizer purchased by 0.92 kg in Nigeria.

Ownership of a mode of transport had a positive influence on the quantity of fertilizer purchased from commercial outlets as expected. This is because ownership of transport equipment reduces transport and travel costs resulting in higher profit margins. This result is consistent with that of Key et al. (2000) who reported that ownership of a means of transport in SSA lowered the proportional transaction costs thereby enhancing the intensity of market participation. In this study, owning to owning a means of transport increased the quantity of fertilizer purchased from commercial outlets by 0.13kg. Demeke et al. (1998) found that ownership of transport equipment lowered transportation costs and increased farmer participation in modern input markets in Ethiopia. Ownership of transport equipment could be attributed to the fact that households with these means of transport could be using them to transport fertilizer from the market to their homes and therefore the positive effect.

The price at which commercial fertilizer was sold exerted a significant and negative effect on quantity of fertilizer purchased from the commercial outlets as expected *a priori*. The finding is consistent with economic theory of the existence of an inverse relationship between price and demand (Imoru and Ayamga, 2015). In this study, an additional ten shillings on price would lower the quantity of fertilizer purchased from commercial outlets by 2.4 kg. Sheahan et al. (2016) found that fertilizer price reduces the amount purchased by household by 0.17 kg in Kenya. This means that, an increase in the price of fertilizer would reduce the quantity purchased as expected.

As expected *a priori*, one kilogram of subsidized fertilizer acquired by a household reduced the quantity of fertilizer purchased from commercial markets. Ricker-Gilbert and Jayne (2009) found that the quantity of subsidized fertilizer provided to farmers in Malawi displaced 0.2 kg from the private market in Malawi. Ricker-Gilbert et al. (2011) also found that an additional kilo of subsidized fertilizer crowded out 0.22 kg of commercial fertilizer in Malawi. Xu, et al. (2009) reported that one kilogram of subsidized fertilizer crowded out 0.12 kg of commercial fertilizer in Zambia. In this study, an additional kilogram of subsidized fertilizer acquired by a household displaced 0.22kg of fertilizer purchased from the commercial outlets in the North Rift of Kenya. In the next chapter, the summary, conclusions and recommendations are presented.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The main focus of this study was to assess the effect of the national fertilizer subsidy on farmer participation in commercial fertilizer outlets in the North Rift region in Kenya. The region was selected because it consumes more than half of the total subsidized fertilizer in Kenya. It also has 13 out of the 30 active NCPB depots in the country through which subsidized fertilizer is distributed. The objectives of the study were (i) to describe the socio-economic characteristics of farmers in the North Rift region of Kenya disaggregated by fertilizer source, (ii) to identify the determinants of the quantity of subsidized fertilizer acquired by households in the North Rift region of Kenya, (iii) to assess the effect of subsidized fertilizer on farmer participation and the level of participation in commercial fertilizer outlets in the North Rift region of Kenya.

The study used primary data collected in 2014 by Tegemeo Institute of Agricultural Policy and Development. The data were collected using a structured questionnaire administered to 1,023 households and 710 households reported to have used fertilizer in the 2013/2014 cropping season. The households were selected through a two-stage stratified cluster sampling technique. Descriptive statistics were used to describe the survey respondents by fertilizer source, while a Tobit model was employed to evaluate the determinants of the quantity of subsidized fertilizer acquired by households. Thereafter, a double-hurdle model was used to assess the effect of subsidized fertilizer on farmer participation as well as the level of participation in commercial fertilizer outlets in the North Rift region of Kenya.

Of the 710 households who used fertilizer, 12.4 percent had accessed credit 12 months prior to the survey while 88.3 percent and 27.7 percent had mobile phone and transport equipment respectively. When grouped in terms of wealth status, 17.0 percent 50.3 percent and 32.7 percent of the households were in the "poor," "middle class," and "rich" categories respectively. In addition, about 48.9 percent and 42.0 percent of households in the "rich" and "middle class" categories respectively compared to 9.1 percent poor households purchased subsidized fertilizer.

Age, being in a male-headed household, years of formal school of the household head, land size, ownership of a mobile phone and transport equipment, and relationship with the Subsidy Fertilizer Location Vetting Committee officials positively influenced the quantity of subsidized fertilizer acquired by households in the North Rift region of Kenya. These findings indicate that the level of social connection affects how much subsidized fertilizer a household receives. Further, being in a "poor" or "middle" income household and access to credit negatively influenced the quantity of subsidized fertilizer acquired in the North Rift region of Kenya. These results indicate that the current national fertilizer subsidy benefits the wealthier households in North Rift region.

The factors that positively influenced farmer participation in commercial fertilizer markets were the number of years of formal school of the household head, non-farm income and use of improved maize seed. The level of market participation was positively influenced by land size owned, household size, non-farm income, TLU, and ownership of a mobile phone and farm transport. These findings provide useful insight on what factors need to be targeted in order to stimulate participation and level of participation in commercial fertilizer markets. These factors must be considered in order to accurately understand farmer market participation decision.

On the other hand, distance to the nearest fertilizer vendor, fertilizer price and the quantity of subsidized fertilizer acquired by the household reduced households' probability and level of participation in commercial fertilizer markets by 29 percent and 0.2 kgs respectively in the study area. These results provide useful information on factors that deter households' participation and level of participation in commercial fertilizer markets.

5.2 Conclusion

Fertilizer use is important for increasing food supply and reducing food costs especially in food insecure countries. In an effort to correct market failure and promote pro-poor agricultural growth, many countries in SSA have increasingly reverted to fertilizer subsidy under the general term "smart subsidies" in an effort to increase food production. In Kenya, the national fertilizer subsidy program aims at encouraging fertilizer use by supporting local fertilizer manufacturing and strengthening distribution. This study assessed the effect of the national fertilizer subsidy program on farmer participation on commercial outlets.

Results show that most of the beneficiaries of the national fertilizer subsidy program were the richer, male, better educated farmers with larger land sizes and the wherewithal to procure fertilizer from commercial sources instead of relying on the subsidy. Female-headed households received disproportionately less subsidized fertilizer than their male counterparts. This may be due to the fact that the process of acquiring fertilizer from NCPB depots is time-consuming and women may be constrained in its acquisition by both the dominance of patriarchy in decision making in the study area as well as time due to being the main providers of family labor at the household level.

In addition, some of these beneficiaries had a relationship with the Location Fertilizer Subsidy Vetting Committee officials and received high quantities of the subsidized fertilizer. This preponderance raises the questions as to whether the program beneficiaries actually need the subsidy and particularly given the huge budget outlay committed to the subsidy by the government. It also exposes potential beneficiaries to problems of rent-seeking and other malpractices by both the vetting committee and the NCPB. That the national fertilizer subsidy was not explicitly designed to focus on smallholder resource-poor farmers raises questions about its equity and sustainability. However, households that used subsidized fertilizer only applied more fertilizer per acre than farmers sourcing it either from commercial only or both commercial and subsidy outlets. This is an indication the fertilizer subsidy increased fertilizer use.

This study found that the quantity of subsidized fertilizer reduced household participation in commercial fertilizer outlets by 29 percent. In addition, a kilogram of subsidized fertilizer acquired by the household displaced 0.2 kg of commercial fertilizer demanded thereby “crowding out” the private sector in fertilizer distribution. These findings provide quantitative information about the displacement impacts of fertilizer subsidies on commercial markets. Therefore, targeting must be effective to minimize displacement effect to ensure that this program achieve the intended purpose of cost reduction and effective fertilizer supply chain.

5.3 Recommendations

1. This study found that the national fertilizer subsidy is distorting commercial fertilizer markets. Therefore, government should consider strengthening the current NAAIAP program which is targeted to resource-poor households through the voucher system as practiced in Nigeria. Studies show that a well-targeted voucher system “crowds in”

commercial fertilizer distributors which increases efficiency and reduces red tape. In addition, the government should consider having an exit strategy in the fertilizer subsidy program which would assure the growth and proliferation commercial input markets in Kenya for increased efficiency and equity.

2. The current fertilizer subsidy program is distributed via NCPB depots which are located in major towns and therefore not fully accessible to households who lack transport equipment or own small land sizes. This study recommends that the government should also consider distributing subsidies through the well-established network of agro-vets in order to reduce transaction costs associated with the acquisition of fertilizer subsidies. A voucher-based fertilizer distribution system like in Nigeria would not only be efficient but also equitable among resource-poor rural-based farmers.
3. The government should monitor the work of the Location Fertilizer Subsidy Vetting Committee officials whose influence this study found had a positive impact on the quantity of subsidized fertilizer acquired by a household. In addition, caution is required to ensure that households report true land sizes owned in order to receive subsidized fertilizer.
4. The design and implementation of subsidy programs should address gender-related constraints especially distance to the nearest subsidized fertilizer distributors which is a main barrier to women in accessing subsidized fertilizer for their small land sizes.
5. Ownership of a mobile phone was positively related to both quantity of subsidized and commercial fertilizer received by a household. Policies that encourage access to information should be enhanced. This could be through strengthened extension services to provide information on fertilizer availability and costs.

5.4 Areas for further research

The current study did not focus on the following areas which are recommended for further research:

1. Measuring the net social welfare effect of the fertilizer subsidy program in Kenya against their opportunity cost in terms of displacement of other investments that are crucial in achieving sustained improvements in rural living standards.
2. Assessing the effect of national fertilizer subsidy on total fertilizer use accounting for possible leakages into commercial markets. This will shed light on whether the subsidized fertilizer has actually increased total fertilizer use or whether farmers who acquire it also leak it to agro-dealers.
3. A comparison of costs and benefits of the national fertilizer subsidy program relative to other agricultural sector programs in Kenya. This will help the government to understand the sustainability of the national fertilizer subsidy program
4. It is also important for a study that looks at the impact of the fertilizer subsidy on Kenya's macro-economic indicators such as gross domestic product, agricultural output, general price levels and the fiscal balance, and rural wages and poverty.

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ANNEXES

Annex 1: Distribution of survey households by counties and AEZs

County	Lower highlands	Lower midlands 3-6	Upper highlands	Upper midlands 0-1	Upper midlands 2-6	Total households
Baringo	20	40	20	0	40	**120**
Elgeyo Marakwet	40	80	100	0	40	**260**
Nandi	60	0	0	40	20	**120**
Samburu	20	20	0	0	20	**60**
Trans Nzoia	40	0	0	0	80	**120**
Uasin Gishu	120	0	40	0	40	**200**
West Pokot	60	40	100	0	20	**220**
Total	**360**	**180**	**260**	**40**	**260**	**1100**

Annex 2: Summary of multicollinearity tests for all independent variables in the models

Variable	VIF	1/VIF
AGE	1.34	0.74
GENDER	1.14	0.88
EDUC	1.34	0.75
TACRE	1.32	0.76
HHSIZE	1.23	0.81
NONINCM	1.29	0.78
TLU	1.21	0.82
WEALTHCAT1		
Poor	1.69	0.59
Middle	1.31	0.76
CRD	1.05	0.95
DISTFERT	1.05	0.96
MOBILE	1.14	0.88
TRANSPORT	1.21	0.83
MAIZEPRIC	1.03	0.97
FERTPRIC	1.02	0.98
IMPROVED SEED	1.04	0.96
Mean VIF	1.37	

Annex 3: Person Correlation Matrix

Variable	AGE	GENDER	EDUC	LANDSIZE	HHSIZE	NONINCM	TLU	POOR	MIDDLE	CRD	DISTFERT	MOBILE	TRANSPORT	MAIZEPRIC	FERTPRIC	QSUBSIDY	IMPROVEDSEED
AGE	1																
GENDER	-0.22	1.00															
EDUC	-0.37	0.27	1.00														
LANDSIZE	0.29	-0.01	-0.02	1.00													
HHSIZE	0.02	0.17	0.09	0.10	1.00												
NONINCM	0.02	0.05	0.08	0.32	0.12	1.00											
TLU	0.13	0.01	0.09	0.27	0.17	0.15	1.00										
POOR	0.10	0.02	0.15	0.13	-0.12	0.11	0.14	1.00									
MIDDLE	-0.03	-0.06	-0.24	-0.20	0.18	-0.22	-0.26	-0.46	1.00								
CRD	-0.09	0.02	0.07	-0.02	0.05	0.09	-0.01	-0.10	-0.04	1.00							
DISTFERT	0.02	-0.02	-0.05	0.00	0.04	-0.02	0.08	0.04	0.00	-0.10	1.00						
MOBILE	0.00	0.10	0.25	0.07	0.16	0.08	0.11	0.04	-0.15	0.11	-0.07	1.00					
TRANSPORT	0.00	0.13	0.27	0.20	0.11	0.24	0.14	0.13	-0.25	0.03	0.02	0.19	1.00				
MAIZEPRIC	-0.01	0.05	0.01	0.00	0.05	-0.02	0.05	0.03	0.06	-0.03	-0.06	0.00	-0.02	1.00			
FERTPRIC	-0.08	0.00	-0.01	-0.05	-0.06	-0.10	-0.01	0.04	0.04	-0.02	0.03	-0.05	-0.05	-0.03	1.00		
QSUBSIDY	0.12	-0.03	0.02	0.36	0.02	0.38	0.07	-0.04	-0.16	0.02	-0.06	0.04	0.25	-0.04	-0.04	1.00	
IMPROVEDSEED	0.10	0.04	0.04	0.01	0.08	0.03	0.07	0.06	-0.06	-0.08	0.05	0.08	0.06	-0.03	-0.11	0.02	1.00

Annex 4: Summary of Breusch-Pagan test for heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity
Ho: Constant variance
Variables: fitted values of Qsubsidy
$Chi^2(1) = 0.43$
Prob > $Chi^2 = 0.5117$

Annex 5: Summary of Durbin Hauman test for endogeneity

Durbin Hausman test for endogeneity
Ho: Exogenous variables
Prob > F = 0.5036

Annex 6: Structured Household Survey Questionnaire uploaded in SurveyCTO server

Identifier

Household Number HHID: _________________

Date: (DD/MM/YY) SURDATE:_____________

Household Name; ____ **HHNAME**

Respondent ID; ____ **MEM**: __________

(Enumerator Instruction: Record the member number of the Respondent from the Demography)

Identifying Variables:

Supervisor: __________________ **SNUM**: ______________

Enumerator: __________________ **ENUM**: ______________

County: __________________ **COUNT**: _______________

IF THE HOUSEHOLD IS NOT ABLE TO PARTICIPATE IN THE SURVEY, WHY NOT? **INTVIEW** __________

(1=head and spouse separated2= refused 3= household members cannot be found

4 =family commitments; (burial, wedding) 5 =working outside area 6= other, specify_______)

LAND

Q1.0 How many acres in total land holding does the household **own**? **tacres_____**

Q1.1 How many acres of land were **rented-in** in the last main season 2013/2014? **rent_____**

Q1.2 Did the household grow any improved varieties for **maize** in the last cropping year 2013/2014? (1=Yes 0=No) **mzimpr____**

Q1.3 For the largest sale made by the household what was the price of 90kg bag of maize **mzprice___**

Q1.4 Did any household member try to get any cash or in-kind credit during the 2013/2014 cropping year? (1=Yes 0=No) **crd____**

Q1.5 Has anyone in household received any extension service in 2013/2014? Yes=1, No=2 **recadv_____**

INFRASTRUCTURE (Enumerator Instruction: Distance should be recorded in kilometers (Km)

Q2.1 Does any member of this household owns a mobile phone? (1=Yes 0=No) **mobile____**

Q2.Distance from your homestead to the nearest fertilizer seller?

Q3. DEMOGRAPHIC CHARACTERISTICS OF HOUSEHOLD MEMBERS (Adults and Children)

(*A household member to be listed is anyone who lived in the household for at least one full month during the last 12 months (*August 2013 to July 2014*). For head and spouse, they are considered household members irrespective of the duration they were physically present at home).*

ID	Name	What is the age of […….] born?	What is the gender of […….]? 1=male 0=female	Relation-ship of [……]o current head 1 Head 2 Other household member	What is the highest level of education […………] Years in schooling? *(See codes below)*	Did [..……..] receive cash from informal /business activity? Include *farm kibarua,* dividends Between August 2014 and July 2015 1=Yes 0=N*o*	Did [.…] receive cash or payment in kind from salaried employment, wage activities, remittances, or pensions Between August 2014 and July 2015 1=Yes 0=No
MEM	**NAME**	**AGE**	**GENDER**	**RHEAD**	**EDUC**	**BUS**	**SAL**

Q4. **BUSINESS AND INFORMAL LABOUR ACTIVITIES**

We would like to know about all the off-farm income earning activities, including share dividends, your household was involved in, except *salaried employment pensions and remittances*. August 2013 to July 2014 (include *jua kali and farm kibarua*). (Probe for charcoal burning, fishing and own tree selling) the activity codes are below.

Business14.sav (*Key variables: hhid, mem, activity)*

Person name	Person code	Activity Code	Please classify each month's net earnings as: 0=None 1=Low 2=Average 3=High												Low earnings month		Average earnings month		High earnings month	
			8/13	9/13	10/13	11/13	12/13	1/14	2/14	3/14	4/14	5/14	6/15	7/15						
NAME	**MEM**	**ACTIVITY**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Mar**	**Jun**	**Jul**	**lgross**	**lcost**	**agross**	**acost**	**hgross**	**hcost**

58	Accounting clerk	8	Charcoal burning	70	Harvesting	24	Mining	38	Transporter (goods)
1	Agricultural	9	Clothes/shoes	17	Hawker	74	Non-agricultural	55	Tree seller, commercial
46	Bar operator	51	Cobbler	57	Hiring out a bull	54	Nurse	52	Vehicle mechanic
64	Battery charging	10	Curio trader	73	Hotel	68	Pet breeder	45	Veterinary doctor
2	Bicycle	11	Dealing	18	Jaggery	25	Photography	67	Video business
60	Boat making	12	Driver	49	Laundry business	63	Pit latrine digger	56	Village elder
3	Brick making	13	Earning dividends	19	Livestock trader	26	Planting	39	Weaving
4	Brokerage	14	Electrician	20	Local brewing	27	Ploughing	40	Welding/painting/blacksmith
62	Building	72	Income from	42	Lumbering/wood	47	Plumber	66	Other specify__________

Q5. SALARIED WAGE EMPLOYMENT/PERMANENT EMPLOYMENT ACTIVITIES

We would now like to talk about all *salaried employment* that anyone in this household engaged in during the past 12 months from August 2013 to July 2014 including pensions and remittances.

Person code from demog	From the list below, please list all the *salaried employment activities* in which this person was engaged at any time during the past 12 months	What is [….] current monthly wage? KShs	Did [….] earn this same monthly wage during all of the past 12 months? 1=Yes (→ *go to incuse)* 2=No	If [……] did *not* earn the same wage during all 12 months, please indicate the wage earned for each month individually (KShs) *(Skip this section if person received the same monthly wage during the whole year)*											
				8/13	9/13	10/13	11/13	12/13	1/14	2/14	3/14	4/14	5/14	6/14	7/14
MEM	**ACTIVITY**	**MNWAGE**	**SAME**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**

Employment Codes:

18	Accountant	2	Civil leader	45	Driver	6	General farm	19	Manager	53	Plumber/battery
5	Administrator	20	Cleaner	4	Doctor	47	Hair dresser	39	Mechanic	11	Policeman/woman
38	Banker/receptionist	23	Clerk	40	Electrician	7	House help	28	Messenger	59	Postmaster
50	Butcher	3	Committee	36	Engineer	8	Industrial	60	Miller	12	Remittance (local)
44	Cane cutter	35	Conductor	56	Equipment	33	Lab attendant	9	Nurse	63	Research
31	Secretary	15	Teacher	57	Soldier	26	Veterinary	29	civil servant	17	Watchman
24	Shop keeper/attendant	54	Technician	62	Sports/coach	16	Waiter/cook	43	Welding	42	Other, specify_________

Q6. FERTILIZER

Q6. Did the household purchase fertilizer in the 2013/2014 cropping season? **FERT________**

Q6. What **CROP INPUTS** did you purchase/hire on **CREDIT OR IN CASH in 2013/14 cropping year**?

Fertilizer14.sav (*Key Variables: hhid; inptype)*

Input codes	Input codes (cont.)	Input sources	Input type [*Select input codes from column on the left*]	Quantity bought	Unit of purchase 2=kg 13=gram 20=5 kg bag 8=10 kg bag 7= 25 kg bag 11=50 kg bag	Source of Fertilizer and other inputs *(Select input sources from column on the left*)	Price per unit specified	Kms from point of purchase to farm	Transport Cost per Unit of the fertilizer (KShs) [*Instruction: fill for ONLY fertilizers*]	Main Crop for which input was used
<u>Input codes:</u> 1=DAP 2=MAP 3=TSP 4=SSP 5=NPK (20:20:0) 6=NPK (17:17:0) 7=NPK (25:5:+5S) 8=CAN (26:0:0) 9=ASN (26:0:0) 10=UREA (46:0:0) 11=SA (21:0:0) 15=NPK (23:23:23) 16=NPK (20:10:10) 17=DAP + CAN 19=Magmax Lime 20=DSP 30=UREA+CAN	21=NPK (23:23:0) 22=NPK (17:17:17) 23=NPK (18:14:12) 24=NPK (15:15:15) 58=NPK(25:5:0) 25=Mavuno-basal 27=Rock-phosphate 28=NPK 14:14:20 29=Mijingu 1100	**Input sources** 1=small trader 2=Stockist 3=large company 4=CBO 5=NCPB 6=County Govt 7=KTDA 8=Farmer group 9=Relative or friend 10=other, specify_____	**inptype**	**Qbought**	**unit**	**inpsorce**	**punit**	**kms**	**trancost**	**mcrop**

Asset

Q6. Did the household have the following assets from July 2013 to June 2014?

Item	Quantity	Value per unit (Kshs)	Total value if unit value is not known
Ploughs for tractor			
Animal traction			
Cart			
Trailer			
Tractor			
Zero-grazing unit			
Sheller			
Planter			
Zero grazing unit			
Ridger			
Boom sprayer			
Zero-grazing unit			
Other specify…			

Thank you