An assessment of the effect of a national fertiliser subsidy programme on farmer participation in private fertiliser markets in the North Rift region of Kenya

Joyce Mumbua Makau*
Tegemeo Institute of Agricultural Policy and Development, Egerton University, Nairobi, Kenya. E-mail: jmakau@tegemeo.org

Patrick Irungu
Department of Agricultural Economics, University of Nairobi, Nairobi, Kenya. E-mail: patrickirungu@yahoo.com

Rose Adhiambo Nyikal
Department of Agricultural Economics, University of Nairobi, Nairobi, Kenya. E-mail: nyikalra@gmail.com

Lilian Wambui Kirimi
Tegemeo Institute of Agricultural Policy and Development, Egerton University, Nairobi, Kenya. E-mail: lkirimi@tegemeo.org

*Corresponding author

Abstract

This study evaluated the effect of the national fertiliser subsidy on farmer participation in commercial fertiliser markets in the North Rift region of Kenya. The study used primary data collected from 710 households. A double-hurdle model and descriptive statistics were used to analyse the data. The results show that the national fertiliser subsidy reduces farmers' probability of participating in commercial fertiliser markets by 30%. On average, an additional kilogram of subsidised fertiliser displaces 0.2 kg of commercial fertiliser from the market. This implies that the national fertiliser subsidy has a displacement effect on commercial sales. The government therefore should consider changes in programme design and implementation by distributing subsidised fertiliser to areas with weak commercial fertiliser distribution networks. In addition, proper targeting of resource-poor households is recommended if the programme objectives are to be achieved.

Key words: fertiliser subsidy; market participation; Kenya; double-hurdle model; displacement effect

1. Introduction

Fertiliser is one of the very important farm inputs to have received excessive government support in sub-Saharan Africa (SSA). Such interventions include import and price controls, the institution of fertiliser subsidies and the establishment of state-owned fertiliser production and distribution systems (Ariga & Jayne 2010). However, government intervention in fertiliser markets, coupled with poor investment to facilitate a competitive private fertiliser distribution channel, has been shown to deter agricultural development in SSA countries (Takeshima & Lee 2012). Furthermore, in most cases the private sector is negatively affected by government intervention in fertiliser distribution, especially if public and private distribution channels exist concurrently (Ricker-Gilbert *et al*. 2011). The level of market distortion is dependent on the efficiency of administrative processes, the size of the subsidy programme, targeting, and the timeliness of fertiliser distribution; hence, its effect on private sector participation is not obvious a priori (Liverpool-Tasie 2014).

Kenya introduced its national fertiliser subsidy in 2009 in line with its Vision 2030. The subsidy is being implemented as a three-tiered fertiliser cost-reduction programme called the "Fertiliser Cost-Reduction Initiative". This initiative, popularly known as "the national fertiliser subsidy", is a state-driven fertiliser subsidy programme implemented by the Ministry of Agriculture, Livestock and Fisheries (International Fertilizer Development Corporation [IFDC] 2012). It was pioneered as an emergency programme in response to high fertiliser prices in 2008. The aim of the programme is to encourage fertiliser use through the reduction of fertiliser costs and an effective fertiliser supply chain (Tier 1), blending (Tier 2), and support to local fertiliser manufacturing (Tier 3) (Ndung'u *et al*. 2009). In an attempt to address Tier 1, the government procures and distributes fertiliser at subsidised prices to farmers across the country through National Cereals and Produce Board depots (NCPB) (IFDC 2012). Fertiliser distribution through the NCPB parallels the commercial distribution, thereby creating a "dual market" scenario.

According to the Ministry of Agriculture, Livestock and Fisheries (2014), the beneficiaries of the subsidy programme are vetted and registered by the location-level subsidy fertiliser vetting committee. The beneficiaries obtain an official, stamped form containing the quantity of fertiliser required based on land size prepared for planting and the crops to be grown. The form is signed and stamped by both the administrative chief/assistant chief and the ward agricultural officer. The form is taken to the nearest NCPB depot, where the fertiliser is paid for and collected (Ministry of Agriculture, Livestock and Fisheries 2014). Although government intervention in the purchase and supply of subsidised fertiliser was expected to be short term so as not to disrupt the private sector, the subsidy programme has continued unabated, fuelled mainly by political considerations (Ariga & Jayne 2010).

Previous studies on the effect of fertiliser subsidies on commercial outlets in SSA have concentrated on targeted subsidies, whereby the fertiliser is channelled to certain intended beneficiaries (see Xu *et al*. (2009), Ricker-Gilbert *et al*. (2011) and Liverpool-Tasie (2012; 2014) for Zambia, Malawi and Nigeria respectively). Although these studies have shed some light on the circumstances under which targeted fertiliser subsidies may promote or suppress private fertiliser markets, they have failed to examine the effect of non-targeted fertiliser subsidies on farmer participation in commercial markets. In particular, few studies have empirically taken into account the effect of parallel commercial and government distribution channels (Xu *et al*. 2009). This study sought to understand the effect of the national fertiliser subsidy programme on privately operated fertiliser distribution channels in the North Rift region of Kenya, one of the country's grain basket regions that consume approximately one-half of the country's subsidised fertiliser. Sections 2 and 3 present the methodology and data description respectively, while the results, conclusions and recommendations are presented in sections 4 and 5 respectively.

2. Methodology

2.1 Theoretical framework

This study is anchored on the Agricultural Household Model (AHM). Following Singh *et al*. (1986), for any production cycle, the ith household is assumed to maximise a utility function:

$$U_i = U_i(X_{a,} X_{m,} X_l) \tag{1}$$

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,

$$p_m X_m = p_a(Q - X_a) - p_l(L - F) + E \tag{2}$$

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

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,

$$T = X_l + F \tag{3}$$

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

$$Q_a = Q(L, A, K) \tag{4}$$

where A is the household's fixed quantity of land and K is its fixed stock of capital. The three constraints on household behaviour can be collapsed into a single constraint. 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 a single constraint:

$$p_m X_m + p_a X_a + \ p_l X_l = p_l T + \pi + E \tag{5}$$

where $\pi = p_a Q(L, A, K) - p_l L$ is a measure of farm profits. In this equation, the left-hand side shows total household expenditure on the market-purchased commodity, the household's purchase of its own output and the household's purchase of its own time in the 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 is any labour income (Becker 1965). The extension of the agricultural household model is the inclusion of a measure of farm profits:

$$p_a Q_a - p_l L \tag{6}$$

In this case, all labour is valued at the market wage. Equations 1 to 5 reveal that the household can choose the levels of consumption for an agricultural staple, a market-purchased good and leisure.

Maximising utility subject to the single constraint in equation 5 above yields the following first-order conditions:

$$\partial U / \partial X_m = \lambda p_m \tag{7}$$

$$\partial U / \partial X_a = \lambda p_a \tag{8}$$

$$\partial U / \partial X_l = \lambda p_l \tag{9}$$

Solving the first-order conditions gives the following input (in this case, fertiliser) demand model:

$$Qprivate = f(Qsubsidy, fertpric, maizepric, K, A\ Z) \tag{10}$$

where $Qprivate$ is the quantity of commercial fertiliser purchased at market price, $Qsubsidy$ is the quantity of subsidised fertiliser received, $fertpric$ is average price of all commercial inorganic fertilisers purchased by the household with the exception of foliar feed, $maizepric$ is the price of output, which in this case is maize, and *K*, *A* and *Z* represent access to credit, land size and household socioeconomic characteristics respectively that affect the demand for fertiliser.

To estimate the extent to which subsidised fertiliser affects farmers' demand for commercial fertiliser, the model in equation 10 can be specified as:

$$Qprivate_i = \beta X_i + \delta Qsubsidy_i + \mathcal{E}_i \tag{11}$$

where $Qprivate_i$ is the amount of fertiliser bought from commercial outlets by the i^{th} farmer, $Qsubsidy_i$ is the amount of subsidised fertiliser received by the i^{th} farmer, X_i is a vector of explanatory variables that may affect the farmer's demand for fertiliser from the private sector, including household demographic and socioeconomic characteristics, β and δ are unknown parameters to be estimated, and $\mathcal{E}_i$ is the error term. Parameter δ estimates the degree to which the subsidised fertiliser affects the farmer's demand for commercial fertiliser.

Endogeneity of the quantity of subsidised fertiliser acquired and the corner solution nature of input demand are the two major problems in estimating the effect of subsidised fertiliser on commercial fertiliser demand. When a farmer decides not to use fertilisers, as some will, then an observation of zero fertiliser demanded can be said to be an optimal choice for that farmer, rather than treating it as unobserved. In addition, the process of vetting for farmers to access subsidised fertiliser is subject to violations by some local leaders. This is because local leaders determine who is eligible for the subsidy after farmers report their land sizes and the crops on which they would want to use the fertiliser. Violation of the vetting process is possible and may be unobserved, and hence could determine the amount of subsidised fertiliser received. These issues make it impossible to use the Heckman, LaLonde and Smith models designed for truncation, where the zeros are treated as unobserved values. Therefore, this study used a double-hurdle model that allows the process that determines the decision to participate in the private market to be different from that which determines the extent of participation. A similar approach has been used Ricker-Gilbert *et al*. (2011) and Liverpool-Tasie (2014), who estimated the effect of fertiliser subsidy on commercial fertiliser markets in Malawi and Nigeria respectively.

In order to resolve the problem of endogeneity, this study used farmer's relationship with the leader of the subsidy fertiliser vetting committee at the location level as an instrumental variable (IV). There are several tests for IV strength, including those of Staiger *et al*. (1997) and Stock and Yogo (2005). However, non-linear models have no known test for IV strength, hence the test for IV by partial correlation in the reduced form model (Ricker-Gilbert *et al.* 2011; Liverpool-Tasie, 2014). A *p*-value of 0.001 is evidence of a strong IV. In this study, because households receiving the fertiliser subsidy have to be vetted by the location-level subsidy fertiliser vetting committee, this was likely to influence the quantity received. However, it was unlikely that a farmer's relationship with the leaders of a such a subsidy fertiliser vetting committee would affect his participation in private fertiliser markets. Therefore, being related to the leadership of a location-level subsidy fertiliser vetting committee was consequently excluded from the estimation of equation 10.

For the control function approach and input demand corner solution problems, the study estimated that:

$$E(Qprivate|Qsubsidy, X_i, \mu) = E(Qprivate|Qsubsidy, X_i, \mu) = \Phi(Y\beta + \mu) \tag{12}$$

$$Qsubsidy = X\varphi + \gamma \tag{13}$$

where $Qprivate$ and $Qsubsidy$ are as defined above, Y is a nonlinear function of $Qsubsidy$, and X_i and μ are excluded factors that may be correlated with $Qsubsidy$. The exclusion means that a subset of X, (X_i), appears in $E(Qprivate|Qsubsidy, X, \mu)$.

The control function approach requires an IV that should be uncorrelated with the error term but correlated with the explanatory variable. This study used farmer's relationship to the leadership of the location-level subsidy fertiliser vetting committee as an instrument, since this may influence the quantity of subsidised fertiliser received.

To assess the factors influencing the amount of subsidised fertiliser received by the ith farmer, a double-bounded Tobit regression was estimated, following Wooldridge (2008). The generalised residuals from the regression were constructed as:

$$\widehat{gt\iota} = \widehat{-\delta}\ 1[Qprivate_i = 0]\alpha(-w_i\hat{\gamma}) + 1[Qprivate_i > 0](Qprivate_i - w_i\hat{\gamma}) \tag{14}$$

where $\hat{\delta}$ and $\hat{\gamma}$ are the Tobit's maximum likelihood estimates (MLE) and α is the inverse Mill's ratio. According to Wooldridge (2008), the generalised residuals are used as regressors in the second stage of analysis, where the double-hurdle model is used.

The first hurdle was the decision to participate in commercial markets or not, while the second hurdle models the extent of participation. This model assumes that, if the data has zeros, it is because that is the optimal choice by an economic agent. These zeros are determined by the density $\mathrm{f}_1(.)$, such that ($Qprivate_i$) = 0 = $\mathrm{f}_1(0)$, and P($Qprivate_i$) > 0 is determined by $1 - \mathrm{f}_1(0)$.

The positive quantities come from the truncated density $\mathrm{f}_2(Qprivate_i|Qprivate_i > 0 = f_2(Qprivate_i/1 - f_2(0))$, which is multiplied by ($Qprivate_i$) > 0, which is multiplied by ($Qprivate_i$) > 0 to ensure that total probabilities are equal to one (Wooldridge, 2006). The first hurdle used the full sample and a probit model was estimated, while in the second hurdle only positive observations were considered and the study estimated a truncated regression. In both hurdles, the generalised residuals are included as covariates.

In both hurdles, the average partial effects (APE) were obtained from the margins command in Stata. The coefficients in the first hurdle were the participation APEs, while those in the second hurdle were the conditional APEs. The p-values in both hurdles were estimated via bootstrapping at 1 000 repetitions.

3. Data

The data used in this study were collected in a household survey conducted by the Tegemeo Institute of Agricultural Policy and Development in the North Rift region of Kenya in 2014. The survey covered two cropping seasons: 2012 to 2013 and 2013 to 2014. The study used a two-stage stratified cluster sampling technique. In the first stage, 70 rural clusters were selected from the Kenya National Bureau of Statistics (KNBS) household-based sampling frame (NASSEP V) using the equal probability selection method (EPSEM). In the second stage, a uniform sample of 20 households in each cluster was selected from a roster of households in the cluster using the systematic random sampling method.

During data collection, no allowance was made for the replacement of non-responding households. Hence, a sample size of 710 households was realised. Table 1 presents a summary of descriptive statistics of the variables used in the double-hurdle model.

Table 1: Descriptive statistics of variables used to assess the effect of the national fertiliser subsidy on commercial fertiliser market in the North Rift region of Kenya

Variable	Mean	Standard deviation	Minimum	Maximum
Quantity of commercial fertiliser purchased (kilograms)	80.18	3.88	0.00	900
Quantity of subsidised fertiliser received (kilograms)	35.74	4.98	0.00	1500
Male (1/0)	0.82	0.02	0.00	1
Access to credit (1/0)	0.12	0.01	0.00	1
Used improved maize (1/0)	0.97	0.01	0.00	1
Owns a mobile phone (1/0)	0.88	0.01	0.00	1
Owns a bicycle (1/0)	0.18	0.02	0.00	1
Poor household (1/0)[1]	0.17	0.01	0.00	1
Middle-income household (1/0)	0.50	0.20	0.00	1
Farmer related to leadership of the location-level subsidy fertiliser vetting committee (1/0)	0.42	0.02	0.00	1
Price of output/90 kg bag	2 580	97.38	758	3 600
Price of fertiliser/kg	73.80	0.51	43.85	150.00
Household size	5.98	0.09	1	14
Years in school	7.65	0.18	0.00	23
Age in years	47.70	0.57	21	94
Land owned (acres)	3.94	0.22	0.00	50.00
Land rented in (acres)	0.42	0.06	0.00	20.00
Distance to the nearest produce market (kilometres)	5.29	0.21	0.01	63.00
Distance to the nearest motorable road (kilometres)	0.55	0.04	0.00	12.00
Distance to the nearest extension service (kilometres)	9.91	0.55	0.01	150.00
Distance to fertiliser seller (kilometres)	8.09	0.31	0.01	60.00
Distance to the nearest NCPB depot (kilometres)	5.07	0.25	0.04	66.00
Distance to the nearest produce market (kilometres)	23.52	0.68	0.99	92.00
Crop income (Kenya shilling)	64 886	5 594	0.00	2 644 677
Total livestock units (TLU)[2]	1.2	0.03	0.00	4.01

Source: Field survey data

1. Principal component analysis (PCA), which aggregates several assets owned by a household, was used to categorise the household as either poor or belonging to the middle income grouping (Moser & Felton 2007).
2. Conversion factors used for TLU: cattle = 0.7, sheep = 0.1, goats = 0.1, pigs = 0.2, chicken = 0.01

4. Results and discussion

4.1 Factors influencing the quantity of subsidised fertiliser acquired by households in the North Rift region of Kenya

Table 2 presents the determinants of the quantity of subsidised fertiliser received by a household. As shown, being male had a significant effect on the quantity of subsidised fertiliser acquired by the household. This is consistent with Ricker-Gilbert and Jayne (2009), who found that female-headed households received less subsidised fertiliser. This is because women farmers in SSA are constrained by a lack of productive resources and assets, such as low property rights – especially to land. This gives male-headed households an upper hand when participating in high-investment ventures, which female-headed households may not do.

Access to credit facilities had a negative but significant effect on the quantity of the subsidised fertiliser acquired by the household. This was probably because farmers who accessed credit had the wherewithal to purchase commercial fertiliser from the market. Additionally, the subsidised fertiliser is often delivered to farmers late, thereby affecting crop performance. Ricker-Gilbert and Jayne (2009) and Ricker-Gilbert *et al*. (2011) found in relation to Malawi that a village with an organised farm credit system received less subsidised fertiliser, while Liverpool-Tasie (2014) found the same for Nigeria.

Table 2: Factors influencing the quantity of subsidised fertiliser received by households in the North Rift region of Kenya

Variables	Coefficient†	Z-statistic
Male (1/0)	2.84	2.95***
Access to credit (1/0)	-2.54	-1.91*
Used improved maize (1/0)	0.71	0.51
Owns a mobile phone (1/0)	0.71	0.61
Owns a bicycle (1/0)	-0.49	-0.46
Poor household (1/0)	-4.24	-3.24***
Middle-income household (1/0)	-3.51	-3.61**
Rich household	-	-
Farmer related to leadership of the location-level subsidy fertiliser vetting committee [IV] (1/0)	4.75	3.34***
Price of output/90 kg bag	0.03	0.17
Price of fertiliser/kg		
Household size	0.18	1.20
Years in school	0.09	3.07***
Age in years	0.19	2.13**
Land owned (acres)	0.02	1.12
Land rented in (acres)	0.46	1.92*
Distance to the nearest produce market (kilometres)	-0.01	-0.13
Distance to the nearest motorable road (kilometres)	-0.61	-1.64
Distance to the nearest extension service (kilometres)	-0.00	-0.06
Distance to fertiliser seller (kilometres)	0.05	1.35
Distance to the nearest NCPB depot (kilometres)	0.08	0.08
Crop income (Kenya shilling)	7.77	3.10***
Total livestock units	-1.10	-2.20**

Source: Field survey data
† Coefficients represent average partial effects (APEs)
*, ** and *** represent statistical significance at the 10%, 5% and 1% levels respectively.

Being in poor and middle-income households had a negative but significant effect on the quantity of subsidised fertiliser acquired by the household. While targeting based on poverty was not the objective of the national fertiliser subsidy, the significance of poor and middle-income households receiving smaller quantities of subsidised fertiliser may reflect that the set of farmers that received subsidised fertiliser included rich households, which increases the displacement effect in the private market (Liverpool-Tasie, 2014).

The IV had a positive effect on the quantity of subsidised fertiliser received by a household. The APEs revealed that being in a relationship with the leadership of the fertiliser subsidy vetting committee increased the quantity of subsidised fertiliser received by 4.8, and this was significant at 1%. This finding highlights the possibility that the vetting process is violated when the committee identifies subsidy beneficiaries.

Years in schooling of the household head had a positive influence on the quantity of subsidised fertiliser received by the household. Makhura *et al*. (2004) found that human capital represented by the head's formal education increased the household's understanding of market dynamics and therefore improved decisions on market participation. This can be explained by the fact that, as an individual accesses more education, he/she is empowered with market knowledge that will spur that individual to participate in the market (Astewel 2010).

The age of the household head had a positive influence on the quantity of subsidised fertiliser acquired by the household. This finding supports the role of age in resource ownership in a rural setup. Ricker-Gilbert *et al*. (2011) found that households with older heads may have strong, long-term networks with the government officials charged with vetting the beneficiaries of subsidised fertiliser.

Rented-in land positively influenced the quantity of subsidised fertiliser received by 0.46 points. This is evidence that households with access to more land receive significantly more subsidised fertiliser. Boughton *et al*. (2007) found that increased access to land enabled farmers to benefit from emerging market opportunities such as fertiliser subsidy programmes. Ariga and Jayne (2010) found that households in Kenya that rent land have a higher likelihood of purchasing fertiliser in order to maximise profit than those who have titled land.

Net crop income was positive and significant at the 5% level. This means that an increase in net crop income increases the household's probability of participating in commercial markets. Melesse (2015) found that if income is invested in farm technology to boost production volumes it may increase the marketable surplus, thereby increasing households' market participation in input markets. A plausible explanation for this effect is that an increase in marketable surplus may translate into increased household participation in input markets.

As expected, total livestock units (TLU) had a negative but significant effect on the quantity of subsidised fertiliser acquired by the household. This is because an increase in TLU means more manure, and therefore households purchase smaller quantities of fertiliser. Minot *et al*. (2000) found that each additional animal in Benin reduced the quantity of fertiliser used by 1 kg.

4.2 Determinants of market participation and the extent of participation in commercial fertiliser markets in the North Rift region of Kenya

4.2.1 Commercial market participation

Table 3 presents the determinants of farmers' participation in commercial markets. The coefficients in the first hurdle are the participation APEs, while those in the second hurdle are the conditional APEs.

The use of improved maize seed increased households' probability of participating in the commercial fertiliser market by 0.47 points in the North Rift region. This is indicative of patterns in adoption behaviour in terms of which farmers adopt improved maize production technologies as a package. Ouma *et al*. (2015) found that the use of fertiliser increased the probability of the adoption of improved maize varieties by 28% in Kenya. Ricker-Gilbert *et al*. (2013) found that farmers in Malawi who planted improved varieties of maize used 50 kg more fertiliser than those who did not.

Household ownership of a mobile phone had a positive effect on households' probability of participating in fertiliser markets. This is because mobile phone communication provides information and market linkages that help to lower uncertainties and information asymmetries. Muto and Yamano (2009) found that mobile phones increased Ugandan households' probability of participating in markets as they provide price regardless of distance from the market centres. In this study, owning a mobile phone increased households' probability of participating in fertiliser markets by 0.47 points.

Fertiliser price had a negative effect on the probability of the household participating in commercial fertiliser markets. This is because higher prices hinder households' participation in fertiliser markets. It is also an indication that farmers who decide to participate in the commercial fertiliser market pay attention to input prices. Ricker-Gilbert *et al.* (2009) and Xu *et al*. (2009) found that commercial fertiliser prices had a negative effect on a household's participation in the private fertiliser market in Malawi and Zambia respectively.

Table 3: Factors influencing farmers' participation and level of participation in commercial fertiliser markets in the North Rift region of Kenya

Variable	Hurdle 1† Participation in private market		Hurdle 2† Quantity of fertiliser purchased	
	Coefficient	Z-value	Coefficient	Z-value
Male (1/0)	0.046	0.693	0.082	0.476
Access to credit (1/0)	0.053	0.722	-0.025	0.843
Used improved maize (1/0)	0.471	0.000***	0.128	0.362
Owns a mobile phone (1/0)	0.1458	0.000***	0.592	0.014**
Owns a bicycle (1/0)	-0.140	0.286	0.296	0.009**
Poor household (1/0)	-0.096	0.542	-0.200	0.126
Middle-income household (1/0)	-0.188	0.114	-0.314	0.300
Rich household				
Price of output/90 kg bag	0.000	0.192	0.000	0.202
Price of fertiliser/kg	-0.007	0.042**	-0.023	0.000***
Household size	-0 .044	0.025**	0.031	0.087*
Years in school	0.036	0.001***	0.013	0.216
Age in years	-0.003	0.399	-0.000	0.774
Land owned (acres)	-0.005	0.558	0.051	0.000***
Land rented in (acres)	0.175	0.004**	0.072	0.019**
Distance to the nearest produce market (kilometres)	0.005	0.472	0.005	0.557
Distance to the nearest motorable road (kilometres)	-0.108	0.001***	-0.075	0.046**
Distance to the nearest extension service (kilometres)	-0.016	0.001***	-0.003	0.507
Distance to fertiliser seller (kilometres)	-0.022	0.000***	0.004	0.578
Distance to the nearest NCPB depot (kilometres)	0.006	0.000***	0.005	0.000***
Crop income (Kenya shilling)	1.736	0.030**	1.716	0.000***
Total livestock units	-0.032	0.556	-0.202	0.000***
Quantity of subsidised fertiliser acquired (kilograms)	-0.291	0.000***	-0.201	0.005***
IMR			-0.938	0.062*
Residual	0.167	0.090*	0.482	0.682

Source: Field survey data
† Coefficients represent average partial effects (APEs)
*, ** and *** represent statistical significance at the 10%, 5% and 1% levels respectively.

Household size had a negative effect on household decision to participate in commercial fertiliser markets. This is consistent with previous literature, such as that of Heltberg and Tarp (2001), who found in Mozambique that the number of people in the household was negatively correlated with output or input market participation because home consumption increases as households become larger, and therefore such households are less likely to participate in markets. In the abovementioned study, a one member increase in household size decreased the household's probability of participating in fertiliser markets by 0.04 points.

Years in school of the household head had a positive effect on households' likelihood of participating in fertiliser markets. In this study, a one-year increase in years of schooling of the household head increased the likelihood of a household participating in commercial fertiliser markets by 0.036 points. The finding is consistent with the findings of Martey *et al*. (2012) and Lubungu *et al*. (2012), who found that formal education is an essential tool for the utilisation of market information dynamics in Ghana and Zambia respectively.

Distance to the nearest fertiliser sellers and motorable road had a negative and significant effect on farmers' participation in commercial fertiliser markets. These findings are consistent with those of Mukundi (2014), who found that increase in distance to the market was associated with a lower level of market participation as a result of the increase in marketing costs in Kenya. Ariga and Jayne (2010) found that households located 10 kilometres away from fertiliser sellers in high-potential areas in Kenya decreased their probability of participating in fertiliser markets by 0.23 points. In this study, an increase of 10 kilometres to the fertiliser seller decreased the household's likelihood of participating in the commercial fertiliser market by 0.22 points.

Nearness to NCPB depot had a positive and significant effect on the probability of a household to participate in commercial markets. This implies that households living farther away from NCPB depots are more likely to purchase commercial fertiliser due to the associated transaction and transport costs in pursuit of subsidised fertiliser. In this study, an increase of 10 kilometres in the distance to the nearest NCPB depot increased households' probability of participating in the commercial fertiliser market by 0.06 points.

The quantity of subsidised fertiliser acquired had a negative but significant effect on farmers' participation in private fertiliser markets. This implies that the national fertiliser subsidy is suppressing farmer participation in the commercial fertiliser market, rather than strengthening it. In this study, 1 kg of subsidised fertiliser was found to decrease households' probability of participating in commercial markets by 0.29 points. Ricker-Gilbert *et al*. (2011) found that 100 kg of subsidised fertiliser led to a farmer being about 10 percentage points less likely to participate in the commercial fertiliser market.

4.2.2 Intensity of market participation

The coefficients in the second hurdle in Table 3 show the effect of the selected variables on the quantity of commercial fertiliser purchased conditional to participation.

Ownership of a mobile phone by the household had a positive effect on households' quantity of fertiliser purchased. This is because, as noted earlier, mobile phone communication provides market information and lower information asymmetries and inefficiencies. Muto and Yamano (2009) found that mobile phones increased households' probability of participating in markets, as they provided price information from the markets centres in Uganda. In this study, owning a mobile phone increased households' quantity of fertiliser purchased by 0.6 kg.

Ownership of a bicycle by households had a positive influence on the quantity of commercial fertiliser purchased. This is because ownership of transport equipment reduces transport costs. This result is consistent with the findings of Key *et al.* (2000), who found that ownership of means of transport lowered the proportional transaction costs, thereby enhancing the intensity of market participation. In this study, ownership of a bicycle by a household increased the quantity of commercial fertiliser purchased by 0.3 kg.

As expected, household size had a positive effect on the quantity of commercial fertiliser purchased by a household. This implies that a large household is more likely to use fertiliser than a small one, suggesting that fertiliser and family labour are complements in production. The results support the findings of Deininger and Okidi (1999), who found that large families in Uganda may use fertiliser to fulfil higher food requirement in cases where the probability of expanding land holding is restricted by imperfect or missing land markets. Minot *et al*. (2000) found that each additional family member raises the quantity of fertiliser used by a household by 0.6 points in Ghana. In this study, each additional member of a household increased the quantity of fertiliser purchased from commercial outlets by 0.09 kg.

The size of land owned by a household had a positive effect on the quantity of commercial fertiliser purchased by a household, as expected. This is because land sizes determine the quantity of inputs used by a household. The positive relationship between land size and quantity of subsidised fertiliser implies that wealthier households were more likely to purchase unsubsidised fertiliser than poor households. These results are consistent with the findings of Liverpool-Tasie (2014) in Nigeria, namely that larger land holdings indicate a potentially larger quantity of fertiliser needed. Minot *et* *al*. (2000) found that each additional hectare is associated with an additional 170 kg of fertiliser on fertiliser plots in Ghana. In this study, a one hectare increase in size of land owned increased the quantity of commercial fertiliser acquired by 5 kg, which is a small margin.

Distance to the nearest NCPB depot had a positive effect on the amount of fertiliser purchased by the household. This implies that, as the distance to the NCPB depot increases, farmers resort to purchasing fertiliser from commercial markets, which probably are nearer than the NCPB. This is because the national fertiliser subsidies are distributed via NCPB depots. In this study, a one kilometre increase in distance to NCPB depot increased the quantity of commercial fertiliser purchased by 0.005 kg. This finding is consistent with Adanikin (2008), who found a positive effect of distance to fertiliser-selling depots on intensity of the adoption of agricultural technologies in Akure South in Nigeria.

Total livestock units had a negative effect on quantity of commercial fertiliser acquired by the household. This is because livestock ownership would mean more manure, hence households are likely to purchase less commercial fertiliser. In this study, a unit increase in TLU increased the quantity of commercial fertiliser purchased by household by 0.2 kg. Jaleta *et al*. (2009) found that, in Ethiopia, ownership of livestock had a negative effect on households' participation in the crop and input markets because it distracted the farmer into an alternative source of income. Minot *et al*. (2000) found that each additional animal reduced the quantity of fertiliser used by 1 kg in Benin.

Subsidised fertiliser significantly reduced the quantity of fertiliser purchased from the private markets. In this study, a 1 kg increase in the quantity of subsidised fertiliser was found to decrease the quantity of fertiliser purchased from the commercial market by 0.20 kg in the North Rift Valley region. Ricker-Gilbert and Jayne (2009) found that the fertiliser subsidy in Malawi displaced 0.2 kg from the private market. Ricker-Gilbert *et al*. (2011) found that an additional kilogram of subsidised fertiliser crowded out 0.22 kg of commercial fertiliser.

5. Conclusion and recommendations

In an effort to correct market failures and promote pro-poor agricultural growth, many countries in sub-Saharan Africa (SSA) are increasingly investing in the distribution of subsidised fertiliser. However, there are concerns about whether such programmes achieve their intended purpose. In Kenya, the national fertiliser subsidy programme aims at encouraging fertiliser use, supporting local fertiliser manufacturers and strengthening fertiliser distribution. This study sought to understand the effect of this programme on the commercial fertiliser market. A double-hurdle model and control function approach were used to account for the corner solution nature of fertiliser demand and endogeneity respectively.

The study found evidence that farmers related to the leadership of location-level subsidy fertiliser vetting committees received greater amounts of subsidised fertiliser. This means that households' social networks affected the quantity of subsidised fertiliser received. Furthermore, greater quantities of subsidised fertiliser went to households with higher land holdings and crop incomes. Using the rich households as the base category, the poor and middle-income households received 4.2 kg and 3.5 kg disproportionately less subsidised fertiliser respectively. This is an indication that Kenya's national fertiliser subsidy does not favour resource-poor households. In addition, the results indicate that households farther away from produce markets receive less subsidised fertiliser, while those nearer to a NCPB depot or living further away from the commercial fertiliser sellers receive more subsidised fertiliser. These results offer evidence that the national fertiliser subsidies do not reach households in areas with weak infrastructure. The national fertiliser subsidy reduces both the probability and extent of participation in the private fertiliser market. On average, an additional 1 kg of fertiliser distributed through the NCPB reduced quantities purchased from the private markets by

0.13 kg. This means that, for every ton of subsidised fertiliser distributed by the government, 130 kg is displaced from the commercial market. This is a clear indication that the national fertiliser subsidy does not achieve its goal of strengthening the existing fertiliser channels.

Therefore, it is important for the government and policy makers to consider redesigning the current national fertiliser subsidy programme to involve the private sector in the distribution to minimise displacement and motivate the stakeholders in the value chain. Once this has been done, proper administration processes for the distribution of the subsidised fertiliser should be put in place to ensure that the private sector does not charge commercial prices for the subsidised fertiliser. Although expensive, if the programme objectives are to be achieved, targeting the beneficiaries is also recommended to ensure that the households who receive subsidised fertiliser are resource poor.

References

Adanikin FF, 2008. Analysis of factors determining adoption pattern of fertilizer technology among small scale farmers in Akure South local government area. Unpublished BTech thesis, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Ariga J & Jayne TS, 2010. Factors driving the increase in fertilizer use by smallholder farmers in Kenya, 1990-2007. In Chuhan-Pole P & Angwafo M (eds.), Yes Africa can: Success stories from a dynamic continent. Washington DC: The World Bank. Available at http://siteresources.worldbank.org/AFRICAEXT/Resources/258643-1271798012256/Kenya_fertilizer_june_2010.pdf (Accessed 15 June 2015).

Astewel T, 2010. Analysis of rice profitability and market chain: The case of Fogera Woreda, South Gondar Zone, Amhara National Regional State, Ethiopia. MSc thesis, School of Graduate Studies, Haramaya University, Dire Dawa, Ethiopia.

Becker GS, 1965. A theory of the allocation of time. The Economic Journal 75(299): 493–517.

Boughton D, Mather D, Barrett CB, Benfica R, Danilo A. Tschirley D & Cunguara B, 2007. Market participation by rural households in a low-income country: An asset-based approach applied to Mozambique. Department of Agricultural Economics, Michigan State University, East Lansing.

Deininger K & Okidi J, 1999. Capital market access, factor demand, and agricultural development in rural areas of developing countries: The case of Uganda. Economic Policy Research Centre, Makerere University, Kampala, Uganda.

Heltberg R & Tarp F, 2001. Agricultural supply response and poverty in Mozambique. Discussion paper no. 2001/114, World Institute for Development Economics Research (WIDER), United Nations University, Helsinki, Finland.

International Fertilizer Development Corporation (IFDC), 2012. Kenya fertilizer assessment. Available at https://ifdcorg.files.wordpress.com/2015/04/kenya-fertilizer-assessment-report-2012.pdf (Accessed 12 March 2014).

Jaleta M, Gebremedhin B & Hoekstra DA, 2009. Smallholder commercialization: Processes, determinants and impact. Addis Ababa, Ethiopia: International Livestock Research Institute.

Key N, Sadoulet E & DeJanvry A, 2000. Transactions costs and agricultural household supply response. American Journal of Agricultural Economics 82(2): 245–59.

Liverpool- Tasie LS, 2012. Targeted subsidies and private market participation: An assessment of fertilizer demand in Nigeria. IFPRI discussion paper No. 1194. International Food Policy Research Institute (IFPRI), Washington DC.

Liverpool- Tasie LS, 2014. Fertilizer subsidies and private market participation: The case of Kano State, Nigeria. Agricultural Economics 45(6): 663–78.

Lubungu M, Chapoto A & Tembo A, 2012. Smallholder farmers participation in livestock markets: The case of Zambian farmers. Working paper no. 66, Indaba Agricultural Policy Research Institute, Lusaka, Zambia.

Makhura MN, Kirsten J & Delgado C, 2004. Transaction costs and smallholder participation in the maize market in the Northern Province of South Africa. In Friesen DK & Palmer AFE (eds.), Integrated Approaches to Higher Maize Productivity in the New Millennium: Proceedings of the Seventh Eastern and Southern Africa Regional Maize Conference, 5–11 February 2002, Nairobi, Kenya. Nairobi: KARI *CIMMYT.

Martey E, Al-Hassan RM & Kuwornu JK, 2012. Commercialization of smallholder agriculture in Ghana: A tobit regression analysis. African Journal of Agricultural Research 7(14): 2131–41.

Melesse TM, 2015. Agricultural technology adoption and market participation under learning externality: Impact evaluation on small-scale agriculture from rural Ethiopia. Working paper no. 2015/06, Maastricht School of Management, Maastricht, The Netherlands.

Ministry of Agriculture, Livestock and Fisheries (MoALF), 2014. Subsidy fertilizer distribution guidelines. Available at http://kenyalaw.org/kenya_gazette/gazette/volume/MTE1NQ--/Vol.CXVII-No.33 (Accessed 22 April 2014).

Minot N, Kherallah M & Berry P, 2000. Fertilizer market reform and the determinants of fertilizer use in Benin and Malawi. MSSD discussion paper no. 40. International Food Policy Research Institute (IFPRI), Washington DC.

Moser C & Felton A, 2007. The construction of the asset index measuring asset accumulation in Ecuador. CPRC working paper 87, Global Economy and Development, The Brookings Institution Massachusetts, Washington DC.

Mukundi EN, 2014. Sweet potato marketing among smallholder farmers in Rachuonyo district, Homa Bay county, Kenya: The role of collective action. Unpublished MSc Thesis, Egerton University, Njoro, Kenya.

Muto M & Yamano T, 2009. The impact of mobile phone coverage expansion on market participation: Panel data evidence from Uganda. World Development 37(12): 1887–96.

Ndung'u N, Thugge K & Otieno O, 2009. Unlocking the future potential for Kenya: The Vision 2030. Paper presented at the CSAE Conference, 22–24 March, Centre for the Study of African Economies, Oxford.

Ouma J, Bett EK & Mbataru P, 2015. Drivers of adoption of improved maize varieties in moist transitional zone of Eastern Kenya. Journal of Economics and Sustainable Development 5(25): 147–56.

Ricker-Gilbert J & Jayne TS, 2009. Do fertilizer subsidies affect the demand for commercial fertilizer? An example from Malawi. Paper delivered at the International Association of Agricultural Economists Conference, 16–22 August, Beijing, China.

Ricker-Gilbert J, Jayne T & Shively G, 2013. Addressing the "wicked problem" of input subsidy programs in Africa. Applied Economic Perspectives and Policy 35(2): 322–40.

Ricker-Gilbert J, Jayne, TS & Chirwa E, 2011. Subsidies and crowding out: A double-hurdle model of fertilizer demand in Malawi. American Journal of Agricultural Economics 93(1): 26–42.

Singh I, Squire L & Strauss J, 1986. Agricultural household models: Extensions, policy and applications. Baltimore MD: John Hopkins University Press.

Staiger D, Stock JH & Watson MW, 1997. The NAIRU, unemployment and monetary policy. The Journal of Economic Perspectives 11(1): 33–49.

Stock JH & Yogo M, 2002. Testing for weak instruments in linear IV regression. Technical working papers no. 284. National Bureau of Economic Research, Cambridge MA.

Takeshima H & Lee HL, 2012. Agricultural inputs subsidy and their developmental impact: Conventional wisdom. Washington DC: International Food Policy Research Institute (IFPRI).

Wooldridge JM, 2008. Quasi-maximum likelihood estimation and testing for nonlinear models with endogenous explanatory variables. Department of Economics, Michigan State University, East Lansing.

Xu Z, Burke WJ, Jayne, TS & Govereh J, 2009. Do input subsidy programs "crowd in" or "crowd out" commercial market development? Modeling fertilizer demand in a two- channel marketing system. Agricultural Economics 40(1): 79–94.