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The impact of farm input subsidies on maize marketing in Malawi

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Abstract

This paper investigates the effects of subsidized fertilizer on marketing of maize in Malawi. It uses the nationally representative two-wave Integrated Household Panel Survey (IHPS) data of 2010 and 2013. The correlated random effects method of analyzing linear and non-linear panel data models is used to estimate the average partial effects. The control function approach of the instrumental variables methods is employed to control for potential endogeneity of subsidized fertilizer. The results suggest that subsidized fertilizer increases farmers' market participation as sellers, quantity sold and commercialization of maize. However, the magnitudes of the effects are relatively smaller, which highlight the challenge of improving farm household income from sales of staple food crops. The results have implication on sustainability of the program, policy formulation and design of programs for the agricultural sector and small farmers in developing countries.

Keywords: Farm Input Subsidy; Maize Marketing; Malawi.

JEL Classification: Q1, Q13, Q18.

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1 Introduction

Small farmers' participation in markets is one of the most important factors necessary for economic growth and poverty reduction in developing countries (Heltberg and Tarp, 2002; Muriithi *et al.*, 2015; Pingali, 2007; World Bank, 2007). Markets offer households opportunities to engage in productive activities through investments in diversified livelihood strategies and sell both labor and products (IFAD, 2003: World Bank, 2000). Access to input and output markets is also important for farm households' adoption of modern technologies (e.g. fertilizers and hybrid seed varieties), which are important for increased productivity and incomes. However, in developing countries poor access to, and low participation in markets are pervasive, especially as far as small farmers are concerned, which limit livelihoods opportunities and perpetuate their poverty (Barrett, 2008; Heltberg and Tarp, 2002; Jayne *et al.*, 2010; Poulton *et al.*, 2006). This is one of the major concerns for governments which depend on agriculture as a pro-poor growth strategy (de Janvry *et al.*, 1991).

Small farmers' poor access to, and low participation in markets, is mainly attributed to barriers to entry (Barrett, 2008; Jayne *et al.*, 2010). These barriers may include high inputs requirements in form of land, chemicals, fertilizer and processing; high products' quality demand, and high transaction costs of marketing (Barrett, 2008; Heltberg and Tarp, 2002; Mather *et al.*, 2013; Poulton *et al.*, 2006). The global agricultural conditions are rather instable due to multiple factors, including changes in farm policies in high-income countries and a significant decline in donor and state support to the agricultural sector (Jayne *et al.*, 2010). As a result, the majority of small farmers in developing countries focus on production of food crops for subsistence.

To increase the use of fertilizers and hybrid seeds by small farmers, and consequently, improve crop production and productivity, farm input subsidy program was one of the policy tools used by many developing countries prior to the implementation of structural adjustment and stabilization programs (IMF, 2008). Although most of the input subsidy programs were phased out in the 1980s and early 1990s in most countries in sub-Saharan Africa (Husain, 1993; World Bank, 2007), since 1998 several countries have reintroduced them, including Malawi (Dorward *et al.*, 2008; IMF, 2008). In the process of implementation of the recent subsidy programs countries have devised the so-called 'market-smart' subsidies. The World Bank, (2007:151) defines 'market-smart' subsidies as: "subsidies whose implementation facilitates development of private sector-led input markets, targets the poor, sustains existing commercial markets, is of limited period and uses instruments such as vouchers, matching grants and partial loan guarantees". Since the input subsidies target specific crops, this may affect farmers' decisions on cropping patterns and, therefore, may have direct effects on marketing of food crops. Such potential marketing effects have not been fully analyzed in previous studies.

The main objective of this study is to estimate the effects of subsidized fertilizer on marketing of maize in Malawi. The specific objectives are to estimate the impact of subsidized fertilizer on (i) farmers' participation in maize market as sellers; (ii) quantity of maize sold; and (iii) commercialization index of maize, i.e. the proportion of maize quantity sold to total maize quantity harvested. Determining the extent of farmers' maize market participation, quantity sold and the degree of commercialization is important to give insights into the potential increase in maize market supply as a result of the fertilizer subsidy program. Such information is essential for understanding the effects on maize prices since most small farmers are net maize buyers. It will also provide indication of the ability of the program beneficiaries to self-finance commercial purchase of fertilizer in the future with income from maize sales and hence the sustainability of the subsidy program. The estimations are based on the nationally representative two-wave Integrated Household Panel Survey (IHPS) data of 2010 and 2013 for Malawi.

There are several recent studies analyzing different aspects of the effects of farm input subsidies (Chibwana *et al.,* 2012; Chibwana *et al.,* 2010; Chirwa *et al.,* 2013; Dorward and Chirwa, 2011; Holden and Lunduka, 2010; Ricker-Gilbert *et al.,* 2013; Ricker-Gilbert *et al.,* 2011; Ricker-Gilbert and Jayne, 2011; Xu *et al.,* 2009) and agricultural marketing in general. To our best knowledge, this is the first study to empirically quantify the effects of subsidized fertilizer on marketing of maize in Malawi. The only studies which are close to some of the aspects analyzed in this paper are Ricker-Gilbert *et al.,* 2013, who investigate the effects of fertilizer subsidy on maize prices in Malawi and Zambia and Takeshima and Liverpool-Tasie (2015), who analyze the effects of fertilizer subsidies on grain prices in Nigeria. In contrast to previous studies which focused on marketing of food crops, this paper adds estimation of factors influencing commercialization of maize, which helps to identifying key factors necessary for the transition of farmers from subsistence to commercial maize farming.

This paper is structured as follows. The next section presents a review of the impact of the recently introduced farm input subsidies in developing countries. Section three presents an overview of the performance of agricultural sector and marketing in Malawi. Section four and five discusses the conceptual framework and the empirical models, respectively. Section six presents the data. Empirical results are presented in section seven and section eight concludes.

2 Effects of farm input subsidies in developing countries: a review of recent studies

Against the orthodox evidence that subsidies distort markets in the economy, a new wave of agricultural input subsidies is emerging in most developing countries. The introduction of input subsidies is aimed at addressing challenges of low output and productivity of poor smallholder farmers who are financially constrained to purchase improved inputs for production and consequently, contributing to achieving self-food sufficiency at household and national levels and alleviating poverty. Table 1 presents a list of countries and the time frame they have been implementing the recently large scale farm input subsidy programs in the Eastern and Western Africa in the period of the post-structural adjustment programs.

Table 1: Implementation period of large scale farm input subsidy programs in Eastern and Western Africa in the period of the post-structural adjustment programs.

Region	Country	Large scale farm input subsidy program implementation period
Eastern Africa	1. Zambia	2002 - on
	2. Malawi	2005 - on
	3. Tanzania	2008 - on
	4. Rwanda	2007 - 2009
	5. Kenya	2007 - on
Western Africa	1. Burkina Faso	2008 - on
	2. Senegal	2008 - on
	3. Mali	2008 - on
	4. Nigeria	1999 - on
	5. Ghana	2008 - 0n

Source: DANIDA, (2011); Druilhe and Barreiro-Hurle, (2012); Ricker-Gilbert *et al.*, (2013).

There are several studies on the impact of the recently implemented farm input subsidy programs in sub-Saharan Africa (SSA). However, the literature shows that there are more studies focusing on Malawi and Zambia. Probably because these two countries were among the first to reintroduce the large scale farm input subsidies in this region in the early 2000s. The recent studies have focused on both direct and general equilibrium impact of farm input subsidies.

Crop output effects of farm input subsidies is one of the areas which has been extensively studied. Studies by Chibwana, *et al.,* (2010); Holden and Lunduka, (2010); Ricker-Gilbert and Jayne, (2011) and Dorward *et al.,* (2013) all find statistically significant positive effects of farm input subsidies on maize production and productivity in Malawi. Ricker-Gilbert and Jayne, (2011) find that an additional kilogram (kg) of subsidized fertilizer increases maize production by 1.82 kg in the current year and 3.16 kg in the third year of using subsidized fertilizer. Analyzing maize yield response to farm input subsidies, Chibwana, *et al.,* (2010) find that using subsidized fertilizer only increases maize yield by 249 kg per hectare, while using both subsidized hybrid maize and fertilizer increases maize yield by 447 kg per hectare. Dorward *et al.,* (2013) evaluate the 2012/2013 FISP and based on simulation results report that a full FISP package increases maize production by at least 500 kg, while only 50 kg bag of subsidized fertilizer or with hybrid maize seed increases maize production between 200 kg and 400 kg. Similar results are reported in a study by Mason *et al.,* (2013) who analyze the effects of subsidized fertilizer on maize production in Zambia and find that an additional kilogram of subsidized fertilizer increases maize production by 1.88 kg. The most recent study is by Wiredu *et al.,* (2015) who analyze the impact of fertilizer subsidy on land and labor productivity in Ghana and find that receipt of subsidized fertilizer increases rice production by 29 kg per hectare.

The effects of farm input subsidies on input market has also been analyzed by several researchers. Ricker-Gilbert *et al.,* (2011) and Mason and Ricker-Gilbert (2013) find that an additional kg of subsidized fertilizer and hybrid maize seed in Malawi crowd-out commercial purchases of fertilizer and hybrid maize seed by 0.22 kg and 0.58 kg, respectively. A similar effect of crowding-out of commercial fertilizer is reported in a study by Chirwa *et al.,* (2013), who find a decrease in purchase of commercial fertilizer of between 0.15 % and 0.21% for a 1 % increase in subsidized fertilizer. However, Xu *et al*, (2009) find both crowding out and crowing in effects on commercial fertilizer purchases in Zambia, and Liverpool-Tasie (2014) find that subsidized fertilizer increases both participation in and quantities of commercial fertilizer bought from the private fertilizer markets in Kano State, Nigeria.

Farm diversification effect of farm input subsidies are examined in the existing literature in the context of their impact on land allocation to various crops at household level. Holden and Lunduka, (2010); and Chibwana, *et al.*, (2012) are some of the recent studies for Malawi. However, these two studies find contradicting results, which is mainly attributed to differences in the analytical methodologies employed (Lunduka *et al.*, 2013). Chibwana *et al.*, (2012) find increased land allocated to maize, while Holden and Lunduka (2010) find reduced land allocated for maize production. However, Dorward *et al.*, (2013) and NSO (2014) show decreasing trend on land located to maize and increasing proportion of farmers growing other crops, mainly legumes. The most recent study is by Yi *et al.*, (2015) who analyze the effects of grain subsidies on grain cultivated area in China and they find positive effects, but only on the liquidity-constrained households.

Several studies have also analyzed the household welfare effects of farm input subsidies in Malawi. Dorward and Chirwa, (2011); Chirwa *et al.*, (2013) and Dorward *et al.*, (2013) all find improvement in adequacy of food availability at household level. A study by Ricker-Gilbert and Jayne, (2011) find that on average, an additional kg of subsidized fertilizer increases farm net crop income by US$1.16, however, they find no evidence of effects on asset worth. Ricker-Gilbert and Jayne (2012) also analyze the effects of subsidized fertilizer on crop income employing quantile regression model and find increased crop income to richer households at the top percentiles and no statistically significant effect on poor households at the bottom percentiles. Chirwa, *et al.*, (2013) analyze the effects of farm input subsidies on poverty, primary school enrolment and sickness of under-five year old children and they find overall increase in primary school enrolment and reduced probability of having a sick under-five year old child, but the study finds no statistically significant effects on subjective self-assessed poverty at household level. However, Dorward *et al.*, (2013) find no significant differences on school attendance, sickness of a household member or of under-five year child based on number of times of receipt of subsidies.

Studies on equilibrium effects have focused on food prices and macroeconomic indicators. Ricker-Gilbert *et al.*, (2013) find small effects on maize prices in Malawi and Zambia. Similar results are found by Takeshima and Liverpool-Tasie (2015) who analyze the effects of fertilizer subsidies on grain prices in Nigeria. Chirwa *et al.*, (2013) study the effect of farm input subsidies on GDP and agricultural sector growth, poverty and inflation trends in Malawi and they find that during the implementation period of the farm input subsidy program, Malawi experienced increased GDP and agricultural sector growth; and a decline in poverty and inflation, which are attributed to the FISP. However, their study does not analyze the causal relationship between the macroeconomic indicators under consideration and the farm input subsidy program.

3 Agricultural sector performance and marketing in Malawi

In the post-structural adjustment reform period the performance of the agriculture sector in Malawi has been poor and this has been attributed to the low productivity and profitability of the sector, emanating from the multiple risks associated with production and marketing processes (World Bank, 2004). Inadequate access to agricultural markets due to high transaction costs is a major challenge to most small farmers in Malawi. The World Bank (2010) reports that the marketing system for the agricultural sector in Malawi is inefficient and this is evidenced by higher traders' margin compared to the profits realized by producers. The unfavorable developments of agricultural terms of trade have been another challenge facing the agriculture sector, which has contributed to low profitability. These adverse development have been due to the high costs of transport for both imports to and exports from the country (World Bank, 2004), and the inefficiency of the marketing systems in rural areas (Dorward *et al.,* 2004).

Low agricultural output and the high transaction costs faced by small farmers have resulted in the fact that only a small proportion of small farmers in Malawi participate as sellers of cereals and legumes. Using the 1997/98 data from the first integrated household survey (IHS1), Chirwa (2006) reports that while in general 39 per cent of households which produced crops participated in markets as sellers, only 9 per cent of households which produced maize participated in the market as sellers. Employing data from the second integrated household survey (IHS2), Chirwa (2009) finds out some improvement reporting that in 2004/05 this percentage increased to 15. Figure 1 presents trends in market participation of farmers as sellers of selected cereals and legumes in Malawi including maize, based on surveys conducted between 1997/1998 (IHS1) and 2013 integrated household panel survey (IHPS).

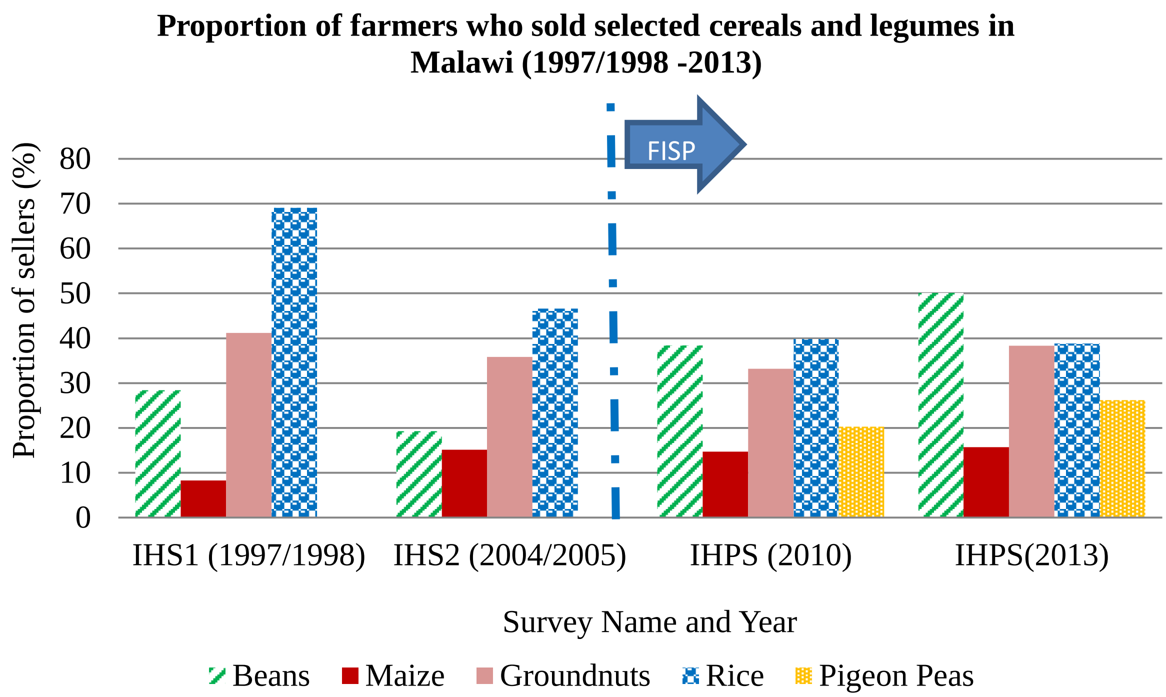

Figure 1. Proportion of farmers who sold selected cereals and legumes in Malawi (1997/1998 -2013)

Notes: IHS: Integrated Household Survey; IHPS: Integrated Household Panel Survey.

Source: Authors based on IHS1 (1997/1998), IHS2 (2004/2005) data and NSO (2014).

The results show that apart from maize, the proportion of farmers who sold beans, groundnuts, and rice significantly decreased following the 2003/2004 agricultural season compared to proportion of sellers following the 1996/1997 agricultural season. A comparison between the period before (statistics based on the 2004/2005 data) and after the implementation of the large scale farm input subsidy program (FISP) suggests there has been no significant increase in the proportion of farmers who sold maize and rice. However, the results show an increase in proportion of sellers of groundnuts, beans and pigeon peas.

The low market participation of small farmers as sellers and the small quantities sold coupled with the low commercialization of cereals is a significant contributing factor towards the persistence of poverty among small farmers whose livelihoods are dependent on production of staple food crops. This raises doubts on the effectiveness of various agricultural policies aimed at facilitating commercialization of major cereals and legumes in Malawi.

However, overall and at national level, the performance of the agricultural sector in Malawi has improved since the reintroduction of the large farm input subsidy program (FISP) in the 2005/2006 agricultural season. In terms of agricultural production at national level, cereals production and productivity has improved since the implementation of FISP (Figure 2).

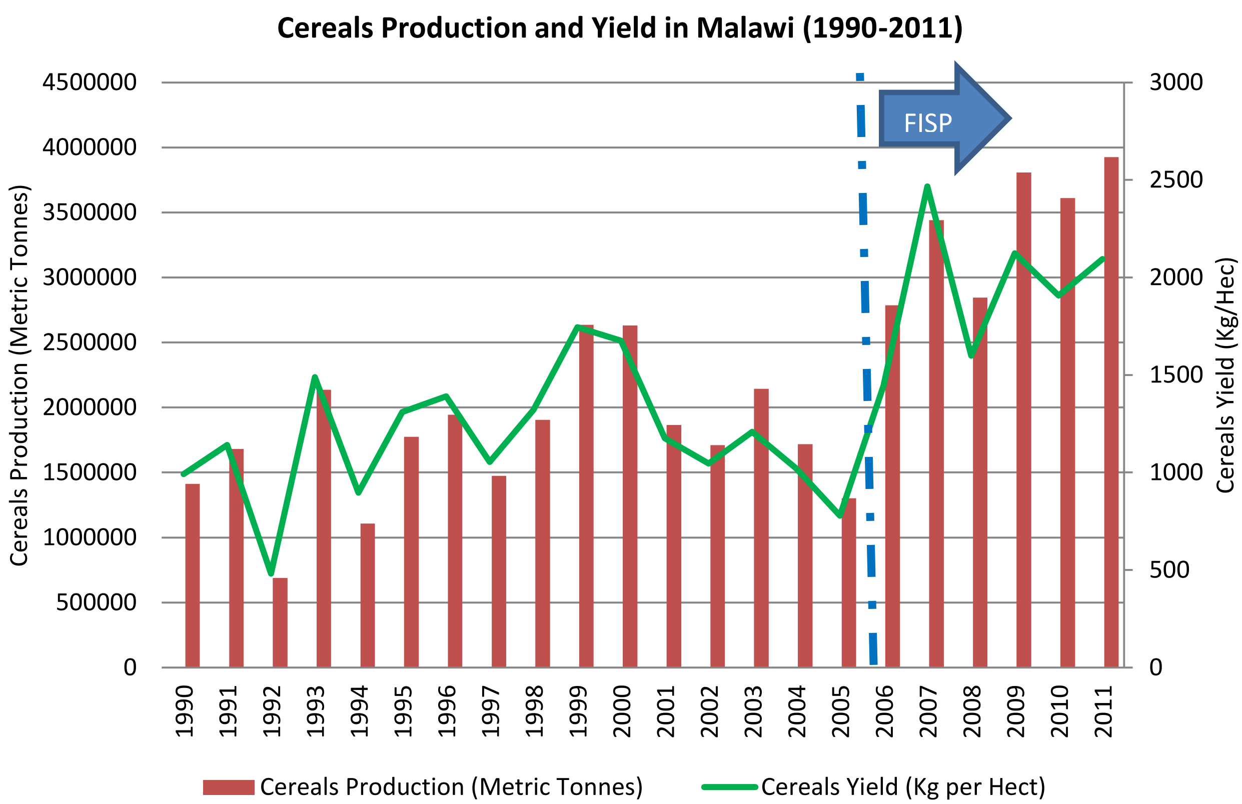

Figure 2: Cereals Production and Yield in Malawi (1990-2011)

Source: Authors' calculations based on FAOSTATS Data (2014).

Similarly, Malawi's international trade balance of cereals shows significant improvement since the implementation of the FISP. The period 2006 to 2011 shows significant increase and decrease of exportation and importation of cereals, respectively, and consequently, significantly improving the cereals balance of trade (Figure 3). Although the statistics in Figures 2 and 3 do not indicate causality relationship between FISP and cereals production, productivity, exports and imports, they suggest improvement in cereals' marketing at national level in Malawi since the implementation of the FISP.

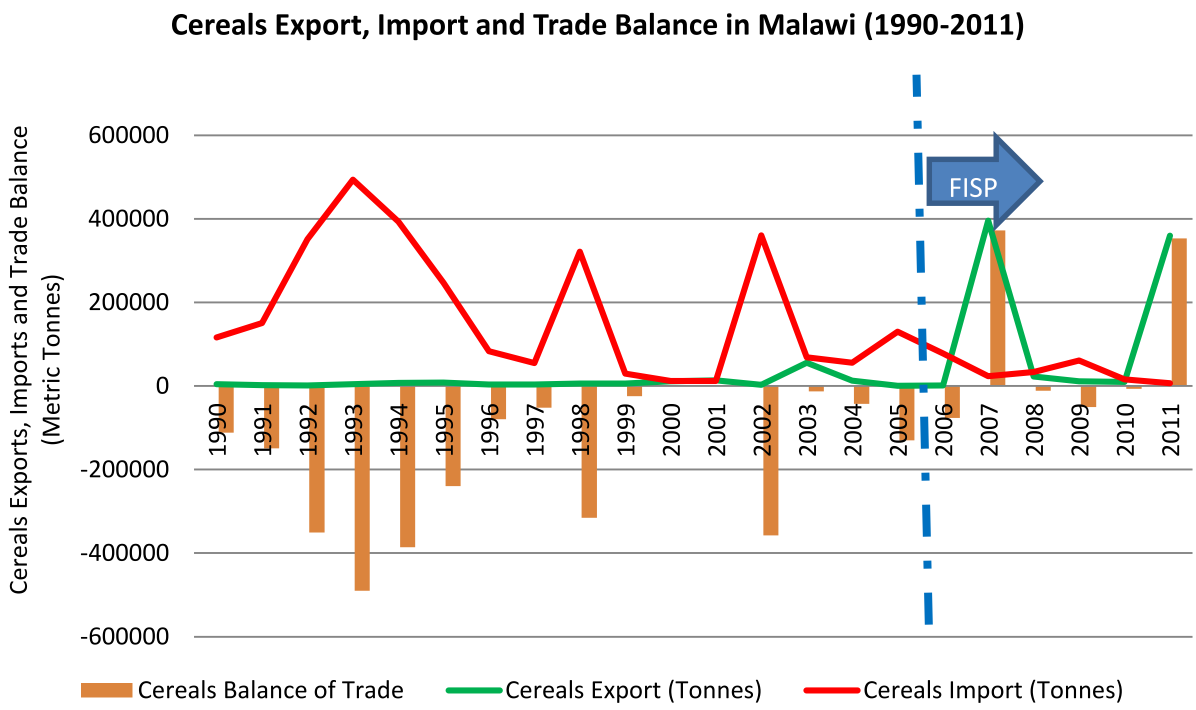

Figure 3. Cereals Export, Import and Trade Balance in Malawi (1990-2011)

Source: Authors' calculations based on FAOSTATS Data (2014).

4 Conceptual framework

This study follows the analytical framework developed in Goetz (1992) in modelling the effects of subsidized fertilizer on farmers' maize market participation as sellers and on the quantities sold. On the supply side, the use of subsidized fertilizer is expected to increase maize production and productivity, and therefore, it is expected to increase maize market participation by farmers benefiting from the subsidy program. However, the farmer decides on the quantities devoted to household consumption not only based on the crop production levels, but also on output prices, consumption characteristics, e.g. the number of household members, exogenous income sources and farm profits.

Production of cereals by most farmers in Malawi is rain-fed and consequently, has an annual production cycle. As a result, farmers also make decisions on production, consumption and sales levels taking into account the annual production cycle. In addition, due to poor storage facilities, the post-harvest losses of cereals and legumes are high. For simplification, in this study it is assumed that there are no inter-temporal decisions on consumption at household level.

It is also assumed that farmers' decision on whether to sell or not to sell (consume) part of the maize output is based on utility derived by the chosen regime. The farmer's decision is based on the expected benefits of either of the regimes (i.e. selling or consuming maize output), taking into account transaction costs. It is also assumed that only one marketing regime is chosen by the famer at a time, thus making the decision binary.

Based on the expected increase in maize production and productivity as a result of the use of subsidized fertilizer, three hypotheses are formulated in relation to farm households' maize market participation; (1): There is positive relationship between the use of subsidized fertilizer and the decision to sell maize; (2): There is positive relationship between the use of subsidized fertilizer and quantities of maize the farm household sell; (3): There is positive relationship between the use of subsidized fertilizer and maize commercialization (i.e. proportion of quantity sold to quantity harvested).

The random utility theory proposed by Greene (2003) is employed in this study in modelling the choice of the marketing regime. Assuming that the i^{th} farmer is faced with two M marketing regimes, the farmer maximizes utility by choosing marketing regime M, which can be presented as:

$$MaxU_{im} = X_{im}^{'}\beta + \varepsilon_{im} \quad (1)$$

where U_{im} is the utility derived from choosing marketing regime M and M=1 if the farmer participates in the market, otherwise M=0; $X_{im}^{'}$ is a vector of attributes of farmer's characteristics; β is a vector of parameter coefficients; and ε_{im} is an idiosyncratic error term.

Suppose the farmer's utility of two choices is represented by U_m and U_c, where U_m is utility of market participation as a seller and U_c is utility of consumption (i.e. no market participation as a seller). If the farmer chooses one of the two regimes, this implies that the observed decision provides greater utility compared with the unobserved utilities. Therefore, the observed chosen marketing decision equals 1 if $U_m > U_c$, and 0 if $U_m < U_c$.

5 Empirical models

Three empirical analyzes are carried out with regard to: (i) farmers participation in maize market as sellers; (ii) quantities of maize sold; and (iii) commercialization index (i.e. proportion of total quantity sold to total quantity harvested).

Since only a small proportion of farmers sell maize in Malawi, this makes the data on quantity sold of maize to have a high proportion of zeros because non-maize market participants have zero quantities sold of maize. The production of maize mainly for subsistence by most small farmers provides economic justification for the decision not to sell maize and this decision is strategic to the farmers' livelihoods. Therefore, this study does not consider non-participation of famers in maize marketing as a pure selectivity issue as is the case with missing data sample selection models, but rather as a corner solution. The quantity sold of maize in this study has characteristics of truncated data, with large number of zeros and small number of continuous data units. For such dependent variables, the ideal models employed in estimations are the Tobit model for corner solution and the Double Hurdle model. In the case of incidental truncation of the data (missing data for non-participants), which causes the problem of sample selection bias, most empirical studies using cross-section data employ the Heckman model or the two stage sample selection model. The sample selection model is based on the assumption that the unobserved quantities sold by non-participants in the market as sellers is attributed to barriers to entry due to constraints conditional on household characteristics, such as assets endowments and transaction costs.

The farm input subsidy program (FISP) in Malawi provides coupons of subsidized fertilizer to beneficiaries using a set of targeting criteria. Since the coupons are not randomly distributed, the unobserved household heterogeneity factors influencing receipt of the coupons may also influence maize market participation and the quantity sold, consequently making subsidized fertilizer endogenous.

Therefore, empirical estimations have to address the potential endogeneity of subsidized fertilizer. In this study the dependent variables are non-linear. For market participation is binary; the commercialization index variable is proportional bounded between zero and one; and for quantity sold of maize is discrete and includes zero quantity for non-maize sellers. The quantity of subsidized fertilizer redeemed by the beneficiaries is also discrete and includes zero quantity for non-beneficiaries. We therefore, estimate market participation, quantity of maize sold, and commercialization index using correlated random effects (CRE) models following Papke and Wooldridge (2008) and Wooldridge (2010, 2013).

5.1 Model of farmers' participation in maize market as sellers (i.e. selling maize).

Farmers' market participation as sellers of maize is estimated using the pooled CRE Probit model, taking into account the potential endogeneity of subsidized fertilizer by using the Control Function (CF) approach as an instrumental variable (IV) method (Papke and Wooldridge, 2008; Wooldridge, 2010, 2013). Therefore, the participation equation to be estimated can be written as follows:

$$y_{it1} = hhc_{it1}\beta_1 + r_{i1}\beta_2 + mkt_{it1}\beta_3 + \beta_4 subfert_1 + \beta_5 v_{it2} + c_i + \overline{Z}_i\beta_6 + \mu_{it} \qquad (2)$$

where y_{it1} is the binary dependent variable and equals one if the farmer participated in the market as a seller of maize, or zero otherwise; hhc_{it1} is a vector of household characteristics and includes gender, age and education of household head, total land, rural location, real value of durable assets, household size and crop diversification; r is a vector of regional dummies representing north, south and central regions location of households; mkt is a vector of marketing factors and includes ICT information on maize marketing and distance to daily market; $subfert$ is vector of subsidized fertilizer redeemed by the household; v_{it2} is a vector of the generalized residuals from the reduced form pooled CRE Tobit model of subsidized fertilizer, $subfert$; c_i is the time-invariant unobserved heterogeneity of the household; $\overline{Z}$ is the time averages of the time-variant explanatory variables; μ_{it} is an idiosyncratic error term; and β are the parameters to be estimated.

5.2 Model of quantity of maize sold.

Maize quantity sold by farmers is estimated using the pooled Double Hurdle CRE Model. We take into account the potential endogeneity of subsidized fertilizer by applying the Control Function (CF) approach of instrumental variables (IV) methods. Recent application of the pooled Double Hurdle CRE Model is by Mather *et al.,* (2013) in estimating maize marketing by smallholder farmers in southern and eastern Africa.

We also estimate two other competing models to check the robustness of the empirical estimates: the pooled CRE Tobit Model for corner solution and the pooled CRE OLS Model, which takes into account both, sample selection bias and the potential endogeneity of subsidized fertilizer. The control function approach is used as an IV method to address the potential endogeneity of subsidized fertilizer (Semykina and Wooldridge 2010; Wooldridge, 2013). All other explanatory variables for the quantity equation are the same as in Eq. (2) with the exception of the ICT and crop diversification covariates, which are not included and are used as exclusions for selectivity into market participation in the pooled Double Hurdle CRE Model and pooled CRE OLS Model. In addition, the quantity equation in the pooled CRE OLS Model includes the inverse Mills ratio as an additional covariate. The quantity equation for estimation of the pooled Double Hurdle CRE Model is as follows:

$$y_{it1} = hhc_{it1}\beta_1 + r_{i1}\beta_2 + \beta_3 dis_{it1} + \beta_4 subfert_1 + \beta_5 v_{it2} + c_i + \overline{Z}_i\beta_6 + \mu_{it} \qquad (3)$$

where y_{it1} is the discrete dependent variable representing quantity of maize sold by farmer i in natural logarithm; v_{it2} is a vector of the residuals from the reduced form pooled CRE Tobit model of subsidized fertilizer $subfert$;and all other explanatory variables are the same as in Eq.(2) with the exception of the ICT and crop diversification covariates.

The selection of this model against the pooled CRE Tobit Model for corner solution and the pooled CRE OLS model is based on the test results on selecting non-nested models (Vuong, 1989). The Vuong test results have shown that the pooled Double Hurdle CRE Model fits better the data with p-value of 0.000 on the Likelihood Ratio statistic.

5.3 Model of maize commercialization index

Estimation of the commercialization index uses the pooled CRE Fractional Probit Model and estimators are obtained by using the generalized linear model (GLM) approach. The potential endogeneity of subsidized fertilizer is taken into account by using the control function approach as an IV method (Papke and Wooldridge, 2008; Wooldridge, 2010, 2013). The estimation equation is as follows:

$$y_{it1} = hhc_{it1}\beta_1 + r_{i1}\beta_2 + \beta_3 dis_{it1} + \beta_4 subfert_1 + \beta_5 v_{it2} + c_i + \overline{Z}_i\beta_6 + \mu_{it} \qquad (4)$$

where y_{it1} is the fractional dependent variable and is a proportion of total quantity sold to total quantity harvested of maize - a continuous variable bounded between zero and one; and all other explanatory variables are the same as in Eq.(2) with the exception of the ICT and crop diversification covariates.

5.4 Estimation approach

In this study, the key covariate of interest is the subsidized fertilizer and therefore, estimation of its average partial effect (APE), represented by β_4 in Eq. (2-4) is the focus of this study. The use of panel data allows us to control for the unobserved time-constant household heterogeneity. For the continuous dependent variables and without sample selection bias consideration, the most common estimation strategy would be to use the fixed effects (FE) estimator. However, as explained above, estimations include binary dependent variable in Eq. (2); discrete dependent variable in Eq. (3); and fractional dependent variable in Eq. (4). This makes the use of FE estimators inconsistent and unable to control for the time-invariant factors (Wooldridge, 2010, 2013). Furthermore, we suspect the covariate subsidized fertilizer, which is discrete to be endogenous in all three equations and this requires estimation with IV method using the control function approach. For the estimators in this study to be consistent and the APEs to be identified, we apply the correlated random effects (CRE) approach (Wooldridge, 2010) following Mundlak (1978) and Chamberlain (1984).

We control for the correlation between the time-invariant unobserved household heterogeneity c_i and all the explanatory variables, represented by X_{it} in all the three equations (Eq. 2-4).

Estimation assumes strict exogeneity of X_{it}, and in case of endogeneity, IV method is applied. The estimation of the CRE estimators allows the correlation between the time-invariant unobserved household heterogeneity c_i and the explanatory variables, X_{it}. In addition to the assumption of strict exogeneity, the application of the CRE estimator method also assumes that the correlation between c_i and X_{it} is of the form: $c_i = \psi + \overline{X}_i\zeta + a_i$ and $c_i | X_i \sim$ Normal $(\psi + \overline{X}_i\zeta, \sigma_a^2)$, where ψ is the constant, $\overline{X}_i$ are the time averages of the time-variant explanatory variables, and a_i is the error term (Wooldridge, 2010). Therefore, estimation of the CRE estimators requires inclusion of $\overline{X}_i$ as an additional set of independent variables in order to control for the time-invariant unobserved household heterogeneity c_i. After estimations, inference of the APEs is done following panel bootstrapping of the standard errors.

Potential endogeneity of subsidized fertilizer in estimation of equations 2-4 has to be addressed. As mentioned before, under the FISP, beneficiaries of coupons for purchasing of subsidized farm inputs are not randomly selected and despite that the program is designed to provide a standard package to all beneficiaries, households received heterogeneous packages. Consequently, the unobserved factors which influence the receipt of coupons for subsidized fertilizer may be correlated with the unobserved factors which influence maize marketing, and thus making subsidized fertilizer endogenous. Furthermore, since not all households in the sample received coupons for subsidized fertilizer, the covariate subsidized fertilizer has a corner solution characteristics, with zero quantity for non-beneficiaries. Since subsidized fertilizer is a discrete variable, we test and control for its endogeneity by using the control function approach of the IV methods, and employ the pooled CRE Tobit model for corner solution in the estimation of the reduced form equation (Wooldridge, 2010).

Application of the CF approach follows a two-step procedure. In the first step, a reduced form pooled CRE Tobit model of corner solution of the subsidized fertilizer is estimated and the generalized residuals, v_{it} is generated. We use as IV a variable indicating whether a Member of Parliament (MP) is a resident in or visited the particular community in the past three months. The economic intuition of using this IV is that subsidy programs are prone to be used by MPs to gain political support, and therefore communities which have resident MPs or their MPs frequently visit them have a greater likelihood to receive more coupons than their counterparts. However, there is no reason to believe that the presence or frequent visit of an MP may affect farmer's decision on maize marketing and empirical results (not included in this paper) show that it is insignificant in all the three equations (2-4). Since the instrument used is at a higher, community level, we assume it is exogenous to the individual households[1].

The second step is the estimation of the structural equations (2-4) and includes the generated generalized residuals, v_{it}, as an additional covariate. The statistical significance of the generalized residuals, v_{it} (i.e. β_5) in the equations indicates that the subsidized fertilizer is not exogenous and therefore, requires to control for the endogeneity.

The use of the pooled Double Hurdle CRE Model in estimation of Eq. (3) allows us to use different covariates for the selection and quantity equations. This is important because the same covariates can be used in estimating the competing pooled OLS CRE model to check the robustness of the estimates[2]. The participation equation (2) is estimated by pooled CRE Probit model, using the receipt of maize marketing information through ICTs and crop diversification as exclusion variables.

The choice of these two exclusion covariates is based on economic intuition that marketing information is a fixed transaction cost, which only affects market participation decision and not the quantity sold (Key *et al.*, 2000). This is because once farmers get marketing information e.g. location of buyers or prices, they can decide any quantities to sell without incurring further costs on the same information. The crop diversification (i.e. the number of crops grown) is also expected to only affect the market participation because the decision to produce crops for the market or only for consumption is made prior to production. Normally when the production is for self-consumption different types of crops are grown in order to satisfy the diversified nutritional needs of the household. The farmer decides on the quantities to sell later, after the harvest. To test the validity of the chosen variables as good exclusions in our estimations, we test their statistical

[1] Ricker-Gilbert and Jayne (2011) use Member of Parliament resident in the community in Malawi; Mason and Ricker-Gilbert (2013) use ruling party victory of household's district presidential election results of 2004 in Malawi and ruling party victory of the household's constituency for last presidential election in Zambia as instruments. Both studies show that subsides are politicized in Malawi and Zambia.

[2] For details on the procedures of estimating a sample selection linear panel data model see Semykina and Wooldridge (2010).

significance in both participation and quantity equations. Inference of the average partial effects (APEs) follows panel bootstrapping of the standard errors.

6 Data source and descriptive statistics

This study uses the nationally representative two-wave Integrated Household Panel Survey (IHPS) data for Malawi from the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) Project. The first wave of the data was collected between March and November 2010; and the second wave between April and December 2013 by the National Statistics Office of Malawi. The IHPS data is a balanced panel sample of 4000 households with an overall attrition rate at household level of 3.78 percent. However, this Study uses a balanced panel sample of 3086 households after excluding non-agricultural and households with incomplete information for main variables used in the empirical analyzes.

Table A1 in Appendix 1 presents descriptive statistics of variables used in the empirical analyzes and a comparison between fertilizer subsidy beneficiaries and non-beneficiaries. The presented means are the household's averages for the two-time period covered by the study. We focus our discussion in this section on descriptive statistics for fertilizer subsidies and maize marketing variables.

The IHPS collected detailed information on the Government of Malawi's FISP covering the 2009/2010 and 2012/2013 agricultural seasons. Furthermore, the survey collected household historical information on maize seed and fertilizer coupon benefits from 2008/2009 to 2012/2013 agricultural seasons. This information has helped this study to identify and categorize households from those who have never benefited to those who have benefited all the five agricultural seasons.

Overall, 53 per cent of farmers nationwide were targeted with coupons to purchase subsidized fertilizer. However, for the whole sample, the average subsidized fertilizer redeemed is 38 Kg, while for beneficiaries only, the average is 80 Kg. This means the government met the objective to reach at least 50 per cent of farmers. The full standard program package was designed to support the purchase of 100 kg of subsidized fertilizer (50 kg bag NPK and 50 kg bag Urea); one pack of improved maize seed (5 kg hybrid or 8 kg open pollinated variety (OPV)); and one legume pack

(Dorward, *et al.*, 2013). Data also show that FISP beneficiaries received different coupon packages (such as coupons for only maize seed, for one 50 Kg bag of fertilizer or for three 50 Kg bags of fertilizer). These statistics are consistent with earlier studies (Chibwana *et al.*, 2010; Holden and Lunduka, 2010; Ricker-Gilbert and Jayne, 2011).

In terms of maize marketing, overall, 13 per cent of the farmers sold maize. Furthermore, 17 per cent of fertilizer subsidy beneficiaries sold maize compared to 9 per cent non-beneficiaries and the difference is statistically significant at 1 % significance level. On quantity sold and for the whole sample, on average only 28 kg of maize is sold and fertilizer subsidy beneficiaries sell more quantities compared to non-beneficiaries with statistically significant difference between the two groups. However, in terms of the average proportion of total output sold to total output produced (commercialization index-CI), only three per cent of the maize produced is sold. Considering only maize sellers (not included in Table A1), the average quantity of maize sold is 214 Kg, and there is a slight difference between beneficiaries and non-beneficiaries, 217 Kg and 210 Kg, respectively. The average CI for maize sellers only is 23 per cent and again there is a slight difference between the two groups with beneficiaries and non-beneficiaries selling 23 and 24 per cent of their maize produce, respectively.

7 Empirical results and discussion

This section discusses the empirical results. It focuses on the results of the subsidized fertilizer covariate, which is of central interest to this study. The discussion is divided into four sub-sections. Factors determining quantity of redeemed and receipt of coupons of subsidized fertilizer are discussed in section 7.1; market participation of farmers as sellers of maize in section 7.2; quantity of maize sold in section 7.3, and commercialization index of maize in section 7.4.

7.1 Determinants of quantity redeemed of and receipt of coupons for subsidized fertilizer

We start by presenting results of Table 2 on factors determining quantity of subsidized fertilizer redeemed of the pooled CRE Tobit model (model I) and receipt of coupons to purchase subsidized fertilizer of the pooled CRE Probit model (model II). The results show that having a resident

Member of Parliament (MP) or being visited by the MP in the community in the past three months increases quantities of subsidized fertilizer redeemed (model I) and increases the probability of receiving coupons of subsidized fertilizer (model II). This confirms the politicization of the subsidy program in Malawi. Mason and Ricker-Gilbert (2013) also find that households in districts where the ruling party won the 2004 presidential election in Malawi redeemed more subsidized maize seed and fertilizer.

Female headed households do not benefit more from the subsidy program compared to male headed households. This is in contradiction to the design of the program which aims at reaching more poor households by among other criteria targeting more female headed households because they are considered to be the most financially constrained to purchase fertilizer at commercial prices. This finding is consistent with previous studies (Chibwana *et al.,* 2010; Chirwa *et al.,* 2013; Dorward and Chirwa, 2011; Holden and Lunduka, 2010; Ricker-Gilbert *et al.,* 2013; Fisher and Kandiwa, 2014).

Old age is associated with receipt of more coupons to redeem subsidized fertilizer and increased probability of being targeted for the subsidy program, and therefore, is consistent with the program design of targeting the elderly headed households. Households which are located in rural areas redeem 22 Kg more subsidized fertilizer and have an increased probability of being targeted by 31 percentage points compared with those in urban areas. Since most farmers reside in rural areas, this shows the program is targeting the right group of farmers. Education level of the household head is found to have no statistically significant effects on access to coupons for subsidized fertilizer. Results on regional location of households show that households located in the central region redeem less quantities of subsidized fertilizer and have lower probability of being targeted for the program compared to households located in the southern region. But household with more land holding size and real durable assets value redeem more quantities of subsidized fertilizer and have increased probability of being targeted for the subsidy program. This may suggest that richer households are benefiting more than poor households, contrary to the program design.

7.2. Impact of subsidized fertilizer on farmers' participation in maize market as sellers

Table 3 presents four regression results on the determinants of farmers' participation in maize market as sellers. Models (I), (II) and (III) are presented to check the robustness of the estimates by applying different estimators. Since the results in model (IV) show that the generalized residuals are statistically significant, thus indicating and controlling for the endogeneity of subsidized fertilizer, our discussion in this section will be based on this model's results. In models (I) and (II) we do not control for the unobserved time-invariant household heterogeneity and the results show higher positive effects of subsidized fertilizer on maize market participation and is almost double the effects shown in model (III) using the pooled CRE Probit model. Ignoring the endogeneity of the subsidized fertilizer also shows has an effect on the estimates and the results in model (IV) on the subsidized fertilizer covariate show slightly higher effects than just controlling for the unobserved time-invariant household heterogeneity in model (III). But the effects are still lower than in models (I) and (II), suggesting the importance of controlling for the unobserved time-invariant household heterogeneity in our estimations.

The results show that subsidized fertilizer is associated with increased probability of selling maize; and for model (IV), an additional kilogram of subsidized fertilizer increases the probability of selling maize by 0.05 percentage point. In other words, the program standard package of 100 kg of subsidized fertilizer increases the probability of maize market participation of farmers as sellers by five percentage points. These results support the notion that improving small farmers' access to modern farm input technologies could lead to increased productivity and hence improve their market participation as sellers of agricultural produce. This is important to farmers who have limited sources of income and their engagement in marketing of maize could provide them incentives to diversify their income sources and commercialize agricultural activities through usage of the income from maize sales. Income from maize sales could also help the farmers to self-purchase improved farm inputs at commercial prices, which is vital for the sustainability of the subsidy program.

Receiving maize market information through electronic media has positive and statistically significant effects on maize market participation. This suggests the importance of information and communication technologies (ICTs) in reducing fixed market transaction costs such as market information searching costs. Growing different types of crops as indicated by the crop diversification covariate also increases the likelihood of selling maize. This may be due to availability of food from other food crops and therefore, enabling households to sell part of their maize produce.

Households with more land holding size and more real durable asset value have higher probabilities of selling maize. An additional hectare of land increases the probability of maize market participation by five percentage points. These results support the notion that household productive resource endowments are a prerequisite for small farmer's market participation in developing countries.

7.3. Impact of subsidized fertilizer on quantity sold of maize

Regression results on factors influencing quantity of maize sold by farmers for models (I), (II), (III) and (IV) are presented in Table 4. Results for models (I), (II) and (III) are presented for robustness assessment of the estimates. Model (IV) results show that the generalized residuals are statistically significant. This indicates and controls for endogeneity of subsidized fertilizer. The discussion in this section will focus on the results of this model. In all the four models we control for the unobserved time-invariant household heterogeneity. Model (I) is the pooled CRE Tobit with the generalized residuals from the reduced form pooled CRE Tobit model for subsidized fertilizer to test and control for its potential endogeneity. Model (II) is the pooled CRE OLS model which include the inverse mills ratio from the pooled CRE Probit model on market participation and the generalized residuals from the reduced form pooled CRE Tobit model for subsidized fertilizer. Since these two additional variables are both statistically significant in this model, this means that subsidized fertilizer is endogenous and there is sample selection bias and their inclusions addresses these problems. Models (III) and (IV) are pooled Double Hurdle CRE and the difference between the two is that in model (IV) we include the generalized residuals from the reduced form pooled CRE Tobit model for subsidized fertilizer to test and control for its potential endogeneity.

Overall, the results show positive effects of subsidized fertilizer on quantity of maize sold. Without controlling for endogeneity, the results on the subsidized fertilizer covariate for the model (III) are relatively of higher magnitude compared with results for model (IV). However, these results are slightly of lower magnitude compared with those of the pooled Tobit CRE Model and the pooled OLS CRE Model with generalized residuals.

Results for model (IV) suggest that on average, an additional kilogram of subsidized fertilizer increases quantity of maize sold by 0.15 per cent. Considering the standard FISP fertilizer package of 100 kg, this means that on average an additional 100 kg of the program subsidized fertilizer increases quantity sold of maize by 15 per cent. These results suggest that maize market supply can significantly increase with the usage of improved farm inputs by small farmers to the benefit of maize net buyers and non-farmers. However, the low magnitude of effect of subsidized fertilizer on maize market supply might be the explanation of the minimal effects it has had on retail maize prices in Malawi and Zambia (Ricker-Gilbert *et al.*, 2013) and on grain prices in Nigeria (Takeshima and Liverpool-Tasie,2015). Furthermore, an income from such magnitude of quantity of maize sold cannot enable subsidy beneficiary households to self-finance future purchases of fertilizer and improved seeds at commercial prices and consequently, casting doubt on the sustainability of the program in the absence of other sources of households' income. These results also highlight the challenge of improving household income through sales of staple food crops. Therefore, this calls for promotion of diversified sources of income for farmers in order to improve both household food and income security.

Large household size has negative effects on quantity of maize sold. This is expected because households with bigger household size have to commit more quantity of maize to consumption. Regional covariates have the expected effects. Households located in the northern and central region sell more quantity of maize than those located in the southern region. This effect is due to regional differences in climatic conditions, which affects maize production. Northern and central regions are considered high maize producing regions compared to the southern region.

Household resource endowment plays a significant role in maize market supply, especially landholding size, and the results show that an additional hectare of land increases quantity of maize sold by 24 per cent. Households with more durable assets also sell more quantity of maize, which suggest the effects on production levels. Rural location of households is associated with more quantity of maize sold. This is expected since most rural households have limited non-farm sources of income and therefore, their households income depend more on crops sales compared with those in urban areas. Since more land is relatively allocated for maize production for most small farmers, relatively more quantity of maize is sold to meet household income demand.

However, we find no evidence of statistically significant effects of education and sex of the household head and distance to daily market. This may be suggesting that the maize market is well integrated, such that access to information on marketing is not dependent on education level of the household head and maize market is accessible to both male and female headed households. This may be due to the influx of small private traders in maize markets, who buy maize on-farm from small farmers, and consequently reducing market information and transportation costs for the farmer due to long distance to central markets.

7.4. Impact of subsidized fertilizer on commercialization index of maize (i.e. proportion of quantity sold to quantity harvested).

We present regression results of models (I), (II), (III) and (IV) on factors determining commercialization of maize in Table 5. As with the preceding two sections, results for models (I), (II) and (III) are presented to check the robustness of the estimates. In models (I) and (II) we do not control for the unobserved time-invariant household heterogeneity. We include the generalized residuals from the reduced form pooled CRE Tobit model for subsidized fertilizer to test and control for its potential endogeneity in model (IV). The generalized residuals are statistically significant, indicating and controlling for endogeneity of subsidized fertilizer. Therefore, this section's discussion will focus on these results.

Subsidized fertilizer has positive effects on commercialization of maize and an additional kilogram of subsidized fertilizer increases the commercialization index of maize by 0.01 per cent. Considering the program standard package, an additional 100 Kg of subsidized fertilizer increases the commercialization index of maize by one per cent. This suggests subsidized fertilizer has marginal effects on maize commercialization and maize is still produced mainly for subsistence at household level despite the government subsidizing its production inputs. The small magnitude of effect shows that the level of maize production at household level is much lower to meet household food requirement and to provide surplus for the market. Since FISP is targeting small farmers, the question is whether this is a strategic group of farmers to be targeted if the objective is to increase maize market supply and consequently reduce maize prices to the benefit of maize net buyers and non-farmers.

Age of the household head and household size covariates have negative effects on maize commercialization, although the magnitudes of the effects are very small. Landholding size has the expected positive effects and an additional hectare of landholding size increases maize commercialization index by one percent. Such a small magnitude of effect also shows that maize is mainly produced by farm households for consumption in Malawi.

8 Conclusion and policy implications

Farm input subsidy programs have enjoyed a resurgence in sub-Saharan Africa as a policy tool for addressing the problems of food insecurity and poverty by improving agricultural production and productivity. Much of this renewed interest has been sold under the guise of 'Market Smart' policies designed to kick start market engagement by small farmers in rural areas with a view to increasing the volume of trade and promoting private sector market activity.

This study has estimated the effects of farm input subsidies on the marketing of maize in Malawi using the nationally representative two-wave Integrated Household Panel Survey (IHPS) data of 2010 and 2013 for Malawi, which also collected information on the farm input subsidy program of 2009/2010 and 2012/2013 agricultural seasons. However, due to small number of households in the panel sample who grew and sold other cereal and legume crops apart from maize, this study has been unable to analyze the effects of the subsidized fertilizer program on the overall household food crops marketing. But since maize is the main target crop in the FISP, the empirical analyzes on the effects on maize marketing are equally more important. Moreover, the less than uniform manner in which the Government of Malawi have allocated input subsidy coupons to households has allowed us to investigate the effect of the program within a pseudo experimental setting.

After controlling for potential endogeneity of subsidized fertilizer, the empirical results suggest that subsidized fertilizer increases the probability of selling maize, quantity sold and the commercialization index of maize. Based on these empirical results, this study suggests several policy implications and avenues for improvements of the farm input subsidy program. First, these results highlight the challenge of increasing household income from staple food crop sales when the households' priority for producing such crops is subsistence. Consequently, this cast doubt on the sustainability and success of the program's objective to achieving household food security and increasing household income from food crop sales concurrently. This is due to the fact that for most small farmers food crops are mainly produced for household consumption. Therefore, apart from food crops, the program improvement should include targeting the same households with subsidized coupons for cash crops production (such as cotton and other high value food crops). Cash crop production could be strategic to farmers with relatively adequate land and they can use income from cash crop sales to finance future farm input purchases at commercial prices and sustainably exit from the subsidy program.

Second, the positive effects on maize market participation, quantity sold and commercialization index suggest that increasing crop productivity should be the main strategy to increase maize market supply. Therefore, complementary interventions to subsidized fertilizer are critical. Such interventions include use of conservation agricultural technologies and recommended crop husbandly practices.

Third, designing programs to suit climatic conditions of specific regions may be more beneficial than the standard program for all regions. Despite maize being the staple food for the majority of the population, some districts are not suitable for its production, such as Lower Shire Valley and mountainous districts in the southern region. Therefore, programs focusing on other interventions and types of crops might have more positive effects on households' incomes.

Fourth, the small magnitude of effects of landholding size on commercialization of maize suggests that maize is not considered a viable commercial crop by farm households. This may have implication on household resource allocation, where more resources may be located to cash than food crops in order to make profit and increase household income at the expense of food crops production. The political intervention in the marketing of maize in Malawi, in which the government ban exportation of maize during acute food shortage months or when estimates shows national food deficit, might have contributed to the commercial unviability of maize. An analysis of the effects of such interventions is important, but is beyond the scope of this study.

Overall, the results in this study suggest that the input subsidy program, as implemented in Malawi, has contributed toward an increased level of maize market engagement for some farm households within the sample. In this sense, the policy has the potential to provide the wider external benefits espoused by the proponents of 'Market Smart' policies. It remains to be seen whether this policy can deliver reduced transactions costs and risks and allow the private sector to take over the delivery of inputs at a price small farmers can benefit from in the future. Further research is also suggested on the effects of subsidized fertilizer on maize market participation and quantity sold and bought by maize net sellers and buyers, respectively; and effects on other cereal and legume crops.

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Table 2: Factors determining quantity redeemed and receipt of coupons to purchase subsidized fertilizer.

Explanatory Variables	Dependent Variable: Quantity of subsidized fertilizer (Kg)		Dependent Variable: Received subsidized fertilizer coupon=1	
	Pooled CRE Tobit Model (I)		Pooled CRE Probit Model (II)	
	APE	P-Value	APE	P-Value
MP resident or visit	2.21**	0.020	0.03**	0.017
Household head (Female)	-1.79	0.408	-0.02	0.590
Household head age (years)	0.38***	0.000	0.01***	0.000
Household size	0.04	0.829	-0.002	0.440
Rural location	21.7***	0.000	0.31***	0.000
Household head primary education	-0.64	0.749	-0.004	0.892
Household head secondary education	-5.51*	0.067	-0.07	0.125
Household head tertiary education	-6.33	0.310	-0.07	0.343
Northern	-0.19	0.890	-0.03*	0.067
Central	-9.09***	0.000	-0.09***	0.000
Total land (hectares)	5.64***	0.000	0.07***	0.000
Log real durable asset value (MK)	0.77***	0.000	0.01***	0.005
Log distance to daily market (Km)	0.23	0.677	-0.001	0.903
Year 2013	-10.3***	0.000	-0.16***	0.000
No. of Observations	6172		6172	
F-Statistic/Wald χ^2: Joint sig. variables	46.81***	0.000	702.74***	0.0000
F-Statistic/ χ^2: Joint sig. time averages	4.28***	0.000	83.74***	0.0000
Sigma	74.60			
Log pseudo likelihood	-18961.794		-3841.823	
Correctly classified			66.82 %	

Note: ***, **, * represents statistically significant at 1 %, 5 % and 10 % levels, respectively; CRE represents Correlated Random Effects; Estimations include time averages of time-varying explanatory variables; APE represents average partial effect.

Table 3: Regression results of factors determining farmers' maize market participation as sellers (Dependent variable: Sold Maize==1)

Explanatory Variables	Pooled Probit Model (I)	Probit RE Model (II)	Pooled CRE Probit (III)	Pooled CRE Probit & CF Residuals(IV)
	APE/SE	**APE/SE**	**APE/SE**	**APE/SE**
Generalized residuals				0.026***
				(0.009)
Subsidized fertilizer (Kg)	0.0007***	0.0006***	0.0003***	0.0005***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Electronic media market information	0.023	0.02*	0.036**	0.035**
	(0.015)	(0.012)	(0.014)	(0.014)
Crop diversification	0.018***	0.016***	0.011***	0.011***
	(0.006)	(0.004)	(0.004)	(0.004)
Household head (Female)	0.004	0.004	0.024	0.024
	(0.012)	(0.01)	(0.021)	(0.021)
Household head age (years)	-0.001***	-0.001***	-0.002**	-0.002**
	(0.0003)	(0.0002)	(0.001)	(0.001)
Household size	-0.009***	-0.008***	-0.017***	-0.017***
	(0.002)	(0.002)	(0.002)	(0.002)
Rural location	0.086***	0.078***	0.055*	0.053*
	(0.02)	(0.015)	(0.03)	(0.031)
Household head primary education	0.029*	0.026**	0.009	0.01
	(0.016)	(0.012)	(0.018)	(0.018)
Household head secondary education	0.05**	0.042***	-0.016	-0.014
	(0.02)	(0.015)	(0.028)	(0.028)
Household head tertiary education	-0.015	-0.01	0.034	0.035
	(0.029)	(0.027)	(0.059)	(0.058)
Northern	0.054**	0.051***	0.054***	0.055***
	(0.023)	(0.012)	(0.014)	(0.014)
Central	0.082***	0.074***	0.06***	0.053***
	(0.015)	(0.01)	(0.011)	(0.011)
Total land (hectares)	0.03***	0.029***	0.047 ***	0.046***
	(0.009)	(0.01)	(0.011)	(0.011)
Log real durable asset value (MK)	0.004***	0.004***	0.004**	0.004**
	(0.002)	(0.001)	(0.002)	(0.002)
Log distance to daily market (Km)	0.014**	0.012***	0.006	0.006
	(0.006)	(0.003)	(0.005)	(0.005)
Number of observations	6172	6172	6172	6172
Correctly classified	86.86%		86.78%	86.78%
Wald χ^2 Joint sig. all variables	227.19***	262.99***	2380.71***	2369.06***
χ^2 Joint sig. time averages variables			67.62***	57.13***

Note: ***, **, * represents statistically significant at 1 %, 5 % and 10 % levels, respectively; CRE estimations of models (III) and (IV) include time averages of time-varying explanatory variables; APE=average partial effect; SE=standard errors; Controls variables include Year 2013 dummy.

Table 4: Regression results of factors determining farmers' maize quantity sold (Dependent variable: Quantity of Maize sold in Log Kg)

Explanatory Variables	**Pooled Tobit CRE Model With CF Res. (I)**	**Pooled OLS CRE Model With IMR and CF Res. (II)**	**Pooled Double Hurdle CRE Model (III)**	**Pooled Double Hurdle CRE with CF Res. (IV)**
	APE/SE	**APE/SE**	**APE/SE**	**APE/SE**
Generalized residuals	0.173***	0.219***		0.132***
	(0.056)	(0.075)		(0.044)
Inverse Mills Ratio (IMR)		1.677***		
		(0.118)		
Subsidized fertilizer (Kg)	0.0029***	0.0023**	0.0017**	0.0015**
	(0.0008)	(0.0011)	(0.0007)	(0.0007)
Household head (female)	0.152	0.408**	0.149	0.148
	(0.124)	(0.189)	(0.121)	(0.121)
Household head age (years)	-0.009**	-0.005	-0.007*	-0.006*
	(0.004)	(0.006)	(0.004)	(0.004)
Household size	-0.098***	-0.05**	-0.039***	-0.037***
	(0.013)	(0.017)	(0.009)	(0.010)
Rural location	0.35*	0.045	0.225	0.232*
	(0.183)	(0.284)	(0.152)	(0.141)
Household head primary educ.	0.061	0.024	0.031	0.031
	(0.111)	(0.2)	(0.108)	(0.108)
Household head secondary ed.	-0.087	0.025	-0.081	-0.082
	(0.168)	(0.265)	(0.143)	(0.151)
Household head tertiary educ.	0.214	0.305	0.137	0.138
	(0.357)	(0.556)	(0.327)	(0.338)
Total land (hectares)	0.323***	0.495***	0.241***	0.244***
	(0.065)	(0.108)	(0.054)	(0.058)
Log real durable asset MK	0.027**	0.042*	0.022*	0.022*
	(0.012)	(0.022)	(0.011)	(0.012)
Log distance to daily Km	0.027	0.118***	0.002	0.002
	(0.033)	(0.042)	(0.002)	(0.002)
Number of observations	6172	804	6172	6,172
Log pseudo likelihood	-4132.75	-3361.576	-3232.842	-3231.367
Wald χ^2/F-Stat.: Joint sig. (all)	44.25***	870.13***	193.13***	210.90***
Sigma	6.41		0.898	0.898
F-Stat: Joint sig. time averages	6.14***		46.73***	46.10***
Pseudo R-square /R-square		0.96	0.0902	0.0906

Note: ***, **, * represents statistically significant at 1 %, 5 % and 10 % levels, respectively; CRE estimations include time averages of time-varying explanatory variables; APE=average partial effect; SE= standard errors; Controls include Year2013 and regional dummies.

Table 5: Regression results of factors determining farmers' maize commercialization (Dependent variable: Commercialization Index of Maize)

Explanatory Variables	**Pooled OLS Model (I)**	**Linear RE Model (II)**	**Pooled CRE Fractional Probit Model (III)**	**Pooled CRE Fractional Probit Model with CF (IV)**
	APE/SE	**APE/SE**	**APE/SE**	**APE/SE**
Generalized residuals				0.005*
				(0.003)
Subsidized fertilizer Kg	0.00014***	0.00013***	0.00004	0.00011**
	(0.00003)	(0.00003)	(0.00005)	(0.00004)
Household head (Female)	-0.001	-0.0003	0.004	0.004
	(0.003)	(0.003)	(0.007)	(0.007)
Household head age (years)	-0.0004***	-0.0004***	-0.001**	-0.001**
	(0.0001)	(0.0001)	(0.0003)	(0.0003)
Household size	-0.002***	-0.002***	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Rural location	0.015***	0.015***	0.001	-0.0002
	(0.004)	(0.004)	(0.009)	(0.009)
Household head primary educ.	0.002	0.002	0.004	0.004
	(0.004)	(0.004)	(0.008)	(0.008)
Household head secondary ed.	0.015***	0.014**	0.002	0.003
	(0.006)	(0.006)	(0.01)	(0.01)
Household head tertiary educ.	0.0002	0.0000	0.002	0.003
	(0.008)	(0.008)	(0.018)	(0.018)
Northern region	0.013***	0.013***	0.016**	0.016**
	(0.004)	(0.004)	(0.007)	(0.008)
Central region	0.016***	0.016***	0.008*	0.006
	(0.003)	(0.003)	(0.005)	(0.005)
Total land (hectares)	0.017***	0.017***	0.015***	0.014***
	(0.004)	(0.004)	(0.005)	(0.005)
Log real durable assets value	0.001***	0.001***	0.001	0.001
	(0.0004)	(0.0004)	(0.001)	(0.001)
Log distance to daily market	0.003**	0.003***	-0.001	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)
Number of observations	6172	6172	6172	6172
F-Stat./Wald χ^2 : Joint sig.	9.58***	131.62***	3610.27***	3610.32***
χ^2: Joint sig. time averages			104.00***	92.12***
Log pseudo likelihood			-744.49	-741.75
R-square	0.04			

Note: ***, **, * represents statistically significant at 1 %, 5 % and 10 % levels, respectively; CRE (Correlated Random Effects) Estimations of models (III) and (IV) include time averages of time-varying explanatory variables; APE represents average partial effect; SE represents standard errors; MK=Malawi Kwacha; Km=Kilometers; CF=Control Function. Controls include Year 2013 dummy.

9 Appendix 1.

Table A1: Summary Statistics (Average of two-time periods – 2010 and 2013)

Variable	All (Full Sample)(1)		Beneficiaries Only(2)		Non-Beneficiaries(3)		Mean Difference(4
	Mean	**Std. D**	**Mean**	**Std. D**	**Mean**	**Std. D**	**Mean**
Household head (female)	0.23	0.42	0.25	0.43	0.20	0.4	0.05***
Household head age (years)	43.56	16.05	46.09	16.3	40.74	15.28	5.35***
Head no formal education	0.19	0.39	0.21	0.41	0.16	0.37	0.05***
Head primary education	0.56	0.50	0.61	0.49	0.50	0.50	0.12***
Head second. education	0.21	0.41	0.17	0.37	0.26	0.44	-0.1***
Head tertiary education	0.04	0.20	0.01	0.10	0.08	0.26	-0.07***
Household size	5.02	2.33	5.34	2.3	4.66	2.31	0.69***
Rural location	0.83	0.38	0.92	0.27	0.72	0.45	0.2***
Northern region	0.20	0.40	0.20	0.42	0.17	0.38	0.05***
Central region	0.39	0.49	0.36	0.48	0.43	0.5	-0.07***
Southern region	0.40	0.49	0.42	0.49	0.4	0.49	0.02
Total land (hectares)	0.70	0.68	0.82	0.70	0.57	0.65	0.25***
Real durable asset 'K1000'	427	24391	33.27	191.2	865.4	35458	-832.13
Distance to daily mkt'Km'	8.14	17.82	10.71	22.05	5.27	10.68	5.44***
MP resident or visit	0.27	0.44	0.30	0.46	0.23	0.42	0.07***
Maize sold (kg)	27.94	148.5	36.92	172.7	17.93	114.9	18.99***
Sold maize dummy	0.13	0.34	0.17	0.38	0.09	0.28	0.08***
Commercialization Index	0.03	0.11	0.04	0.12	0.02	0.10	0.01***
Subsidized fertilizer	37.98	44.38	79.92	28.14	-	-	-
Number of obs.	6172		3252		2920		

Note: *** represents statistically significant at 1 % level; K=Malawi Kwacha; Km=Kilometers.