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The Interactive Effects of Farm Input Subsidy Program and Agricultural Extension Services on Smallholder Maize Production and Technical Efficiency in Malawi

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This study assessed the interactive effects of access to agricultural extension services and Farm Input Subsidy Program (FISP) on maize production, maize production technical efficiency and maize production uncertainty in Malawi. It employed a stochastic frontier model within the spheres of two-stage estimation technique applied on the fourth Integrated Household Survey (IHS4). The results indicated that households that have access to both FISP and extension services experience about 0.773% higher maize yield compared to households that have access to FISP only. Further, the study found that enhancing extension services within FISP environment improves maize production efficiency and reduces maize production uncertainty in Malawi.

JEL Classification: Q1, D1, D2

Key words: Agricultural extension, FISP, stochastic frontier model, technical efficiency, IHS4

1. The Rudiments

Although the contribution of the agricultural sector to Gross Domestic Product (GDP) in Malawi has been decreasing[1] over the past three years, it still remains the largest contributing sector (MoF, 2020). The sector comprises two main subsectors: smallholder and estate. Apart from being highly subsistent, the smallholder production is characterized by low levels of input and low output levels. Approximately 25% of smallholder farmers cultivate less than 0.5 hectares; 55% cultivate less than 1.0 hectares; 31% cultivate between 1.0 and 2.0 hectares; and 14% cultivate more than 2.0 hectares. Despite being resource poor, smallholder farmers produce about 80% of Malawi's food and 20% of its agricultural exports (Imani-Capricon, 2001). The estate subsector is the nation's principal foreign exchange earner. While it contributes only about 20% of the total national agricultural production, it provides over 80% of agricultural exports mainly from tobacco, sugar, tea and, to a lesser extent, tung oil, coffee and macadamia. The estate subsector operates on leasehold or freehold land (Chirwa, 2003).

Smallholder farmers are further divided into three sub-groups: net food buyers, intermediate farmers and net food sellers (Chirwa, 2003). Net food buyers are those farmers with less than 0.7 hectares who cannot produce food to satisfy their subsistence needs given the technology and remain dependent on off-farm activities. Intermediate smallholder farmers are those with land holding between 0.7 hectares and 1.5 hectares who produce just enough for their survival but have very little for sale. Net food sellers are those farmers with land holdings of more than 1.5 hectares and produce

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[1] According to MoF(2020), the sector's contribution to GDP was 28.2%, 27.3%, and 27.1% in the years 2017, 2018, and 2019 respectively.

more than their subsistence needs for survival during a year. According to Chirwa (2003), nearly 35% and 40% of smallholder farmers in Malawi fall in the categories of net food buyers and intermediate farmers, respectively.

Maize, being a staple food crop, is the most cropped food crop in Malawi and accounts for more than two-thirds of caloric availability (Ecker & Qaim, 2011). As of 2016/2017 cropping season, 76% of all plots cultivated in Malawi were under maize, on an average plot area of 0.8 acres NSO (2017). And, NSO (2012b) found that 85% of households in Malawi cultivated maize (69% in urban areas, and 88% in rural areas). Further to that, rain-fed smallholder maize production accounts for around one quarter of agricultural GDP. Hence, the relatively large size of the maize sub-sector means that improvements in maize production lead to significant and strong increases in overall agricultural GDP growth. With the ever-increasing demand for food following population growth pressures, it is obvious that one of the ways to improving food production is to raise the land productivity through improving the technical efficiency and reducing production uncertainty. As noted by Tchale and Sauer (2007), the relative role of technical efficiency and productivity with respect to smallholder agriculture is subject of a long debate in development economics (also see Schultz, 1964 & Chayanov, 1932). Hence, the paper analyses the technical efficiency of maize production among smallholder farmers and identifies the drivers that explain the variation in the efficiency of individual rural smallholder farmers.

Because of the importance of the agricultural sector let alone maize the government has over the years implemented a lot of policy interventions in the sector in order to improve maize production. For example, increased agricultural productivity is one of the key focus areas of the Malawi Growth and Development Strategy (MGDS) III, an overarching medium term national development framework. A number of sectoral strategy documents have since been formulated in this regard including: a National Agricultural Policy (NAP, 2015), and an Agricultural Sector Wide Approach (ASWAp, 2011). Under MGDS III, the most significant policy intervention towards improving maize output has been the Farm Input Subsidy Program (FISP). FISP was initiated in the 2005/06 agricultural season following a poor maize-harvest season and a high maize import bill with the aim of improving resource-poor smallholder farmers' access to agricultural inputs (CDM & FUM, 2017). It provides low-cost fertilizer and improved maize seeds to poor smallholders.

Most studies that have evaluated the impact of farm input subsidies on food security outcomes have established the existence of positive impacts (Dorward et al, 2008; Dorward & Chirwa, 2011; Sibande et al, 2015; Mukozho, 2015). However, effects of the program are still not straightforward as some studies find the program to have no impact. One of the explanations given for the inconsistencies in the impact of FISP is the inadequacy of the information provided to farmers on best maize production practices (Ragasa et al, 2015; Snapp et al, 2014). Actually, Snapp et al. (2014) suggest that lack of farmer training and extension services may have been a factor in the low nutrient use efficiency observed among beneficiaries of the FISP which limited the productivity and development impact of the program. They show the huge difference in nutrient use efficiency between maize grown in plots following researcher management protocols (14 to 50 kg maize per kg nitrogen) and farmer-managed plots (7 to 14 kg maize per kg nitrogen). As also observed by Ragasa et al(2018), this gap signals the magnitude of the constraints to increased crop production that Malawian smallholder farmers face. Ragasa et al(2018) suggest that a more holistic approach that includes education and extension services on integrated crop and soil fertility management is needed to support programs aimed at enhancing access to fertilizer to improve crop production.

Agricultural extension services in Malawi have undergone a lot of reforms over time, moving from use of the master farmer scheme and the progressive farmer approach around 1950 to use of the farmer group approach in 1970, the training and visit system in 1980, to the 2000 national extension policy with focus on farmer demand, stakeholder accountability, pluralism and coordination in agricultural extension service provision (Ragasa et al, 2018). The policy has good elements and strong intentions to transform the provision of extension services in Malawi. However implementation has been a problem as many elements of the policy remain largely unimplemented. One of the challenges facing the provision of extension services in Malawi is poor funding.

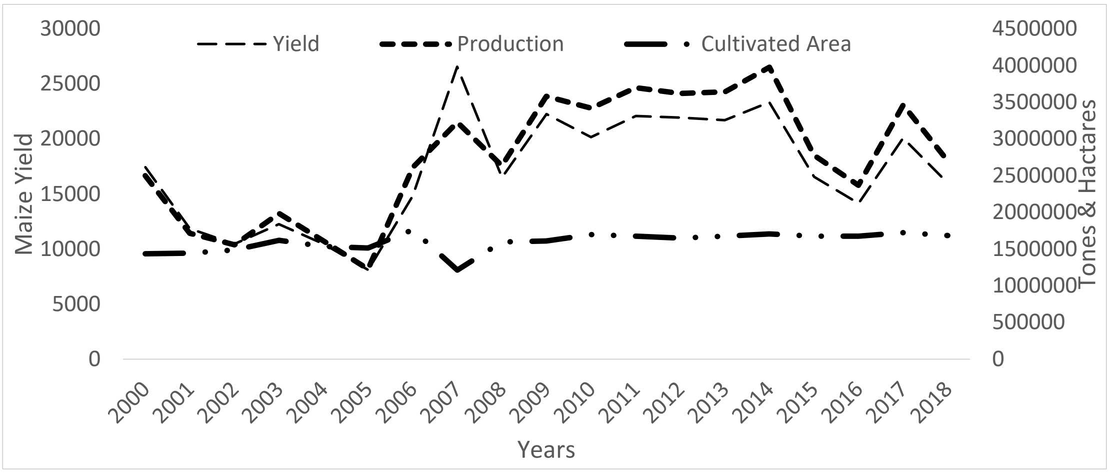
Huge government spending on the FISP has left minimal funds for other public agricultural services and programs in the past years. Notably, investment in agricultural extension has been on the decline over the years[2]. This poor flow of funding for agricultural extension activities raises concerns among experts, who suggest that it might be part of what explains inconsistent impact achieved by FISP. The foregoing discussion begs the policy question as to whether indeed, if properly funded, agricultural extension services can act as a catalyst towards making sure that FISP bears greater benefits in terms of both production and technical efficiency of maize in Malawi. This study therefore aims to: assess the interactive effects of accesses to agricultural extension services and FISP on household maize production and technical efficiency in Malawi.

2. Research Problem

Following the introduction of FISP, maize yield improved significantly as shown infigure 1 below, which traces out maize production, maize yield and land size cultivated. While maize production land has remained almost constant since 2007 maize output sharply increased following the introduction of the FISP in 2005. Similarly, Mussa (2014) notes that the season preceding the subsidy (2004/05), the yield was 0.8 metric tons per hectare, and for the cropping season 2006/07, the yield was 2.7 metric tons per hectare. However, when compared with other countries Malawi's maize output per hectareis and has always been significantly lower in terms of average maize yield. For instance, Mussa (2014) notes that although the maize productivity rose to an average yield of 2.1 metric tons per hectare between 2006 and 2012, it was still significantly lower when compared with other countries in the region.

[2] For instance, Ragasa and Niu(2017) observes that percentage of agriculture sector spending going to extension was 2.0%, 19.0%, 3.1% and 1.6% for the years 1991-92, 200-01, 2010-11 and 2012-13 respectively.

Figure 1: Maize Output, Yield and Area Cultivated



Source: Authors' calculations using Food and Agriculture Organisation (FAO) 2020 data set

These facts indicate that although maize production increased significantly following the introduction the FISP, maize productivity has remained low in Malawi even in the post-FISP period. This raises questions regarding the efficiency of maize production in Malawi. Why has productivity in maize production remained low in Malawi? Studies on maize production in Malawi particularly in the post-FISP period are rare. Existing studies on maize production efficiency in Malawi are either too old or do not carefully take into consideration the policy interventions that have since been implemented by the government of Malawi in improving maize production and efficiency, specifically the FISP(see Chirwa, 2003; Tchale & Sauer, 2007).

3. Related Literature

3.1 Theoretical Literature

There are so many theoretical developments in the literature regarding technical efficiency in agricultural production. In this context, most theoretical postulations concern household decision making regarding resource allocation. One such theoretical postulation is the collective farm household model developed by Udry (1996) and Udry et al (1995) which recognizes the complexity of household decision making in intra-household resource allocation and test the Pareto efficiency hypothesis using plot level information and characteristics. In this case, Pareto efficiency implies that factors of production will be allocated efficiently across plots and that there will be no differences in the productivity of different plots with the same crop controlled by different members of the household.

The Udry et al (1995) and Udry (1996) approach is more relevant in the analysis of smallholder agricultural production in Malawi for three reasons. First, as noted by Chirwa (2007), smallholder agricultural land in Malawi -with the growing population- has become more fragmented and there is a tendency for households to own several plots in different areas. Thus, plot level characteristics may be important in determining the efficiency of production activities. Secondly, also noted by Chirwa (2007), the unitary household model in Malawi is less appealing given the fact that the concept of the family is still strong. Thirdly, this approach is suitable for analyzing the decisions of farmers who are not fully commercialized or who operate with missing or imperfect markets (Singh, Squire, and Strauss

1986; de Janvry et al, 1991). In Malawi food and financial markets are weak and villages are often isolated, with limited access to various input, output, and product markets. In this environment characterized by market failures, market prices do not reflect the full opportunity cost of various goods, particularly inputs and services such as agricultural knowledge and fertilizer. In this study we therefore follow the collective farm household model by testing the Pareto efficient hypothesis in the allocation of factors of production to various plots within the same household.

3.2 Empirical Literature

There is a growing literature on the technical efficiency of African agriculture so far in the region (see Heshmati & Mulugeta, 1996; Fulginiti & Perrin, 1998; Shaffer et al,1998; Weir & Knight, 2000; Mochebelele & Winter-Nelson, 2000; Chirwa, 2007; Tchale & Sauer, 2007; Sherlund et al, 2002; Okike et al, 2004). In Malawi there have been only four studies done regarding maize production efficiency (see Chirwa, 2003; Chirwa, 2007; Tchale & Sauer, 2007; Simwaka et al, 2011). Among the factors that influence technical efficiency, farmers' education, extension, credit, market access, farmers' access to improved technologies through the market or public policy interventions and land holding size, have been given priority in most of the studies. Most studies report a positive impact of these variables on technical efficiency (see Tian & Wan, 2000). As also noted by Tchale and Sauer(2007), most of these studies report low to moderate technical efficiency ranging from as low as 0.24 to 0.36 among farmers in Lesotho to 0.56 in Ethiopia, thus confirming the evidence that most countries in the developing world in general and Sub-Saharan Africa(SSA) in particular still experience relatively low efficiency levels in agriculture.

3.2.1 Late Prof Chirwa's Contribution to The Literature

Chirwa (2003) and Chirwa (2007) pioneered the study on economic efficiency of smallholder maize farmers in Malawi. Studies that had existed before then in food production in Malawi related to research on; maize varieties and technological adoption; the impact of structural adjustment programs (Sahn & Arulpragasam, 1991; Kherallah & Govindan, 1999; Harrigan, 1988); the liberalisation of food produce pricing and marketing (Chirwa, 1999; Chilowa et al, 2000; Goletti & Babu, 1994; Kaluwa, 1992; Kaluwa & Chilowa, 1991; Mkwezalamba, 1989). However, as noted by Chirwa (2007), there was an apparent lack of empirical research on the productivity or economic efficiency of smallholder farmers in the Malawian agricultural sector. In both papers he estimates, using stochastic frontier modelling, technical efficiency among smallholder maize farmers in Malawi and identifies sources of inefficiency using plot-level data. The results based on the stochastic production function show that many smallholder maize farmers are technically inefficient, with mean technical efficiency scores of 46.23%.

3.2.2 Critique and Possible Extension of Chirwa's Work on Technical Efficiency

Although Chirwa (2003) and Chirwa (2007) pioneered studies on agricultural technical efficiency in Malawi, there are a few criticisms that can be directed on them and hence open doors for possible extensions to the work on technical efficiency. Firstly, the studies were based on a small sample of smallholder farmers in one of the districts in southern Malawi and could not be truly representative of the smallholder sector with varying land holding sizes in different ecological zones. In fact, only 156 farm households were sampled from Machinga district in the southern region of the country. According to Chirwa (2007) the 156 households interviewed had a total of 444 plots used for the production of various crops with 206 plots used for maize production. Of the total 206 plots on which maize was the main crop, only 50 plots from 37 households were used purely for maize production. Since the output and input data was only collected with respect to the main crop grown on the plot, he used data from 50 plots on which maize was mono-cropped. It is clear here that 50 plots from Machinga district could not necessarily be a true representation of the smallholder sector in Malawi. Suffice to say that this problem is also observed in other studies on technical efficiency in Malawi. For example, Tchale and Sauer (2007) used farm household and plot level data collected from nearly 376 households (or 573 plots) in Mzuzu, Lilongwe and Blantyre Agricultural Development Divisions (ADD) from May to December 2003.

Secondly, the studies did not take into account the major agricultural policy interventions and how they may impact on technical efficiency. These major policy interventions are FISP and extension services, as already pointed out. A study on smallholder famers maize technical efficiency that not only uses a nationally representative data but also takes into account the major agricultural interventions is therefore imperative.

3.3 Our Contribution to the Analysis of Maize Production and Technical Efficiency

In Malawi, studies have examined the impact on agricultural productivity alone while evidence on technical efficiency has not been examined (see Ragasa, 2018). This paper aims to analyse the interactive impact of access to agricultural extension services and FISP on both production and technical efficiency. The study therefore boosts of being the first study in this anterior. But why should the examination of the impact on technical efficiency matter? Well as noted by Mussa (2014), crop production faces inherent uncertainty caused by variations in weather, diseases, insects, and other biological pests. Farming households with access to agricultural extension services would be better able to cope with these production uncertainties and risks and hence achieve technical efficiency. As such looking at the interactive impact of access to agricultural extension services and FISP on agricultural technical efficiency is imperative.

4. Methodology

4.1 Data Description

In this paper, we use the Fourth Integrated Household Survey (IHS4), a nationally representative survey designed to provide information on the various aspects of household welfare in Malawi. The survey was collected by the National Statistical Office from April 2016 to April 2017, under the umbrella of the World Bank Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) initiative. The survey collected information from a sample of 12,480 households statistically designed to be representative at national, district, urban and rural levels.

There are 28 districts in Malawi. However, Blantyre city, Zomba city, Mzuzu city and Lilongwe city are treated as separate districts. Further Likoma district was excluded since it only represented about 0.1% of the population of Malawi, and it was determined that the corresponding cost of enumeration would be relatively high. The total number of districts or strata covered was therefore 31. A total of 768 communities were selected from the 31 districts across the country. In each district, a minimum of 24 communities were interviewed while in each community a total of about 16 households were interviewed. In total about 53,885 individuals were interviewed.

This paper focuses on farm households as they are more involved in maize production. After data cleaning, we end up with non-missing maize production data for 7139 farm households. By providing rich information on type of maize grown by a household (local maize, hybrid maize and composite maize); the type of cropping (mono-cropped or mixed cropped) per plot; number of plots and respective plot sizes owned by a household, amount of produce by the household per crop per plot; and output prices the inputs and produce the data was rich enough for use in calculating maize yield.

4.2 5.2 Outcome Variable

The dependent variable is agricultural productivity which was proxied by the natural logarithm of maize yield. We chose maize as a measure of agricultural output owing to the fact that maize is a staple food and therefore it is highly used in agricultural policy interventions. We understand, however, that some of the maize fields are mixed stand fields with more than one crop planted in a season. Since most inputs (land, fertilizer and labor) are at the field level, and cannot be uniquely assigned to maize production only, we follow Mussa (2014) and Liu and Myers (2009), and generate a maize output index. The dependent variable, maize yield is therefore measured as follows;

$$yield_{ij} = \begin{cases} \dfrac{\sum_m p_m yield_{ijm}}{p_1}; int\,e\,rcropped \\ \\ yield_{il1}; monocropped \end{cases}$$

Where $yield_{ij}$ is the maize output index, p_m is the market price of crop m, $yield_{ijm}$ is the field yield of crop m for household i in community j, and crop 1 is maize. Thus, for mono-cropped fields, maize yield is simply the actual yield.

4.3 Conceptual Framework

Following Ragasa et al (2016), we propose to use the theory of the agricultural household (Singh et al, 1986; De Janvry et al, 1991) as a conceptual framework for our empirical strategy. In this framework, the household combines farm resources and family labor to maximize utility over leisure and consumption goods produced on the farm or purchased on the market (Ragasa et al,2016). Farm decisions are constrained by a production technology conditioned on the farm's physical environment, family labor time allocated to labor and leisure and a full income constraint (Ragasa et al, 2016).

We model production as the result of a constrained utility maximization problem for a household. Following the agricultural household theory and constrained utility maximization model of Singh et al (1986) and later by Van Dusen and Taylor (2005), the household chooses a vector of consumption levels (*X*, *Z*) such that the general solution to the maximization of household utility under the binding constraints is a set of constrained optimal production and consumption levels (*X*, *Z*):

$$X = X(P, Y_C, Q_{hh}, Q_{farm}, Q_{market})$$
$$Y = Y(P, Y_C, Q_{hh}, Q_{farm}, Q_{market})$$

Where *P* represents prices; *Y* represents the full income constraint; *X* represents consumption of goods produced on the farm; *Z* represents all other purchased goods; Q_{hh} is a vector of exogenous socioeconomic and household characteristics; Q_{farm} is a vector of exogenous farm physical characteristics; and Q_{market} is a vector of market characteristics. The household's constrained production levels can be expressed in reduced form as an indirect function of price, income, household farm and market parameters:

$$yield = f\left(P, Y_C, Q_{hh}, Q_{farm}, Q_{market}\right)$$

Notice that in this production technology Q_{farm} includes access to extension, and FISP among other things. As such, access to agricultural extension services and FISP dummies enter the model as a factor of production (see Birkhaeuser et al, 1991; Owens et al, 2003; Peterman et al, 2011; Dinar et al, 2007; Ragasa et al, 2016).

4.4 Identification Strategy

4.4.1 The Stochastic Frontier

There are different techniques to measure technical efficiency in the literature including: deterministic, stochastic, parametric as well as non-parametric approaches. The stochastic frontier approach is capable of capturing measurement error and other statistical noise influencing the shape and position of the production frontier. As such, in the Malawian agricultural context which is largely influenced by randomly exogenous shocks such as climatic changes, we adopt the stochastic frontier model.

Stochastic production frontier models were introduced by Aigner et al (1977) and Meeusen and van de Broeck (1977). According to Aigner et al (1977), suppose that a producer has a production function$f(X_i, \beta)$. In the world without error or inefficiency, the i^{th} farm household would produce;

$$Y_i = f(X_i, \beta)$$

Stochastic frontier analysis assumes that each firm potentially produces less than it might due to a degree of inefficiency. Specifically,

$$Y_i = f(X_i, \beta)\xi_i$$

Where ξ_i is the level of inefficiency for household *i*; ξ_i must obviously be in the interval (0,1]. If ξ_i=1, the farm household is achieving the optimal output with the technology embodied in the production function. When ξ_i<1, the firm is not making the most of the inputs X given the technology embodied in the production function. Since output is assumed to be strictly positive, the degree of technical efficiency is assumed to be strictly positive. Output is assumed to be subject to random shocks, implying that;

$$Y_i = f(X_i, \beta)\xi_i \, exp(\eta_i)$$

Taking natural logs of both sides of the equation gives;

$$ln\, Y_i = ln\big(f(X_i, \beta)\big) + \eta_i + ln\, \xi_i$$

Assuming that there are J inputs and that the productions function is linear in logs, and defining $\mu_i = -\, ln\, \xi_i$ yields;

$$ln\, Y_i = \alpha_0 + \sum_{j=1}^{J} \beta_j \, ln\big(X_{ji}\big) + \eta_i - \mu_i$$

Following Mussa (2014) we adopt a stochastic frontier model developed by Wang (2002) based on the fact that it nests two modelling approaches. The first approach focuses on factors affecting the mean technical inefficiency while the other approach deals with factors affecting production uncertainty. In this sense, therefore, the paper will be able to show the impact on both efficiency and production uncertainty. Therefore, the production structure for maize field p belonging to household h which is in community c is specified using a single-output, multi-input Cobb-Douglas production.

$$ln\, yield_{phc} = ln\, yield^{*}_{phc} - \mu_{phc} = \alpha_0 + \sum_{k=1}^{K} \alpha_k \, ln\, x_{phck} + \sum_{j=1}^{J} \delta_m Z_{hcj} + \theta D_{hc} + \beta' W + \eta_{phc} - \mu_{phc}$$

$$\eta_{phc} \sim N\left(0, \sigma_\eta^2\right);\ \mu_{phc} \sim N^{+}(0, \sigma_u^2)$$

Where $Yield_{phc}$ represents total maize yield for maize field p belonging to household h which is in community c; $Yield^{*}_{phc}$ is unobserved frontier/potential yield for maize field p belonging to household h which is in community c, D is a vector of the extension access, FISP and interaction dummy variables; α_0 is an intercept, $\alpha_k (k = 1,2, \ldots . K)$ are output elasticities with respect to inputs x_{phck}. Z_{phcj} is a vector of household characteristics; W is a vector of agro-ecological zone dummies; η_{phc} denotes the traditional error component and μ_{phc} the non-negative inefficiency component. The inefficiency μ_{phc} estimates are related to the exogenous factors of maize production and agricultural extension services as follows:

$$\mu_{phc} = \gamma_0 + \vartheta D + \gamma' S$$

Where; S is a vector of determinants of inefficiency such as land husbandry practices, climatic and soil characteristics as well as regional location and individual characteristics. μ_{phc} is a two sided random variable representing random variations in the economic environment facing production units, reflecting luck, weather, measurement errors, and omitted variables from the model. It is a technical inefficiency effect which is a non-negative truncation of a normal random variable. It represents deviations from potential output that reflects inefficiency such as farm-specific knowledge, the will and skills of farmers, and other disruptions to production. The notation "+" means that the underlying distribution is truncated from below at zero so that realized values of the random variable μ_{phc} are positive. Similarly, the production uncertainty σ_u^2-as measured by the variance of the inefficiency effects estimates-are related to exogenous factors of maize production and agricultural extension services as follows:

$$\sigma_u^2 = exp(\pi_0 + \lambda D + \gamma' S)$$

4.5 Identification Challenges

The estimation considers and addresses two econometric challenges. First, both the allocation of extension efforts and participation in FISP are not random processes. With regard to FISP, the non-randomness is due to the fact that the determination of programme beneficiaries is purposive since it targets poor small-scale farmers. As such it would be inappropriate to assume that households are equally likely to receive the fertiliser coupons. This implies that throwing a dummy variable for FISP in a regression equation, as most papers (see Dorward et al, 2008; Dorward & Chirwa, 2011; Sibande et al, 2015; Mukozho, 2015) that have studied the impact of FISP in Malawi have done, is not appropriate. This is because of endogeneity that may arise due to the non-randomness of FISP. Following Karamba (2013) and Chibwana et al (2012) this study employed Instrumental Variable (IV) approach in order to deal with potential endogeneity. We use the number of years that the household head has been staying in the community as an instrument. Following Chibwana et al (2012), choice of the instrumental variable is premised on the fact that it is highly probable that a household whose household head has stayed a long time in a community has strong social connections within the community. In this case, it is highly likely that the village head considers such a household in the distribution of farm input subsidy coupons. But, having stayed long in a community has no direct connection at all with household maize yield. This makes length of stay in a community by a household a possible valid instrument.

Analytically, to solve this FISP endogeneity problem, we run the Cobb-Douglas production function in two steps:

Step 1: Run the following models to get predicted FISP treatment assignments

$$FISP_{hc} = \varphi + \vartheta(years\_head)_{hc} + \omega(permanent)_{hc} + \Omega X + \varepsilon_{hc}$$

Step 2: Use the predicted treatment assignments (i.e. $FISP^P$ in place of FISP) in running the Cobb-Douglas function;

$$ln\, yield_{phc} = \alpha_0 + \sum_{k=1}^{K} \alpha_k \, ln\, x_{phck} + \sum_{j=1}^{J} \delta_m Z_{hcj} + \theta D_{hc} + \beta^{'} W + \eta_{phc} - \mu_{phc}$$

$$v_{phc} \sim N(0, \sigma_v^2);\ \mu_{phc} \sim N^{+}(0, \sigma_u^2)$$

In the first stage, the endogenous variable, FISP is regressed on a set of exogenous variables (X) and the instruments ($years\_head$,$permanent$). In so doing, the instruments generate exogenous variation in the programs participation that is not correlated with the error term thereby addressing the source of bias. The predicted values capturing the exogenous variation of program participation obtained in the first stage (i.e. $FISP^P$) are then included in the second stage.

Similarly, the allocation of extension efforts is not random across and within localities. For example, governments may decide to concentrate extension resources in areas that have high agricultural potential (Ragasa et al, 2016). If this effect is not taken into account, estimates of impact will be biased upward. Gautam and Anderson (1999), however, argued that when district fixed effects are incorporated, this bias disappears. This paper addresses this potential bias by using agro-ecological zones. We could not use district fixed effects as proposed by Gautam and Anderson (1999) since this would result in loss of degrees of freedom considering that we have 31 districts in the data.

The second econometric issue regards the fact that measuring the impact of extension services is not straightforward. As noted by Ragasa et al(2016), various challenges arise in this regard, including: (1) issues of attribution, because of the diversity of service providers and their delivery methods; (2) difficulty in determining the incremental contribution of additional advice, given that several instances of receiving advice contribute to a stock of knowledge over time; (3) and difficulty in measuring the contribution and impact of extension services where services and inputs are usually bundled into a package or program. In this paper we are able to only address problem (1) and (3) but we are not able to address (2) due to data challenges. Following Ragasa et al(2016), we address these two difficulties by using receipt of any agricultural advice, regardless of the source or method and independent of any program, to avoid the issue of attribution between providers and bundles of services.

5. Empirical Results

5.1 Descriptive Statistics

Table 1 below shows the summary statistics of the variables employed in the analysis. With regard to smallholder maize production, the table shows that with an average land holding of about 0.6075 hectares (roughly around 1.5 acres) of land per household, the average maize yield is around 475.945 Kilograms per household which translates into about 10 50-KG bags. Averages of 77.785 Kilograms of maize seeds are sowed per household. The table also shows that a majority of the farmers have access to agricultural extension services. Specifically, about 90% of the farm households reported having received agricultural extension services. On the contrary, a smaller proportion of farmers have access to the subsidy coupons with only 26% of the farm households in the sample having had access to fertilizer coupons under the FISP program.

Table 1: Descriptive Statistics (sample size: 7,170)

Variable Name	mean	Standard deviation
Maize Output (in Kilograms)	475.945	776.104
Household visited by extension agent	0.909	0.288
FISP	0.255	0.436
Seeds in Kilograms	77.785	490.360
Land in acres	1.551	1.699
Household Size	4.479	1.952
Head is permanent resident	0.040	0.195
Years in the community	0.288	3.404
Age of household head	45.631	17.011
Sex of the household head	0.030	0.172
Residential area(1=rural)	0.920	0.271
Highest qualification by any adult in the household is:		
PLSC	0.132	0.338
JCE	0.108	0.311
MSCE	0.068	0.252
Tertiary	0.019	0.138
Region		
Centre	0.341	0.474
South	0.482	0.500
North	0.177	0.382
Number of individuals in the household with :		
Females with JCE	0.106	0.307
Males with JCE	0.003	0.050
Females with MSCE	0.066	0.248
Agro ecological Zones		
zone1: Nsanje, Chikwawa districts	0.024	0.152
zone2: Blantyre, Zomba, Thyolo, Mulanje, Chiradzuru, Phalombe districts	0.238	0.426
zone3: Mwanza, Balaka, Machinga, Mangochi districts	0.196	0.397
zone4: Dedza, Dowa, Ntchisi districts	0.109	0.311
zone5: Lilongwe, Mchinji, Kasungu districts	0.133	0.339
zone6: Ntcheu, Salima, Nkhotakota districts	0.083	0.277
zone7: Mzimba, Rumphi, Chitipa districts	0.117	0.321
zone8: Nkhatabay, Karonga districts	0.047	0.212

Further, table 1 shows that the average household size in the sample is 4.47 individuals, slightly above the 4.3 persons observed in the main report (NSO, 2016). The average age of household head is about 46 years, and 97% of the heads are male.

5.2 Maize Cobb-Douglas Production Function Results

Having examined the descriptive statistics, we then move on to present the results of the Cobb-Douglas smallholder maize production function. As we explained in the methodology section, running the Cobb-Douglas production equation directly would potentially result in biased and inconsistent estimates due to endogeneity. The first step in our regression analysis, therefore, was to test for endogeneity. We used the Durbin-Wu-Hausman test of endogeneity. According to this test, we run the FISP participation equation, from which we predicted residuals. We then run Cobb-Douglas production function with the residuals included as regressors. The results of the FISP participation model are presented in appendix A whereas the results of the Cobb-Douglas with the residuals included as one of the regressors are presented in table 2 below;

Table 2: Durbin-Wu-Hausman test of endogeneity results

Variable Name	Coefficient	T-statistic
Log of land	0.457^{***}	(29.27)
Log of seeds	0.067^{***}	(7.44)
Agro ecological Zones		
Zone 2	0.502^{**}	(2.00)
Zone 3	0.494^{**}	(1.99)
Zone 4	1.018^{***}	(4.02)
Zone 5	0.812^{***}	(3.23)
Zone 6	0.936^{***}	(3.70)
Zone 7	0.559^{**}	(2.19)
Zone 8	0.155	(0.58)
extension	0.170^{**}	(2.33)
FISP	2.037^{***}	(9.18)
c.extension#c.FISP	-0.208^{**}	(-2.31)
uhat_FISP	-1.635^{***}	(-7.90)
_cons	4.957^{***}	(18.42)
N	7139	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The regression results as presented in table 2 above indicate that *uhat_FISP* is statistically significant. This technically implies that indeed FISP is endogenous, confirming our previous suspicion. Our adoption of the IV approach is, therefore, justified. In the spirit of IV approach, we then run the Cobb-Douglas production equation, this time with the estimated FISP participation. The results of the model are presented in table 3.

From the Cobb-Douglass production function results, it is clear that the production frontier is well behaved since the marginal products are positive. With regard to our study objective, it is clear that both access to extension services and being a beneficiary of FISP are separately yield-enhancing. Specifically, a household that has access to extension services experience about 0.798 % higher maize output compared to farm households with no access to extension services. Similarly, farm households that benefit from FISP experience about 2.918 % higher maize yield as compared to households that are non-beneficiaries. Interestingly, the interaction term also has a positive and significant coefficient with a magnitude of about 3.691% that obviously is higher than the coefficients of FISP and extension services. What this means is that, if a household has access to both extension services and FISP, it experiences about 3.691% increase in maize yield compared to households with access to neither. Recalling that FISP alone improves household maize yield by about 2.918%, this means that having access to extension services, for a household that already has access to FISP, increases the magnitude of the impact of FISP on maize yield even further. Specifically, households that have access to both FISP and extension services experience about 0.773 % (3.691%-2.918%) higher maize yield compared to households that have access to FISP only.

To shed more light on this interpretation, let us assume an average smallholder farmer produces 100 50-Kg bags of maize but has no access to extension services nor FISP. If this farmer is to be a beneficially of FISP in a certain cropping season, then they will realize an increase of about 3 bags (2.918% of 10 bags), producing about 13 50-Kg bags of maize. However, if this farm household is to receive extension services over and above the FISP, they will on average realize an increase of about 4 bags (3.691% of 10 bags), producing about 14 50-Kg bags of maize. This implies that extension services are translating into about 1 bag increase in maize yield over and above what a farmer would get with FISP alone. We find these increments economically significant bearing in mind the challenges that smallholder farmers face in order to produce just 1 50-Kg bag of maize in the country.

Table 3: Cob-Douglas, inefficiency and uncertainty estimates (without Endogeneity)

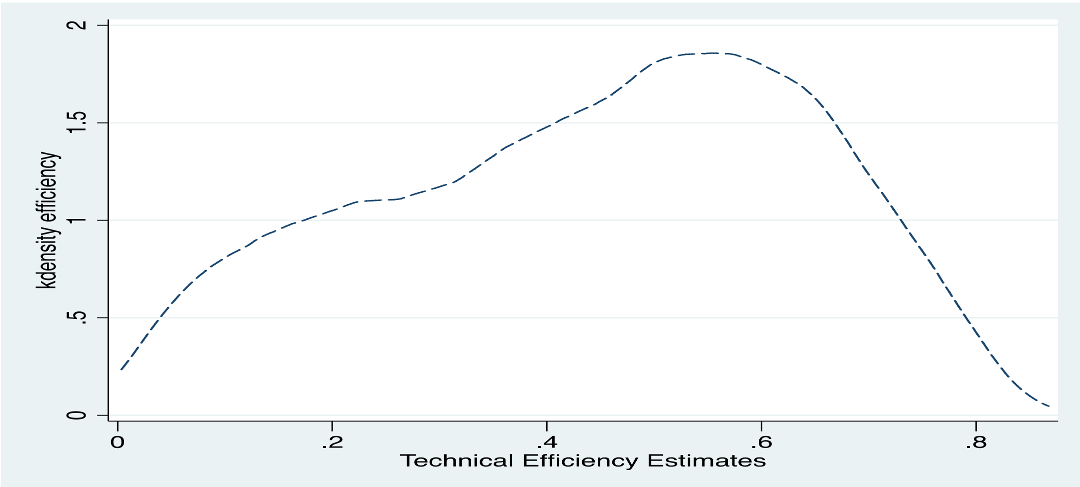
Variable Name	Cob-Douglas	Inefficiency	Uncertainty
Log of land	0.482***	-	-
Log of seeds	0.063***	-	-
Extension	0.798***	1.174**	-2.057***
yhat_FISP	2.918***	9.671***	-10.370***
c.extension#c.yhat_FISP	3.691***	5.145**	-8.840***
Agro ecological Zones			
Zone 2	0.553**	-0.809**	-0.239
Zone 3	0.503**	-0.930***	-0.431
Zone 4	1.024***	-0.815**	-0.655*
Zone 5	0.844***	-0.736**	-0.781**
Zone 6	0.961***	-0.888**	-0.209
Zone 7	0.559**	-0.507	-0.869**
Zone 8	0.072	-0.331	-0.702
Zone 9	1.128***	-1.098***	0.016
_cons	6.201***	0.424***	-0.238***
Sample Size	7139	7139	7139

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.3 Technical Efficiency and Production Uncertainty

The distribution of maize technical efficiency estimates are as shown in figure 2. Evidently, most maize farmers are inefficient. The average technical efficiency is estimated to be at 0.47 implying that maize yield can be increased by 53% by simply improving technical efficiency alone without increasing input usage. A farm household with the lowest technical efficiency had efficiency estimate of around 0.002 while the highest technical efficiency estimate is 0.906.

Figure 2: Distribution of technical efficiency estimates



Source: Authors' calculations using IHS 4 data set

Going to the estimated coefficients in the inefficiency and uncertainty models (table 3, column 3 and 4) we note that access to agricultural extension services on average increases maize output and reduces maize output uncertainty. Ceteris paribus, a household with access to agricultural extension services experiences higher output and lower maize output uncertainty by about 1.174% and 2.057%, respectively, as compared to a household with no access to agricultural extension services. Similarly, ceteris paribus, a household which is a beneficiary of FISP experiences higher maize output and lower maize output uncertainty by about 9.671% and 10.370%, respectively, as compared to a household that is not a beneficiary. In addition, a household that is a beneficiary of both FISP and extension services experiences higher output and lower maize output uncertainty by about 5.145% and 8.840% respectively, as compared to a household that is a beneficiary of FISP program only.

6. Conclusion and Policy Implication

This study has assessed the interactive impact of access to agricultural extension services and FISP on household agricultural production and technical efficiency in Malawi. Results of the well behaved estimated stochastic model showed that both access to extension services and being a beneficiary of FISP have statistically significant positive effects in the production function. This means that they are separately yield-enhancing. The results also show that having access to extension services increases the magnitude of the impact of FISP on maize yield. This implies that the country can benefit more from FISP if it enhances efforts towards increasing supply of agricultural extension services to smallholder maize farmers. Finally, the results have indicated that a household that is a beneficiary of both FISP and extension services experiences higher output and lower maize output uncertainty as compared to a household that is a beneficiary of FISP program only. This means that enhancing extension services within FISP environment can also improve maize production efficiency and reduce maize production uncertainty in Malawi.

Having said this, we must say that our study, just like any study, is not free of problems. Most importantly, we noted in section 5.5 that one of the econometric challenges, particularly with respect to extension services, was the difficulty in determining the incremental contribution of additional advice given that several instances of receiving advice contribute to a stock of knowledge over time. We did mention in that section that the dataset we have used in this study is not rich enough to help us solve this problem. In fact, while the dataset used in this paper has information on advice received in a particular year, it does not include access to advice in previous years by an individual household. As such, we could not solve this problem. Our results therefore should be interpreted with caution in this regard. Of course, Ragasa et al (2016) proposes use of village level information on access to extension services from previous years which is available in the data set. However, we think that this is not a good proxy to use in solving this problem since village level access may not always imply household level access. This obviously opens up an area of extension to this study in the future if one is able to use/find a data set that has such kind of information.

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Appendix A: Determinants of participation in FISP

FISP participation Model

Variable Name	**Coefficient**	**T-stat**
Age of household head	0.003***	(9.89)
Sex of household head	0.020	(0.55)
Household head	0.008***	(2.86)
Years in the community	-0.001	(-0.94)
Head is permanent resident	-0.056*	(-1.72)
Highest qualification by any adult in the household is:		
PLSC	-0.001	(-0.04)
JCE	-0.003	(-0.17)
MSCE	-0.029	(-1.38)
Tertiary	-0.176***	(-4.72)
_cons	0.083***	(4.04)
r2_a	0.019	
F	16.222	
p	0.000	
N	7170	