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**Effects of Maize Fertilizer Subsidies
on Food Security in Malawi**

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Abstract

This study employs spatial analysis to examine the impact of smallholder fertilizer subsidies on national and household food security in Malawi. It illustrates that at national level, food security is positively linked to fertilizer subsidies. However, at household level, maize production is heavily skewed with the south lagging behind the centre and the north. In the short-to-medium term, replacing the current countrywide subsidy program with a more targeted one is highly recommended. Furthermore, by diversifying into other crops or small-scale businesses, smallholders may be able to increase their income and hence food buying power.

Keywords

maize
subsidy
food security
Malawi

JEL Code

C01; Q18

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1. HISTORICAL BACKGROUND OF MAIZE PRODUCTION IN MALAWI

Maize, whose origins are traced to central Mexico nearly seven thousand years ago, was introduced to southern Africa by Portuguese sailors and tradesmen (McCann, 2001). Although the exact date of arrival is not known, by the early 1800s various native groups in southern Nyasaland¹ grew maize. However, cultivation was limited to very small quantities because at that time the staple food crops were sorghum, millet, rice, potatoes, groundnuts, pumpkins and cassava of which the first two were most important. According to Vaughan (1982, p. 354), people of the Shire highlands, especially the Nyanja, grew maize by exploiting riversides. ‘River-sand was placed on top of the waterlogged *dambo* mud and maize planted in it, allowing the roots to take what moisture the plant required from the clay below, without becoming saturated.’

Cultivation of maize took a new turn in the early 1900s with the arrival of Lomwe migrants from Mozambique which led to shortage of agricultural land in the Shire highlands. ‘It was in this period that this section of the peasantry began growing increasing amounts of maize at the expense of the older staples, millet and sorghum’ (Vaughan, 1982, p. 359). Maize was prioritized mainly because of its higher productivity per unit of land compared to the other crops. By the end of the 1960s, maize was cultivated nearly throughout the country as a staple crop. Since then, its importance and consequently land allocated to its cultivation has steadily increased. Currently, the crop is cultivated by 98 percent of rural farming households (GoM, 2005) covering nearly 65 percent of the country’s arable land.

The 1960s’ government campaign for turning maize into the national food crop was supported by policy interventions such as fertilizer and seed subsidies. At that time the main objective was to ensure that there was food security at both national and household levels. In the 1990s, increase in rural household income and reduction in income inequality between smallholders and large landowners² were added to the original objective of the subsidies. These subsidies were initially channelled through the state owned Agricultural and Marketing Corporation (ADMARC), which, between 1964 and 1994, was the sole seller and buyer of agricultural inputs and outputs. Losses that ADMARC incurred on its subsidized maize trading were covered through profits made from tobacco exports and other cash crops that it purchased from smallholders at below export parity producer prices. Currently, the subsidies are administered directly by the Ministry of Agriculture and Food Security through various regional and district outlets where coupons are distributed to beneficiaries. We return to this issue later in section three.

¹ Nyasaland was Malawi’s former name before 1964. In particular the country was named Nyasaland in 1891 when it was declared a British protectorate.

² According to Lofgren (2001), smallholders refer to households that own less than 2 hectares of land. Those who own between 2 and 5 hectares are referred to as medium landowners while those who have more than 5 hectares are referred to as large landowners or estate owners. For the purpose of this paper, large landowners stand for all those that own at least 2 hectares of land.

Over a period of twenty years after independence in 1964, maize production and hence national food security was a success story for Malawi. During that period, the country became a net exporter of maize to countries such as Zambia and Tanzania. However, the food security policy was fragile as it hinged on an overall agricultural strategy that favoured the estate sector. The smallholder sector, the core producer of maize, was simply regarded as a provider of food to the nation and low cost labour to the estate sector, which, at that time, was the sole producer of the lucrative burley tobacco and tea. Consequently, by the end of the 1970s 'whilst the estate sector grew at over 17 percent per annum, smallholder growth was less than 3 percent' (Harridan, 2008, p. 241).

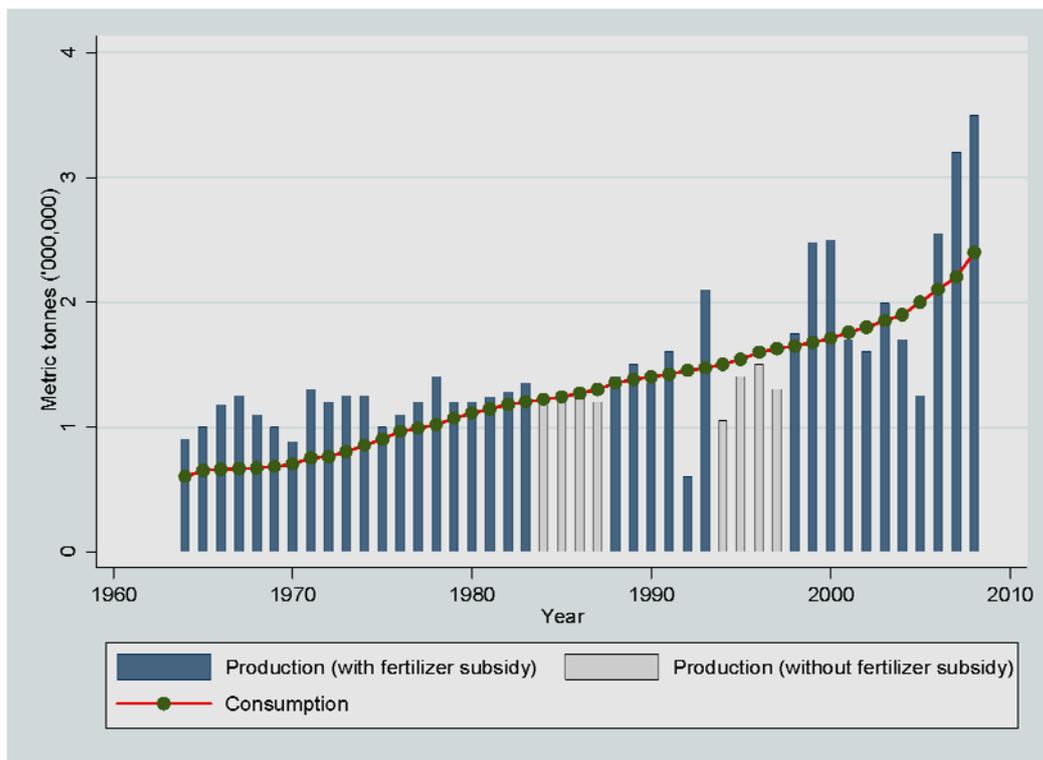
The smallholder maize sector started to falter from the early 1980s mainly due to inconsistent fertilizer subsidies as explained in the following section. Since then, Malawi has registered erratic trends in smallholder maize production and food security. The situation has drawn interest from a number of researchers. For instance, Forward (2006), Cheraw *et al.* (2006) and Harridan (2008) have carried out insightful explanatory work regarding performance of the agriculture sector, poverty and food security in Malawi. However, studies based on empirical analysis to examine the impact of maize fertilizer subsidies on food security are surprisingly scarce. It is this shortfall that motivates this paper. Our main objective is to examine the effects of maize fertilizer subsidies on national and, more importantly, household food security.

2. DEVELOPMENTS IN FERTILIZER SUBSIDIES AND MAIZE PRODUCTION IN MALAWI

The first phase of Malawi's fertilizer subsidies occurred between 1964 and 1983. During that time, smallholder fertilizer was subsidized by about 25 percent of the commercial price of the day (Mkandawire, 1999). However, subsidies on fertilizer were phased out in 1983 under the structural adjustment policies that started in 1981. After removing these subsidies, the country's maize output fell by nearly 10 percent in 1984 as indicated in Figure 1 below.

From 1984 to 1987, there was stagnation in maize production, a situation that compared unfavourably against an increasing national consumption trend. By 1987, Malawi was forced to import 140,000 metric tons of maize (Stambuli, 2002). The poor performance of the smallholder maize sector compelled the Malawi government to resume fertilizer subsidies in 1988 but this was opposed by the donor community. Donors felt that subsidies on smallholder fertilizer were one of the major factors that led to high public deficits, which Malawi was required to address. The feud that followed between Malawi and the donors over the issue of the subsidies partly led to foreign aid withdrawal in 1992 and precipitated change of government in 1994. However, during the time the subsidy was reintroduced (1988-1993), the country registered food surpluses except for 1990 and 1992 due to drought which was particularly severe in 1992.

Figure 1: Maize production and consumption in Malawi (1964-2008)



Source: Ministry of Agriculture and Irrigation (various issues)

At the end of 1993, price subsidies for fertilizer and hybrid seeds were abolished once again. The marketing of fertilizer and hybrid seed was liberalized and the Fertilizer Farm Feeds and Remedies Act was amended to allow for private sector importation and distribution (GoM, 2003; Mkandawire, 1999). The years that followed were characterized by severe food shortages as most farmers were unable to purchase fertilizer for their maize production. In the commercial agricultural sector, most smallholder farmers were equally unable to grow tobacco and other cash crops due to similar problems. For those who managed to grow tobacco, the quality was generally poor leading to low prices at the auction floors. These socio-economic problems led to massive devaluation of the Malawi currency, rising inflation and food insecurity especially amongst the rural poor (Kherallah *et al.* 2001).

By 1997, the Malawi government started to negotiate with the donor community for support to resuscitate smallholder productivity and ensure food security in the country. Towards the end of 1997, an agricultural investment project was approved which marked the introduction of what can be termed as the second phase of fertilizer subsidy programs, which started in 1998. In that year, the starter pack scheme (SPS) was devised and funded jointly by the Malawi government, the Department for International Development (DFID), the European Union (EU) and the World Bank to a tune of US\$25.6 million. The scheme was primarily designed as a short term rescue plan. About 2.8 million starter packs were distributed to smallholders country-wide. The free input packs included fertilizer (about 10 kilograms of urea or NPK) and seeds (about 2.5 kilograms of maize and legumes) for 0.1

hectare per smallholder household. For two consecutive years after the introduction of the SPS, Malawi recorded unprecedented high maize yields of about 2.48 million metric tons and 2.50 million metric tons in 1999 and 2000, respectively (GoM, 2001).

However, by the end of the year 2000, the Malawi government and the donor community were again at loggerheads over continued funding and poverty effects of the SPS. Some donors faulted Malawi's intention of turning the SPS into a long term rescue plan, contrary to its initial objective. They viewed the SPS as a waste of donor aid with a potential of stifling private sector input delivery, promoting corruption and locking Malawi into a maize poverty trap. The above disputes made the World Bank discontinue and the EU curtail their financial assistance towards the scheme. With one committed donor, DFID, Malawi was forced to scale down the SPS to a targeted input program (TIP). Under the TIP, the number of beneficiaries was reduced from an average of 2.8 million households between 1998 and 2000 to 1.5 million households in 2001 and 1 million households in 2002. Total funding was also reduced from US\$25.2 million in 1999 to only US\$7.6 million in 2001. Unfortunately, the TIP coincided with a drought that affected the country from 2001 to 2002 which led to another food crisis in which many people became destitute and lost their lives. During that time maize output dropped to an average of 1.5 million metric tons against an expected demand of about 1.9 million metric tons.

DFID increased its financial support from US\$9.9 million in 2002 to US\$10.9 million in 2003 and, for this reason, the TIP was renamed Extended TIP (ETIP). Combined with Malawi's contribution, ETIP total funding in 2003 stood at US\$12.1 million. This led to an increase in the number of beneficiaries to 2 million households. In that year, maize output went up to 2 million metric tons. In 2004, ETIP total funding declined to about US\$9 million which catered for a reduced number of 1.7 million smallholder families. The drop in the number of beneficiaries was matched by a drop in maize yield to 1.7 million metric tons. In 2005 the harvest went down further to about 1.25 million metric tons partly due to another drought that affected a number of districts in the country.

From 2005/06 growing season, the ETIP was once again renamed 'smallholder fertilizer subsidy' and in that year about US\$50 million was allocated for the program. This marked the beginning of what can be referred to as the third and current phase of fertilizer subsidies in Malawi. This phase is similar to the first one except for the fact that today's price ceiling is much higher than before. For instance, in 2006/07, the price ceiling was at 72 percent while it was at 79 percent, 95 percent and 88 percent in 2007/08, 2008/09 and 2009/2010, respectively (GoM, 2008, 2009, 2010, 2011). However, from 2006, the country has enjoyed bumper maize harvests. For the first time in about three decades, out of its 3.2 million metric tons of maize harvest in 2007, Malawi was able to export about 0.4 million metric tons to Zimbabwe.

In general, the above analysis suggests that, at national level, high maize production and hence food security is positively linked to fertilizer subsidies. Based on data from 1964 to 2008 (see Figure 1), the study finds that there is a statistically significant correlation

coefficient of 0.389 (with P-value= 0.008) between fertilizer subsidies and national maize output. However, correlation is not a good indicator of causality. Therefore, in section four we conduct an econometric test to examine the extent to which fertilizer subsidies explain national maize output in Malawi. Before that, we briefly discuss the impact of political influence on the distribution of fertilizer subsidies in Malawi.

3. THE ROLE OF POLITICS IN SPATIAL DISTRIBUTION OF FERTILIZER SUBSIDY IN MALAWI

Fertilizer subsidies are administered directly by the Ministry of Agriculture and Food Security through various regional and district outlets where coupons are distributed to beneficiaries in all administrative areas in the country. In the rural areas, administrative areas are overseen by traditional authorities (TAs) and senior chiefs while in the urban areas, administration areas fall under the authority of councillors and mayors. When it comes to distribution of coupons, which takes place primarily in the rural areas, officials from the Ministry of Agriculture and Food Security, ensure that they involve TAs and senior chiefs.

However, there is evidence pointing to the fact that distribution of the subsidized fertilizer in Malawi is spatially selective based on political influence and affiliation. For instance, in 2008 the then Minister of National Defence, Bob Khamisa, confessed to the media that government ministers were given 2000 coupons each to dispense in their districts. Since the majority of the ministers come from the president's home and the surrounding districts, this meant that smallholders in these areas benefitted more compared to other areas.

Holden and Lunduka (2010, p.16) summarized the politically motivated rent seeking behaviours associated with Malawi's subsidized fertilizer in a number of bullets, some of which are as follows.

- A top political party member being caught with coupons that he had obtained from a minister in the government.
- A paramount chief being caught selling coupons and therefore put in prison until the president himself reacted quickly to get him released.
- Use of the subsidy system in relation to the parliamentary elections to buy votes.
- Partly distributing coupons to and through the chiefs to get their support and have them organize the identification of beneficiaries with use of village level committees...

Ricker-Gilbert *et al.*(2010, p. 40) employ a 'Double-Hurdle' model of fertilizer demand in Malawi with an objective of examining how fertilizer subsidies affect farmer demand for commercial fertilizer. Among other things, their 'findings indicate that the level of social and political connections affects how much subsidized fertilizer households receive.' Of course, Malawi's case is not an isolated one. Elsewhere, Banful (2010) found out that political influence affected the way the 2008 subsidized fertilizer was distributed in Ghana. Earlier, Robinson (2002, p. 854) revealed that smallholders that were chosen for the irrigation

scheme in Zimbabwe ‘had some affiliation with those in political power.’ Finally, in South Korea, the Park regime of 1961 to 1979, which was dominated by people from Kyongsang, ‘imposed regionally biased policies through the recruitment of elites and the allocation of public resources to secure political support from Kyongsang’ (Park, 2003, p. 814).

Cox and McCubbins (1986, p. 379) argue that ‘politicians will adopt strategies in which they invest little (if at all) in opposition groups, somewhat more in swing groups, and more still in their support groups.’ Although ‘political colour of governments influences the distribution of access to scarce goods...’ (Westert and Groenewegen, 1999, p. 237), public finance theories postulate that political influences lead to inefficient resource allocation (Oates, 1999). Therefore, the key question is: taking into account the impact of political incentives, how effective are these subsidies on the Malawi’s maize production? To answer this question, we conduct ordinary least squares (OLS) and spatial regression analyses in the following section.

4. THE MODEL AND REGRESSION ANALYSES

Our model is based on data from the 2008/09 Annual National Census of Agriculture conducted by the Ministry of Agriculture and Food Security covering all (246) administrative areas in the country. The log linear production function³ that is used to estimate how fertilizer subsidies and other factors affect maize production in Malawi is expressed as follows:

$$\ln Y_i = \ln \alpha_0 + \sum \ln \alpha_j X_{ji} + \varepsilon_i \quad (1)$$

where, Y_i is administrative area i^{th} average maize output in tonnes per hectare. α_0 is a constant while α_j is an estimated coefficient of parameters and ε_i is the error term. X_{ji} is a vector of explanatory variables, namely topography, temperature, fertilizer subsidy, rainfall, access to credit, use of machinery and lagged maize price in administrative area i . Under topography we consider the percentage of farmers that grew maize in plains in each administrative area during the 2008/09 agricultural season. In Malawi, maize tends to do well in plains most of which have fertile loamy soils suitable for maize production. We therefore expect its coefficient to be positive.

Temperature is another important factor for maize production that is considered in a number of studies. According to Taba and Twumasi-Afriyie (2010, p. 2), ‘maize can grow in a temperature range of 5–45 °C, but generally does best at 25–35 °C. Extreme high temperatures, especially combined with low humidity, may reduce pollen viability and cause poor seed set.’ Until recently, Malawi’s average temperatures have been oscillating between 15 and 35 °C. However, of late, in a number of areas, Malawi has been experiencing a steady

³ Power production functions have often been employed to estimate the importance of these factors in agricultural production (Gbetnkom, 2008; Olarinde and Manyong, 2007). One major reason for the popularity of a power function is that it can be easily transformed into a log linear function with more than two exogenous variables.

increase in temperatures above 35 degrees Celsius, a phenomenon that has been attributed to global warming. It is feared that sustainable increases in average temperatures might have a negative impact on maize production in the country. We therefore expect its coefficient to be negative.

At the heart of this study is the impact of fertilizer subsidies on maize production. We consider the percentage of farmers that received fertilizer subsidy in the 2008/09 growing season. On average, farmers that received the subsidy would be expected to obtain higher maize output than the ones that did not. A positive coefficient is therefore expected. Similarly, the amount of rainfall received in each administrative area and previous season's maize price are also expected to have a positive impact on each area's average maize output per hectare⁴. Farmers that had access to credit and those that used machinery such as ploughs and tractors are expected to achieve higher maize yields per hectare than those that did not, we therefore expect positive coefficients for these variables. A summary of these variables is provided in Table 1.

Table 1: A summary of the model variables (2008/09)

Variable Name	Maize	Subsidy	Rainfall	Temperature	Topography	Price_1	Credit	Machinery
Definition	Maize yield per hectare in kilograms	Households receiving fertilizer subsidy (%)	Rainfall in millimetres	Temperature in degrees celsius	Households growing maize on plains (%)	Previous season maize price in Malawi Kwacha	Number of maize farmers receiving credit	Number of maize farmers using machinery
Minimum	478	15	713	23	10	42	1	1
Maximum	2715	86	1465	37	26	95	12	21
Mean	1659	56	1075	28	16	71	2	4

Traditionally, a classical ordinary least square (OLS) regression analysis could be employed to estimate the above model. However, there is a growing literature pointing to the fact that location can be a major factor in explaining crop production (Cliff and Ord, 1970). According to the first law of geography (Tobler, 1979)⁵, distant (contiguous) locations can have different (similar) topographies and experience different (similar) weather patterns that may impact differently (similarly) on crop production. It is in this regard that we incorporate a diagnosis for spatial dependence in our model. The other reason for testing for spatial association is that we have used cross-sectional data which may subject our model to spatial

⁴ Rainfall and temperature statistics were supplied by the Department of Climate Change and Meteorological Services in Blantyre, Malawi while maize prices were sourced from the National Statics Office (2008b).

⁵ The first law of geography states that contiguous locations tend to be more similar to each other than distant locations.

autocorrelation (Anselin and Rey, 1991). Should that be the case then our estimates may either be inefficient or biased.

Spatial association is typically analyzed by a global Moran's I correlation coefficient as follows:

$$I = \frac{n}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij} (x_i - \mu)(x_j - \mu)}{\sum_i (x_i - \mu)^2} \quad (2)$$

where, x ($i, j = 1, \dots, n$) stands for all observations with their mean given as μ and w_{ij} is an element of the spatial weight matrix, W that identifies neighbouring spatial units.

There are two main kinds of spatial association, namely spatial error and spatial lag. In the case of spatial error autocorrelation, it is the error terms across regions that are correlated. With spatial error autocorrelation, equation (1)'s error term becomes:

$$\varepsilon = \lambda W \varepsilon + \mu \quad \text{with } \mu \sim N(0, \sigma^2 I) \quad (3)$$

where λ is the spatial autoregressive parameter and ε is a vector of error terms while the rest of the variables are as defined before. Equation (3) violates the assumption of uncorrelated error terms governing the OLS regression which in turn makes the estimates inefficient. The solution is to take into account the spatial autocorrelation of the error term in equation (1) as follows:

$$\ln Y_i = \ln \alpha_0 + \sum \ln \alpha_j X_{ji} + \lambda W \varepsilon + \mu = \ln \alpha_0 + \sum \ln \alpha_j X_{ji} + (I - \lambda W)^{-1} \mu \quad (4)$$

On the other hand, the spatial lag hypothesizes that it is possible for a dependent variable in one spatial location to be influenced by independent variables from neighbouring spatial locations. If that happens, then both assumptions of uncorrelated error terms and independent observations are violated making the estimates biased and inefficient. In this case, the way forward is to include a spatially lagged dependent variable in equation (1) as follows:

$$\ln Y_i = \ln \alpha_0 + \sum \ln \alpha_j X_{ji} + \rho W \ln Y_i + \mu = (I - \rho W)^{-1} [\ln \alpha_0 + \sum \ln \alpha_j X_{ji}] + (I - \rho W)^{-1} \mu \quad (5)$$

where ρ stands for the spatial autoregressive coefficient of the dependent variable that has been spatially lagged.

In line with equations (2), (5) and (6), three tests are used to measure spatial autocorrelation in OLS regression models, namely, Moran's I, Lagrange Multiplier (Error) and Lagrange Multiplier (Lagged). While the Moran's I 'provides reliable results for alternative forms of ignored spatial dependence', the Lagrange Multiplier tests 'supply precise information about the kind of spatial dependence' (Niebuhr, 2001, p. 10). Table 2 indicates results of the spatial autocorrelation tests.

Table 2: Diagnostics for spatial dependence on OLS model

Test	MI/DF	Value	Probability
Moran's I (error)	0.604	15.386	0.000
Lagrange Multiplier (lag)	1	6.864	0.009
Robust LM (lag)	1	0.455	0.500
Lagrange Multiplier (error)	1	196.668	0.000
Robust LM (error)	1	190.259	0.000
Lagrange Multiplier (SARMA)	2	197.123	0.000

Highly significant positive values for Moran's I suggest that there is a strong positive spatial autocorrelation as far as maize production is concerned. The Lagrange Multiplier (lag) tests yield significant positive values suggesting strong spatial autocorrelation between independent variables. Similarly, the Lagrange Multiplier (error) tests yield significant positive values suggesting strong spatial autocorrelation of residuals. This implies that spatial autocorrelation with respect to maize production in Malawi is explained by both spatial lag and error. We therefore run classical OLS, spatial lag and spatial error regression analyses with the results being presented in Table 3.

OLS results indicate that the effects of topography, subsidy and rainfall on maize production are statistically significant at 1 percent level while use of machinery is statistically significant at 10 percent level. Removal of spatial lag slightly improves results evidenced by an increase in R-squared from 76 percent to 77 percent. Subsidy, topography and use of machinery remain statistically significant at 1 percent (for the subsidy and topography) and 10 percent (for use of machinery), respectively. However, the statistical significance of rainfall drops to 5 percent level. Furthermore, temperature which was not statistically significant under OLS is now significant at 5 percent level, although with an unexpected sign.

Removal of spatial error also improves results as indicated by an increase in R-squared to 91 percent. Both subsidy and rainfall remain statistically significant at 1 percent level while topography is no longer statistically significant. Lagged price of maize which is not statistically significant under OLS and spatial lag, is now significant at 1 percent level. The rest of the variables are statistically insignificant. As pointed out earlier, our regression analyses were designed mainly to examine the relationship between fertilizer subsidies and maize production in Malawi. Based on the above three tests, it can be concluded that, indeed, price fertilizer subsidies have a positive impact on average maize yield in the country. In all cases, a 1 percent increase in the number of fertilizer subsidy recipients leads to 0.2 percent increase in average maize yield per hectare.

Table 3: Classical OLS, spatial lag and spatial error regression results

Dependant variable: Log(Maize yield/hectare)

Number of observations: 246

Variable	OLS		Spatial lag		Spatial error	
	Coefficient	t-Statistic	Coefficient	z-value	Coefficient	z-value
Constant	0.043	0.324	0.165	1.221	0.076	1.343
Log(Subsidy)	0.206	2.729***	0.211	2.869***	0.195	2.868***
Log(Rainfall)	0.401	2.645***	0.378	2.564**	0.457	3.222***
Log(Temperature)	0.373	1.541	0.471	1.979**	0.053	0.229
Log(Topography)	0.731	5.491***	0.740	5.722***	0.259	1.502
Log(Price_1)	0.124	1.033	0.085	0.725	0.565	5.017***
Log(Credit)	0.005	0.146	0.010	0.321	0.022	1.206
Log(Machinery)	0.048	1.669*	0.048	1.762*	-0.006	-1.385
W_Maize (Rho)	-----	-----	0.035	2.721***	-----	-----
Lambda (λ)	-----	-----	-----	-----	0.944	52.135***
R-squared	0.76		0.77		0.91	

The ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively.

Although the above regression analyses provide important information with regard to the impact of fertilizer subsidies on maize production in the country, it does not reveal the distribution of the relationship at administrative area level. This is particularly important because, as indicated earlier, politics have an influence on the spatial distribution of the subsidy. We turn to this issue in the following section.

5. LOCAL SPATIAL ASSOCIATION BETWEEN FERTILIZER SUBSIDIES AND MAIZE PRODUCTION IN MALAWI

First, we use box maps to reveal quartile distributions of fertilizer subsidy and maize production in Malawi. Second, we employ local Moran's I BiLISA cluster map to examine areal-level spatial autocorrelation between the two variables. Based on the formula of Anselin (1995, p. 98), local Moran's I BiLISA statistic can be represented by the following equation:

$$I_i = z_{ai} \sum_{j=1, j \neq i}^N w_{ij} z_{bj} \quad (6)$$

where, a and b are the two variables under consideration for the two spatial neighbours, i and j ; z_a and z_b are the respective standardized scores of variables a and b . 'The spatial weight matrix w_{ij} is a binary contiguity matrix that defines the spatial structure for the locations that are included in the calculations of the local Moran's I' (Sunderlin *et al.*, 2008, p. 4). The weight can be written as:

$$w_{ij} = \frac{c_{ij}}{\sum_{j=1}^N c_{ij}} \text{ with } c_{ij} = 1 \text{ if } i \text{ and } j \text{ are contiguous, otherwise, } c_{ij} = 0. \quad (7)$$

GeoDa, the software used in this study to compute spatial autocorrelation, identifies two main contiguity matrices, namely rook contiguity and queen contiguity. A contiguity matrix, C_{ij} is an array designed to indicate which spatial locations share a common boundary. A value of one at spatial location (i, j) is indicated if the two spatial units are contiguous as indicated in equation (7) above. While rook contiguity ignores neighbours at the edge, queen contiguity takes into account all the surrounding neighbours. We employ first-order queen contiguity which means we take into account all administrative areas in the country with at least a single shared boundary point. Figure 3 and 4 indicate box maps while Figure 5 shows BiLISA cluster map which reveal quartile distributions and spatial autocorrelation of fertilizer subsidy and maize yield, respectively.

Figure 3 indicates the distribution of fertilizer subsidy for the 2008/09 growing season in the 246 administrative areas across the country. The national mean for recipients stood at 56 percent of smallholder households per administrative area (see Table 1). At national level, 189 administrative areas (77 percent) received fertilizer subsidy above the national mean. Notably, the majority of beneficiaries that received the subsidy above the national mean were from the south (68 out of 110 administrative areas = 62 percent). This was followed by the

north (30 out of 51 administrative areas = 59 percent), On the other hand, only 34 out of 85 administrative areas (40 percent) in the centre received the subsidy above the national mean.

Figure 3: Box map for fertilizer subsidy in Malawi (2008/09)

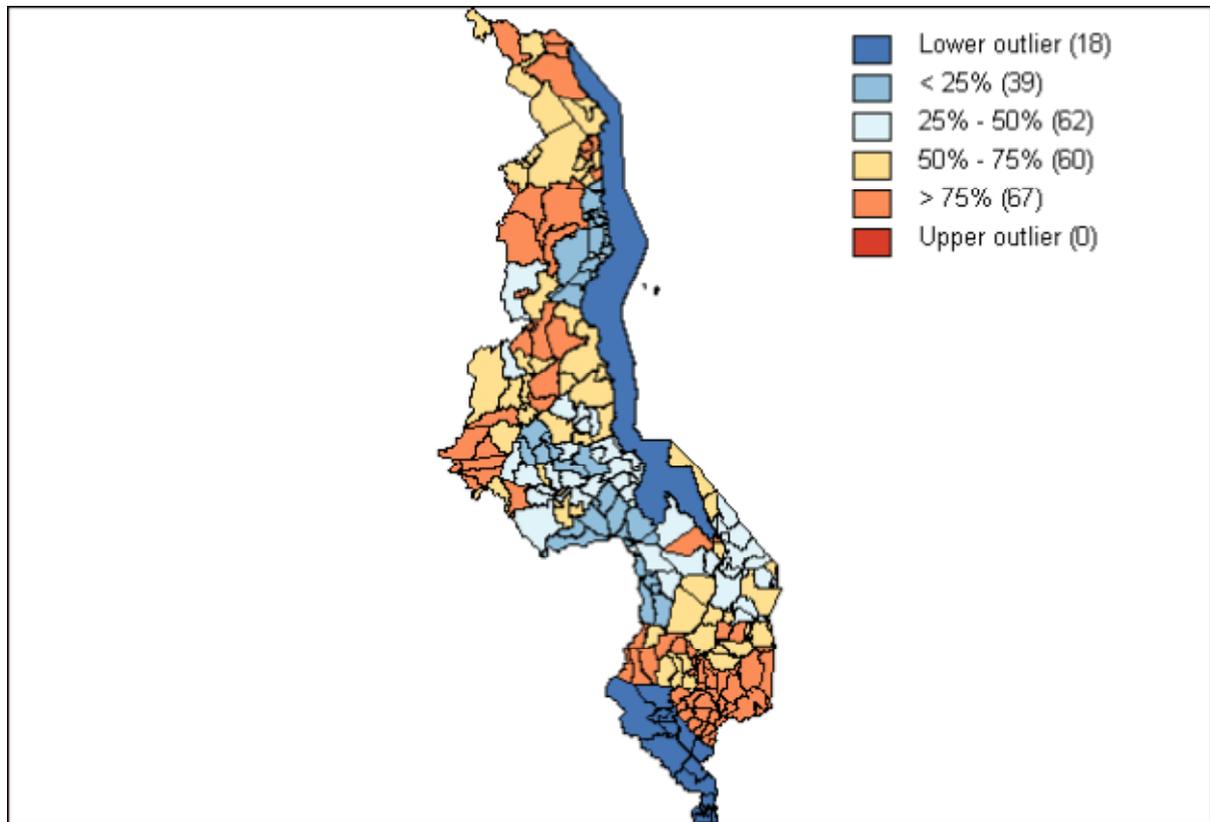
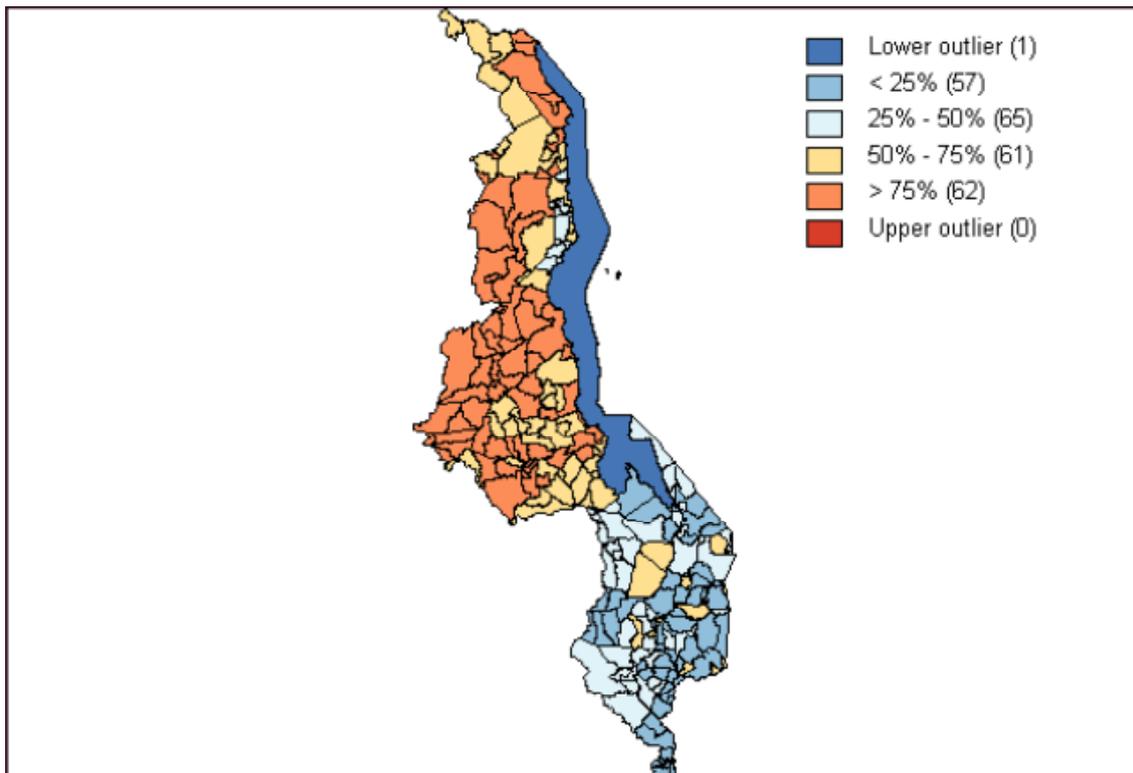


Figure 4 indicates average maize yield per hectare per administrative area during the same growing season with a national mean of 1.7 metric tons per hectare. In the centre, the majority of administrative areas (76 out 85 = 89 percent) recorded average maize yield per hectare above the national mean⁶. This was seconded by the north where 32 out of 51 administrative areas (63 percent) had average maize yield per hectare above the national mean. The south came last with only 22 out of 110 administrative areas (20 percent) registering average maize yield per hectare above the national mean. Figure 4 further reveals that the first law of geography of spatial dependence holds. Contiguous locations largely display similar patterns as far as maize production is concerned. This is in line with our findings (Moran's I) in Table 2.

⁶ High maize production in the central region can be attributed to favourable weather conditions (receives adequate rainfall) and fertile soils.

Figure 4: Box map for maize yield per hectare in Malawi (2008/09)



With regard to spatial autocorrelation between the subsidy and average maize production, Figure 5 shows that the relationship is mixed across the country. In the centre, all areas where beneficiaries had the subsidy above the national mean recorded average maize yield per hectare above the national mean. In these areas, the bivariate local Moran's I (BiLISA) is 'High-High' implying that the association between the subsidy and average maize output is significantly different from zero and positive.

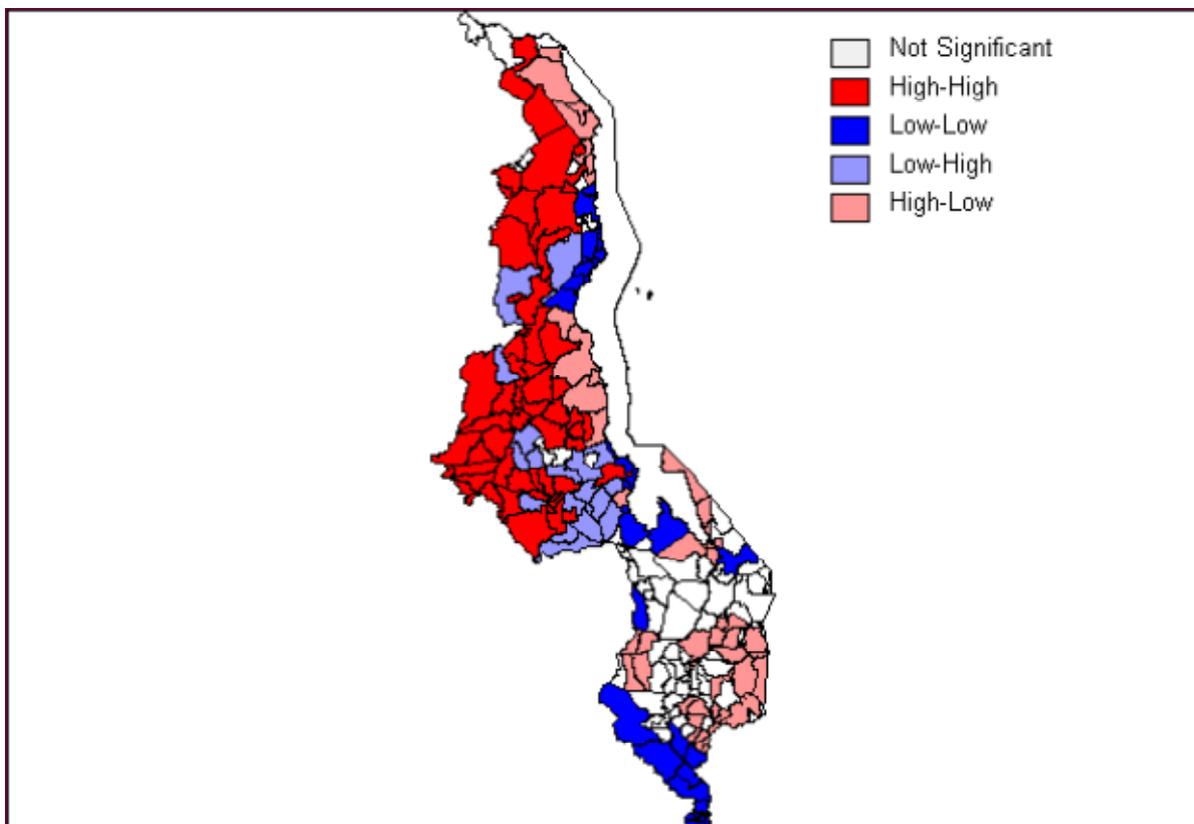
BiLISA is 'Low-High' in some other administrative areas in the centre suggesting a significantly negative relationship between the two variables. In these areas, on the one hand the subsidy was less than the national mean while on the other average maize production was above the national mean. A few areas, particularly along the lake shore in the central region show a 'Low-Low' Moran's I suggesting that they received fertilizer subsidy below the national mean and had maize yield per hectare also below the national mean. The pattern in the centre is largely repeated in the north with many areas indicating 'High-High' Moran's I.

However, in the south, the opposite is true. Many areas are either insignificant or have a 'High-Low' BiLISA indicating a statistically significant negative relationship. These areas had fertilizer subsidy above the national mean but registered average maize yield per hectare below the national mean. There are also a number of areas, particularly in Shire valley where the BiLISA is 'Low-Low' which can be interpreted as above.

The foregoing suggests that unlike the centre and the north, majority of households in the south produce below the national minimum requirement and hence are likely to be more food insecure. Since most of these households rely on fertilizer subsidies, it can be concluded that the politically motivated subsidies are not of much benefit to household food security in the south. In the short-to-medium run, it might be beneficial if government considered replacing the current countrywide subsidy program with a more targeted one by, *inter alia*, focusing on areas of ‘High-High’ and ‘Low-High’ bivariate associations.

Areas where maize cultivation is hampered, as is the case with many parts in the south, should be utilized for other agricultural or economic activities. Encouraging smallholders to cultivate other exportable cash crops that do well in these places can be a good option. For instance, cotton does very well in the Shire valley but so far there has been limited support from the government to enhance the sector. Smallholders can also be encouraged to invest away from agriculture into small-to medium scale businesses. For instance, government can devise deliberate policies to promote micro-finance programs where soft loans are extended to smallholders. Such activities may increase people’s incomes and hence their food buying power. Government revenue may also be saved through reduced subsidies that are currently extended to the majority of smallholders in areas where maize production is constrained.

Figure 5: BiLISA map for maize production and fertilizer subsidy in Malawi (2008/09)



6. CONCLUSIONS

The objective of this paper was to examine the effects of maize fertilizer subsidies on national and household food security. The study has illustrated that maize production in Malawi, from 1964 to 2008, has oscillated between periods of high and low production. At national level, high maize production and hence food security are positively linked to fertilizer subsidy.

At household level, food security is heavily skewed with the south lagging behind the centre and the north. The Moran's I results indicate that there is spatial autocorrelation between maize production and location. The central region stands out to be the main country's food basket as far as maize production is concerned. In the same region, there is high correlation between fertilizer subsidy and maize production suggesting that targeting the region with fertilizer subsidies would be more beneficial than a politically motivated country wide distribution of the subsidies.

Finally, in places where maize fails to do well, encouraging smallholders to diversify into other crops or small-scale businesses may help them increase their income and hence food buying power. This may also save government revenue through reduced subsidies that are currently extended to majority of smallholders in areas where maize production is hampered.

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