Fertilizer subsidy, political influence and local food prices in sub-Saharan Africa: Evidence from Nigeria

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Abstract: We investigate the effects of previous fertilizer subsidy program on local grain prices in Nigeria. The program has been considered ineffective in targeting and stimulating demand for fertilizer, with potentially rampant leakages. If the program has reduced food price, however, it can still be partly justified regardless of targeting efficiency. We exploit the panel structure of Living Standard Measurement Survey – Integrated Survey on Agriculture (LSMS) collected in 2010 post-planting season and 2011 post-harvesting season. Our methods use Euclidian distance between each district and state governors' origin district in each state to identify fertilizer subsidy distribution. We also use proxy variable that accounts for both direct subsidy provision and indirect leakage effects to measure the effective size of subsidy. Fertilizer subsidy generally had no effect on maize and sorghum price. In northern Nigeria, fertilizer subsidy might have lowered district level price of local rice, but only to a limited extent. Low market orientation of many subsidy recipients, crowding out of commercial fertilizer, and political influence in subsidy allocations may explain such low impact. We also discuss how our methods minimize potential biases due to errors-in-variable and sample selection.

Keywords: fertilizer subsidy, food price, fiscal federalism, political influence, Nigeria

1 Introduction

In the last two decades, many countries in Sub-Saharan Africa (SSA) have re-introduced fertilizer subsidy programs. The goals of these subsidies in countries like Nigeria have often been multi-faceted, including increasing farmers' income through higher agricultural productivity and stimulating the growth of the private input sector (FMARD 2011). Since the food price spike in 2008, food price reduction also became a reason for justifying fertilizer subsidies in these countries. Relatively little is, however, known about the effect of fertilizer subsidy on local food prices in SSA countries like Nigeria. Most empirical evidence on fertilizer subsidies focus on their effects on fertilizer use, productivity and private market development (Dorward et al 2008; Xu et al 2009; Ricker-Gilbert et al 2011; Liverpool-Tasie 2012; Mason and Jayne 2013; Takeshima et al 2013). Though longstanding as a policy in these countries, evidence is limited of the wider effects of fertilizer subsidy on food prices and welfare.

Rising (and high) food prices have been demonstrated to exacerbate poverty and food insecurity (Ivanic and Martin 2008; Ravallion 1990; Ravallion 2000) where majority of rural households are net food buyers spending large fractions of their income on food. Historically, substantial benefits from increased use of improved agricultural production technologies, including fertilizer, has accrued from indirect effects on consumers through lower food price, rather than through the direct benefits realized by the farmers involved (Evenson & Gollin 2003; Minten & Barrett 2008). Higher production among market oriented farmers due to increased access to and use of fertilizer via subsidy programs could potentially lower food prices. If such mechanisms exist and markets are well integrated, subsidy benefit may depend less on targeting and who obtains subsidized fertilizer.

On the other hand, many factors can still weaken the linkage between fertilizer subsidy and local food prices. Increasing literature has shown that recent fertilizer subsidy programs in Africa often crowded out the commercial fertilizer sector (Xu et al. 2009; Ricker-Gilbert et al. 2011; Takeshima et al. 2013; Ricker-Gilbert et al. 2013), except when they are implemented under the close supervision by Non Governmental Organizations (NGOs) (Liverpool-Tasie 2012) or implemented in poorer areas where private retailers are relatively inactive (Xu et al. 2009). In addition, if many beneficiary farmers are still relatively subsistence, which may be the case in Nigeria as we show in this study, the effects of fertilizer subsidy on food price may be weaker.

While often hypothesized, the effect of fertilizer subsidy on food prices and welfare remains largely unexplored in SSA. Two exceptions are Ricker-Gilbert et al (2013) who consider the effects of a targeted input subsidy program on maize prices in Malawi and Zambia and Burke et al (2012) who consider the effects of fertilizer subsidy on food production and poverty reduction in Zambia. Ricker-Gilbert et al (2013) finds that fertilizer subsidies have either no statistically significant effect on retail maize prices or, a statistically significant but very small negative effect on maize prices. This calls to question the validity of the huge costs of these programs; particularly when targeting is absent or inefficient, at best.

We contribute to this literature using Nigeria as a case study. While Ricker-Gilbert et al (2013) consider the effect of fertilizer leakages on fertilizer use, our study explicitly accounts for the price effect of these leakages. The lower price for commercial fertilizer as a result of leakages from fertilizer programs constitutes an indirect fertilizer price effect in localities receiving subsidized fertilizer which if not accounted for does not capture the full price effect of subsidized fertilizer. Our analyses also sheds light on differences across major crops, namely rice, sorghum and maize, with respect to the degree of market orientation of these crops and effect of fertilizer subsidy on their prices. Given that fertilizer subsidy constitutes a significant portion of government agriculture expenditure (sometimes as much as 68%[1]), it is important to understand if this often hypothesized effect of increased production and consequent lower food prices holds true. The limited evidence on Nigeria's large scale fertilizer subsidy program reveals that it has been poorly targeted (often received by wealthier farmers and farmers more likely to purchase fertilizer from the private market) and thus had a negative effect on the private fertilizer sector (Takeshima et al 2013). Evidence of broader effects of this program on food prices in Nigeria is thus important for proper evaluation of the program. Lower food prices due to fertilizer subsidy not only indicates a possible underestimated effect of such programs but can have significant effect on the welfare of numerous net buying households in Nigeria.

This paper also contributes to the growing literature on how political influence affects allocation of input subsidies in developing countries (Chinsinga, 2010; Banful 2011; Chapoto, 2012; Chinsinga, 2012; Holden and Lunduka, 2012; Mpesi and Muriaas, 2012;Mason et al 2013). With political influence, subsidized fertilizer may be allocated sub-optimally from a productivity perspective. If a market is less integrated, subsidy benefits will be most likely be captured by actual recipients and those who are well connected to those recipients, exacerbating the consequence of wrong targeting. Government interventions in SSA prior to the structural adjustment period were partly "aimed at development and partly at nation-building, i.e. the consolidation of power." (Holmén 2005, 90). Thus, subsidies were part of government efforts to ingratiate themselves with their largely agrarian populations and "malpractices, nepotism and diversion of resources from their intended use were often tolerated". Politically well-connected villages have been known to receive more inputs than demanded compared to less connected villages who received only a fragment of their requirement (Holmén (2005). Other studies like Bazaara and Muhereza (2003, 8) and Morris et al.(2007,32) present cases where the main beneficiaries in agricultural programs in Uganda and Zambia respectively were politically connected people and political supporters; often those who had nothing to do with farming or wealthy farmers who least needed such support. Along similar lines, Olayide and Idachaba (1987) describe a similar outcome of the agricultural interventions in Nigeria where credit and subsidized inputs were funneled to and captured by "absentee farmers, retired civil servants, and soldiers."

The use of subsidies to secure or build socio political capital continues today. Decentralization can advance patronage politics (Sadanandan 2012) where both central and local politicians distribute patronage to enhance their political support. Since local elections reveal information to central leaders about the geographic distribution of salient voters, central leaders can use this information to target particular benefits to these voters. In addition to the clientelistic strategies of political parties, elected local politicians also have individual strategies to distribute patronage (Sadanandan 2012). More specific to fertilizer subsidies, descriptive studies have shown how past election outcomes correlate with subsequent targeting of subsidized fertilizer (Chinsinga, 2010; Chapoto, 2012; Chinsinga, 2012; Holden and Lunduka, 2012; Mpesi and Muriaas, 2012). Banful (2011) finds the allocation of fertilizer subsidies to be targeted at opposition areas in Ghana while Mason et al (2013) and Mason and Ricker-Gilbert (2013) that the fertilizer in Zambia and Malawi is used to reward loyalty; being targeted toward areas won by the ruling party in the last election. At the household level the politicization and elite capture of input subsidies has also been demonstrated. Pan and Christiaensen (2012) find empirical evidence from Tanzania, that households with elected officials are much more likely to receive

[1] Liverpool-Tasie and Takeshima (2013)

an input voucher than other households. In Nigeria, anecdotal evidence suggests that, governors of many states patronize their origin district buy providing fertilizer subsidy. Combined with the potentially substantial leakages of these subsidized fertilizer, distance from governor origin district may particularly affect the access to fertilizer subsidies.[2]

We investigate the effects of a fertilizer subsidy program on food prices in Nigeria. The Nigerian government has implemented fertilizer subsidy programs since 1970s where both Federal and State governments directly procured fertilizer from importers and distributed subsidized fertilizers to farmers (Liverpool-Tasie & Takeshima 2013). While commercial marketing of fertilizer has not been prohibited in Nigeria, Nigerian government has historically allocated substantial shares of agricultural capital spending into fertilizer subsidy (Mogues et al. 2012). The quantity of fertilizer initially intended for subsidy has been large relative to the actual consumption, and substantial leakage of subsidized fertilizer into commercial "unsubsidized" market has been shown to reduce commercial fertilizer prices in Nigeria (Takeshima et al. 2013). While subsidy programs in Nigeria have generally been inefficient in targeting, little is known about its effect on local food price. Though targeting might have failed, if indirect subsidy effects were captured by more market-oriented farmers who may be more efficient in fertilizer use, there might still have been substantial effects on food price. On the other hand, if as anecdotally perceived, allocation of subsidized fertilizer in Nigeria has been politically influenced, then fertilizer subsidy might be less efficient.

In addition to limited evidence on the effect of subsidy programs on local food prices, the characteristics of subsidized fertilizer recipients, including their degree of market orientation, has also been poorly investigated in Nigeria. Thus, this article investigates the effect of government distributed fertilizer through a subsidy program[3] on district level prices of major cereals in Nigeria, while providing some indicative evidence of aforementioned political factors and subsidy recipients' characteristics. We consider rice, maize and sorghum which are, as is shown later, major crops on which fertilizer is applied in Nigeria. We use the district level panel data constructed from the Living Standard Measurement Survey – Integrated Survey on Agriculture (LSMS-ISA) 2010 post-planting season and 2011 post-harvesting season. We address the previously mentioned structure where subsidy benefits are captured both directly through accession of subsidized fertilizer and indirectly through reduced price of "unsubsidized" fertilizer in commercial market. We use the import parity price of fertilizer to construct a rough measurement of effective subsidy, which combines both direct and indirect benefits. We also use unique instruments, the distance of a district from the district of origin for the state governor, to control for political factors potentially affecting the direct allocation and indirect spillover of fertilizer subsidy, which is particularly relevant in Nigeria where spatial leakage of subsidy is suspected.

Our results indicate that fertilizer subsidy in Nigeria has generally had little effect on the local prices of these cereals except for rice in northern Nigeria. Many farm households are still fairly subsistence for maize and sorghum production, while they earn income from off-farm activities. Although rice producers are generally more market oriented, direct subsidy recipients tended to be less so and earn greater income from non-farm activities. In northern Nigeria, a greater subsidy was provided in general compared to the other regions of the country. Furthermore, direct subsidy was received more by market oriented rice producers. There,

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[2] Based on informal communication with local experts.

[3] In Nigeria, currently Federal Government is implementing voucher based subsidy and not involved with direct fertilizer distribution. Many state governments, however, still distribute subsidized fertilizer.

effective subsidy had typically reduced the local market price of local rice by 10 ~ 20%. This may l be relatively modest since consumption of local rice, although increasing, accounts for relatively small share of total household expenditure in Nigeria (Johnson et al. 2013), and given the large federal and state government budgets allocated for fertilizer subsidy in Nigeria.

2 Conceptual Framework

Under the assumption of perfect markets, market prices are exogenous to a household and all products (output and inputs) are tradables. Market prices reflect the true opportunity cost of products and serve as the prices upon which household consumption and production decisions are based. In such settings it does not matter whether a household consumes its own products or sells them and buys its necessary consumption items with the resultant income and we can treat the household's production and consumption decisions as solved sequentially. First, households determine what to produce given output and input prices as well as household-specific characteristics, determining the household's income, which then serves as part of its budget constraint in its consumption decisions (Sadoulet & de Janvry, 1995).

In rural Nigeria, where rural financial markets are very thin and where villages are often isolated with limited access to various input and output markets, the assumption of separability between production and consumption decisions is unlikely to hold. Here technology choice by a farmer can be more appropriately modeled as a constrained utility maximization problem, as in Singh, Squire, and Strauss (1986). In this context, the utility maximization problem that results is:

$$Max_c \ U(c, z^h) \tag{1}$$

This maximization is subject to various constraints, including a cash income constraint, a credit constraint, a production technology constraint, and a price constraint (to reflect its endogeneity), and the necessary equilibrium condition for nontradables. As in the traditional analysis, c refers to the goods consumed and z^h is a vector of household structural factors, such as farm size, weather, soil conditions, age and gender, farm implements, and access to credit and education. As described in Sadoulet & de Janvry (1995), the solution to this constrained maximization problem yields reduced form specifications of demand for inputs and technologies and supply of outputs which depend not only on prices but on these household characteristics as well. The input demand for input i can be expressed as:

$$q_i = q(p_i*, z^{hq}), \tag{2}$$

where $q_i < 0$ because we are dealing with an input, fertilizer; z^{hq} refers to household characteristics associated with the need for input i (fertilizer) and p_i* refers to the endogenous prices for the relevant input. The resulting reduced form input demand for fertilizer corresponds to the quantity of fertilizer a farmer decides to use which depends on the price of fertilizer and the structural characteristics of the household.

In line with de Janvry et al (1991), we expect a fall in the price of fertilizer (that a subsidy provides), to increase household demand for fertilizer as well as its supply of crops for which fertilizer is an important input (e.g. rice,maize and sorghum in Nigeria). At a more aggregate level, this increased production would lead to a fall in the output price for maize, sorghum and rice in the community. Within the particular context of this study, failure to observe the price effect described could be caused by at least three factors:

First is where the profitability of fertilizer application is low. This could be due to the poor input and/or output market conditions faced by farmers or a low yield response of fertilizer in maize (and rice) production. Furthermore, because rice and maize are both potentially food and cash crops, simultaneous failures in input and output markets means that the income effect of the reduced fertilizer cost could also encourage increased consumption of rice and maize. The overall effect on marketed surplus in this case is ambiguous. If the price effect of reduced fertilizer cost on output supply is sufficiently large then the positive output supply effect might outweigh any increase in maize and/or rice consumption. If the price effect of subsidized fertilizer on output supply is weak, then we might not see an increase in the quantity of maize/rice in the market. Two key factors that will affect the supply response of farmers to lower fertilizer prices are the marginal physical product of fertilizer in rice and maize production and the size of the subsidy. In Nigeria, the range of the fertilizer subsidy varies across states. The level offered by the Federal government is 25%. This serves as a lower bound on fertilizer cost reduction if the cost savings is fully transferred to farmers. While we do not have estimates on the marginal physical product of fertilizer in maize and rice production across various agro ecological conditions in Nigeria, a study in Nigeria indicates that yields of open pollinated maize per kg of nitrogen are around 17 to 19 (Bello et al. 2012) which are close to the figure of 15 for the West Africa by Yanggen et al. (1998)..Using data on maize production in rural Kenya, Sheahan et al (2012) find marginal value cost ratios (MVCRs[4]) between 1.37 and 1.88 and average value cost ratios (AVCR[5]) of between 1.67 and 2.28 depending on the year for their entire sample. Disaggregating the results they find MVCRs and AVCRs of up to 5 in certain regions. If similar values obtain in rural Nigeria, then it can be expected that the price reduction from a fertilizer subsidy could significantly increase farmer production of maize/rice.

The second factor that could explain an outcome where we see no price effect of input subsidy on output prices is where we have a very well integrated output market such that even if there is an increase in the marketed supply of maize and rice, this gets easily absorbed into the larger market beyond the community. This would occur in areas where infrastructural development allows for the quick and affordable transportation of products from the farm gate to the market. In similar light, if mobility in rural areas is limited by transportation costs (not by cultural preferences) then good infrastructure could also lead to increased migration which could also reduce the price effect due to the increased demand for food.

A third factor that could weaken any price effect of input subsidy on output prices is the extent of market orientation of farmers receiving the subsidized input particularly as well as generally in the regions which enjoy lower fertilizer prices due to increased presence of leaked subsidized fertilizer. As mentioned earlier, if farmers are largely subsistence then increased production will likely have stronger consumption effects and could leave market participation unchanged or reduced if such households demand less from the market; being able to meet a larger fraction of consumption needs from own production. If majority of subsidized fertilizer is applied on cash crops (which could also be food crops) and/or recipients are more market oriented, the effect of subsidized fertilizer is more likely to be evident.

Thus, in this study, we explicitly control for potential fertilizer response (using soil and weather related information), market orientation (using the proximity to the nearest town, intra intra-LGA shares of farmers who use either owned or rented tractors) as well as the level of infrastructural development at the local government level to account for these and to see the extent to which price changes are dependent on such factors. Consequently, the input demand model of interest stemming from the solution to the constrained utility maximization model of

[4] This is calculated as the expected value of the marginal product of fertilizer divided by the price of fertilizer
[5] This is calculated as the expected value of the average physical product of fertilizer dived by its price

the Singh, Squire, and Strauss model (1986) and the associated output price equation can be expressed as

$$QFert_{LGAi} = f(\ PFert_{LGAi}, Poutput_{LGAi},\ Z_{LGAi}), \tag{3}$$
$$POutput_{LGAi} = f(QOutputD_{LGAi}, QOutputS_{LGAi}\ Z_{LGAi})$$

where $QFert_{LGAi}$ refers to the quantity of fertilizer purchased in Local government i, $PFert_{LGAi}$, refers to the price of fertilizer in local government i, $Poutput_{LGAi}$, refer to the prices of the major crop (maize and rice) produced in the local government, $QOutputD_{LGAi}$ and $QOutputS_{LGAi}$ are the quantity of output(maize and rice) demanded and produced in the local government while Z_{LGAi}refers to other local government characteristics and socioeconomic variables.

3 Empirical method

Following the conceptual framework, we employ the following estimation methods;

$$\Delta S_{jt} = S_{jt+1} - S_{jt} = f\left(X_j, Z_j\right) + u_{jt} \tag{4}$$
$$\Delta p_{jt} = p_{jt+1} - p_{jt} = \beta_s \Delta S_{jt} + \beta_z X_j + \beta_z \Delta Y_j + v_{jt} \tag{5}$$

in which S_{jt} is the measurement of the iextent/quantity of fertilizer subsidy received by farmers in LGA j at time t, and p_{jt} is the natural log of prices of local rice, maize and sorghum in LGA j at time t. Here t and t + 1 are post-planting period (August) and post-harvesting period (around November to March). u_{jt} and v_{jt} are idiosyncratic errors. X_j are levels of set of factors that are considered to affect both ΔS_{jt} and Δp_{jt}, ΔY_j are vectors of variables measuring the differences in other key factors between t and t +1, and Z_j are factors that affect ΔS_{jt} but not Δp_{jt} and not correlated with v_{jt}.

We consider various indicators for ΔS_{jt}; (a) share of farmers receiving subsidized fertilizer in LGA j; (b) average amount of subsidy received by the farmers in LGA j. In (b), S_{jt} is calculated as

$$\Delta S_{jt} = \frac{1}{n_j} \sum_{i=1}^{n} \left[q_{ij}^{s} * \left(\widehat{w}_j - w_j^{s} \right) + q_{ij}^{c} * \left(\widehat{w}_j - w_j^{c} \right) \right] \tag{6}$$

where $\{s, c\}$ = {subsidized, commercial}, q_{ij}^{s} and q_{ij}^{c} are the quantities of subsidized and commercial fertilizer obtained by farmer i in LGA j respectively, $\hat{w}_j$ is the theoretical price of fertilizer that would prevail in the absence of subsidy (Takeshima et al. 2013), which is assumed the same within each geo-political zone and vary only across zones (Table 1). w_j^{s} and w_j^{c} are the LGA median prices of subsidized and commercial fertilizer respectively. The ΔS_{jt} is the average among farmers in LGA j. Therefore, if there are fewer farmers i in LGA j, ΔS_{jt} can be high even though LGA j as a whole received less subsidy.[6] In our study, these subsidy variables are policy variables at the district level rather than at the Federal level. They proxy for the actual subsidy received by farmers, which is influenced by the Government of each state, and other factors within the state as well as LGAs, which are often beyond the Federal Government's control. The

[6] In our analysis, we also tried calculating ΔS_{jt} across the entire observation in LGA j. We find that results and implications remain robust.

term $q_{ij}^{s}*(\hat{w}_j - w_j^{s})$ captures the direct subsidy benefits, while the term $q_{ij}^{c}*(\hat{w}_j - w_j^{c})$ captures the indirect subsidy benefits due to the price reduction of commercial fertilizer through leakage of initially subsidized fertilizer.

Variables Z_j, X_j and ΔY_j are listed in Table 2. Variables Z_j include distance from LGA j to the LGA where the state governors are from (G_j), and distance from LGA j to the state capital (D_j). G_j and D_j are measured as Euclidean distance between centroid of each LGA.[7] These variables capture the political influence on how subsidized fertilizer is distributed in each state. Anecdotal evidence indicates that state governors often favor their origin LGAs and allocate more subsidized fertilizer there. Subsidized fertilizer is often traded informally by connected individuals and through the local market in Nigeria (Banful et al. 2010; Liverpool-Tasie et al. 2010). Each state has its own subsidy policy in terms of the state subsidy rate and procurement quantity, and distance G_j may significantly affect the likelihood of farmer acquisitions of subsidized fertilizer. Alternatively, since many subsidized fertilizer is stored at the warehouse of the State Ministry of Agriculture that is located in each state capital, we also use D_j.

Variables X_j include various agro-ecological characteristics. Farming system dummies indicate which farming system classified by Dixon et al. (2001) is the dominant in each LGA. Farming system dummies can capture potential variations in rice production patterns and its supply response. *Flood* and *Poorrain* variables are the shares of farmers in LGA who had experienced harvest loss due to flood and poor rain in 2010 production season, respectively, used to capture natural production shocks. Distance to the nearest town (*Disttown*) is measured in average minutes in LGA calculated from the pixel level information estimated by the HarvestChoice (2012). Road density (*Road*) is calculated as km of road per square km of area in each LGA, where the total road length in each LGA is calculated from the road information based on the Digital Chart of the World.[8] *Distance* and *Road* are expected to capture the level of integration to market, which can affect the price change.

Cheaper labor, production technologies and extension service access can all affect rice production capacity and may reduce food price increase. We control for these factors by using LGA median daily wage of land clearing / preparation for adult male (*Wage*), intra-LGA shares of farmers who use either owned or rented tractors (*Tractor*), and who received agricultural related extension service (*Extension*). The average asset level in LGA (*Asset*) controls for wealth. Rice consumption is generally rising among wealthier households, and the asset level may affect the rice price change.

The variables ΔY_j include the change in the prices of imported rice and bread at LGA j. These are considered substitutes for local rice, but both are imported and their change in price is exogenous. ΔY_j also includes the share of farmers in LGA j in who lost their harvest from wild fire, pest, flood and poor rain, which can represent the LGA specific shocks that could affect the price of local crops.

Proportion of subsidized fertilizer recipients (ΔS_{jt}) is censored at 0 and 1. (4) and (5) are still consistently estimated through two-stage least square (2SLS) where ΔS_{jt} is treated as an uncensored variable. We assess the robustness of 2SLS results by also estimating (4) and (5)

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[7] For Bauchi state, while Bauchi LGA is the origin of Bauchi state governor, Alkeri LGA is the origin of FCT state governor. However, because of geographical locations of these two LGAs, all LGAs within Bauchi state is closer to Bauchi LGA than to Alkeri LGA. Therefore, for distance from the governor-LGA within the same state, we use Bauchi LGA as the reference. We use both Bauchi and Alkeri LGAs as references when calculating distance from any governor-LGAs to LGAs in other states.

[8] For more information about the DCW, see http://www.princeton.edu/~geolib/gis/dcw.html.

through instrumental beta (IB) regression.[9] We estimate IB in the following way; we first estimate (4) by Beta regression, and obtain fitted value $\Delta\widehat{S_{jt}}$; we then estimate (5) using $\Delta\widehat{S_{jt}}$ as an excluded instrument (and not using Z_j). When using $\Delta\widehat{S_{jt}}$ as the instrument instead of regressor, estimation of (5) is more robust against potential misspecification in (4)(inferred from Wooldridge 2002; need more citation).

We initially included more variables, but dropped them after we discovered high multi-collinearity based on Variance Inflation Factor (VIF) test (those variables include whether the dominant soil is alluvial soil in the LGA, historical rainfall variation, population density, distance to the nearest town with 100,000 population).

There were also some outliers. We excluded the LGAs reporting extremely high price (above N500 for 1 kg of local rice). Gombe state is dropped because of the high price. We also excluded the following states with questionable price data from the rice analysis; Adamawa, Anambra, Borno, Cross River, Ebonyi, Enugu, and Taraba. In these states, the local rice price in majority of sampled LGAs either more than doubled or reduced to less than half from post-planting to post-harvesting, which is unrealistic and possibly due to the systematic data reporting errors. Including these states give us qualitatively similar results, but with reduced significance.

Our LGA crop prices (p_{jt}) are from the community surveys conducted as part of LSMS data collection in the same enumeration areas as the household survey. Crop prices are therefore from the market where the residents in the communities principally purchase these crops from. In most LGA, only one community was interviewed. However, in some LGAs, more than one community was surveyed, in which case we calculated the median of reported crop prices for the LGA. Obtaining crop prices from community survey is advantageous because price data are likely to be more reliable. In addition, as is shown later, while in substantial cases farmers are subsistence in which case no crop prices are reported at the household levels, those prices are reported at the community level in many cases.

State dummies capture a number of factors. First, it captures the subsidized fertilizer procured from the Federal Government, as well as subsidized fertilizer procured from direct imports[10]. Both of these figures are difficult to obtain, but the state dummies should at least net out such state specific effects of the government procured fertilizer entering into the state.

ΔS_{jt} contains both a direct subsidy portion and an indirect subsidy through leakage. Direct subsidy portion accounts for close to half of the total subsidy benefits, though the total quantity of subsidized fertilizer purchased is smaller than the commercial fertilizer purchased. This is because, although subsidy depresses commercial fertilizer price through leakages, price reduction is still much greater for subsidized fertilizer (Table 3).

Errors-in-variables

Some of the variables including the subsidy variable (ΔS_{jt}) (which is our key variable of interest) are calculated from observations within each LGA. These variables can contain sampling errors, and if the sample is too small, it could lead to an errors-in-variables problem. If sampling errors are uncorrelated with the true values of these variables, then calculated values like our variables are automatically correlated with the sampling errors, which can lead to classical errors-in-variables (EIV) issue (Wooldridge 2002). Literature has been relatively thin in

[9] Use of the fitted value as the IV is suggested by Professor Wooldridge.

[10] In Nigeria, state governments make requests to the Federal government about the quantity of fertilizer they would like to purchase through the Federal Market Subsidization Program. States can also procure additional fertilizer directly.

the case where multiple explanatory variables have EIV issues. Many studies simply use these types of generated regressors if they are not the variables of main interests but rather controls included to reduce omitted variable biases.[11] In the case where the variables with potential errors are of the main interests, however, more adjustments are necessary.

We address this in two ways. The potential bias due to EIV for variable ΔS_{jt} is mitigated by our methodology where ΔS_{jt} is treated endogenous. We also limit our analysis to LGAs which reported at least 5 farmers, so that we exclude the LGAs with extremely large sample errors.[12] We then bootstrap the entire estimation procedures using randomly resampled data with replacement. At each run, LGAs with at least 5 samples of farmers are selected and used for the estimation. Use of such paired bootstrap (Efron 1979) of the entire multi-stage estimations is becoming more common in the literature (Barrett et al. 2008; Takeshima & Winter-Nelson 2012). Bootstrap is useful in resolving the problem of accumulated errors in sequential estimators (Horowitz 2001). For robustness, we also present the results when we limit our analysis to LGAs with at least 10 samples of farmers.

For other calculated regressors, bias may still remain. For calculated first differenced variable, such as the incidence of flood and poor rainfall in LGAs, we proxied them as 0 or 1, which are likely to mitigate the EIV issue. For some of the time-invariant variables like *Extension, assets*, we run different specifications where those variables are excluded, assuming that these time-invariant variables have no effect in short-term food price change.

Lastly, although crop prices are also likely to contain errors, estimates are still consistent as long as those errors are uncorrelated with any omitted variables, since they are dependent variables. In addition, as was mentioned earlier, while we calculated median crop prices in LGAs with multiple community surveyed and such methods can lead to sample errors of crop prices, many of these LGAs were found among the aforementioned outlier states which we excluded from our analyses. Thus any bias from errors in crop price variable is expected to be minimal.

4 Results

4.1 Determinants of subsidy level (first stage)

Results of (4) are presented in Table 4 (rice) and Table 5 (maize and sorghum). Differences in Table 4 and Table 5 are because of difference in samples, i.e. some LGAs report the price of rice but not other crops, or vice versa. We also present the results of (4) based on all samples in Table 6 and Table 7. Table 4 and Table 5 indicate that a greater share of farmers received subsidized fertilizer in the LGAs closer to the governor origin LGA in the same state. These results are also similar when we use the Beta regression. Similarly, average subsidy amount received, as expressed in (6), is greater in locations with close proximity to governor origin LGA. These results also generally hold if we run the same regressions for all the LGAs (Table 6 and Table 7). We therefore have robust evidence that the proximity to governor origin LGA often improves the access to subsidized fertilizer. This result is similar to those of Sadanandan (2012) Mason et al (2013) and Mason and Ricker-Gilbert (2013) who demonstrate that the allocation of fertilizer subsidies tends to be in favor of supporters of government officials. It also corroborates the findings of Pan and Christiaensen (2011) and where political connections positively affect benefits received from government programs.

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[11] For example, an increasing number of studies use correlated random effects model (Chamberlain 1984), where averages of explanatory variables over time are used as additional variables.

[12] Sampling errors of calculated averages reduce as the sample size increases.

The receipt of subsidized fertilizer is also sometimes negatively affected by the incidence of flood, and remoteness from state capital LGA. This is possibly because both of these factors are likely to reduce demand for fertilizer generally and could also reflect the fact that subsidized fertilizer is sometimes stored in the state warehouse located in the state capital LGAs. The influence of other factors on the share of subsidy recipients and subsidy amount differs depending on the samples (Table 4 and Table 6). The share of subsidy recipients may also depend on other factors such as remoteness and factor endowments as well as access to public services, mostly reflecting demand for subsidized fertilizer. Among restricted sample of Table 4, share of subsidy recipients are generally higher than the whole sample of Table 6, because more rice farmers are included in the former sample LGAs, who tend to use more fertilizer than other farmers.

If access to government tractor hiring service is good and labor is cheap in those areas, demand for labor increasing inputs like fertilizer may be higher, while remoteness may raise commercial fertilizer price and farmers may lobby more for subsidized fertilizer. However, in rice producing LGAs in Table 4, farmers received greater subsidy if wage is high and extension contact is good, which is opposite of Table 6. This is possibly because of the higher labor requirement in rice production compared to the other crops. Furthermore, if rice farmers are more market oriented, higher wage prices indicate a higher production cost and thus are likely to increase farmer's interest and demand for subsidized fertilizer. For other crops, produced mainly for food consumption, the higher wages is likely to serve as a disincentive for investment in inputs; particularly those seen as optional like fertilizer. Higher share of farmers receiving subsidized fertilizer due to larger changes in imported rice price (for the entire sample in Table 6 compared to Table 4) indicates that higher prices for imported rice increases the demand for subsidized fertilizer in maize and sorghum producing areas but not rice producing areas. Higher fertilizer price becomes less problematic in rice growing areas as local rice price also tends to rise. Maize and sorghum prices, however, may not rise as fast as local rice price, increasing pressure to reduce fertilizer price through subsidy in maize / sorghum growing areas.

4.2 Effect of fertilizer subsidy on local food price change (second stage)

Results of (5) are presented in Table 8 (rice) through Table 10 (maize and sorghum). Importantly, for all of rice, sorghum and maize, neither the share of subsidy recipient nor the average subsidy amount had statistically significant effect on the price changes at the national level. Statistically significant effects are found only for the rice in the North. Results are qualitatively similar for rice when OLS is used for (5)(Table 9). Therefore, generally the fertilizer subsidy had little effect on the local market price of major cereals for the most parts of Nigeria in 2010.

Is the statistically significant effect on rice price in the North substantial? In a typical LGA in the North, all farmers on average received 1000 naira worth of effective subsidy including indirect price reduction of commercial fertilizer (which is equivalent to, for example, receiving 20 kg of fertilizer with a subsidy of 50 naira per kg, discounted from the theoretical price). Using the estimated coefficients, this much subsidy might have lowered the price of local rice in the local market at the 2010 post-harvesting season by approximately 20% (= 1000*-.0002). The percentage reduction is greater than the effect on maize price reported by Ricker-Gilbert et al. (2013?) in Southern Africa. This is partly because our study does not net out the seasonality in prices (we are examining price change between post-planting and post-harvesting months). Assuming that a typical household buys 100 kg of rice at 50 naira / kg, 20% reduction in price amounts to approximately 1000 naira. Therefore, even in these LGAs, the fertilizer subsidy cost is almost the same as the cost of directly subsidizing rice. Given that effects were insignificant in other LGAs, fertilizer subsidy appears not to be an efficient way to reduce local food price.

The coefficients of other variables are intuitive. Given the substitutability, 1% increase in price of imported rice leads to approximately 0.2 ~ 0.3 % increase in the price of local rice, often with statistical significance. The coefficient magnitude indicates that either local and imported rice are imperfect substitutes (probably because of quality differences) or that the rice market is not well integrated (Delgado, 1986). The insignificance of the price of imported rice and bread on maize and sorghum prices indicates that maize and sorghum are not strong substitutes with these items. This could also be driven by the fact that maize and sorghum are also more likely to be largely food crops than rice which is often a cash crop in rural areas. LGAs which had better access to government tractor hiring service in 2010 experienced negative price change possibly because of increased rice supply and reduced land preparation cost.[13] As a proxy for market orientation, this indicates that where farmers are more market oriented, we do see greater price effects, which could be a direct effect of the subsidy or an indirect effect due to lower commercial prices. Price change of local rice also depends on some of the time invariant factors. Price increase for local rice was sometimes greater in LGAs closer to towns, which might indicate faster food price inflation due to urbanization in Nigeria. Price increase was also sometimes greater in LGAs closer to the nearest dam, potentially because rice from irrigation schemes is more likely to be sold in larger urban areas where rice price may be rising faster. Effects of these factors are, however, generally statistically insignificant.

4.3 Some estimation issues

Prevalence of rice production

Maize and sorghum are relatively widely grown across Nigeria because they can grow in relatively marginal environments. Rice, on the other hand, may be produced only in certain areas that may be located far away from where it is traded. In such case, weak effects of subsidy on rice prices in certain district may be simply because rice is not grown in the district. We checked whether rice is actually produced in each LGA. In LSMS data, no rice producers were sampled in many LGAs reporting local rice price, indicating that there may be no rice production in these LGAs and the effect in local rice price may not be through the rice production in the LGA but through the market distributions. It is, however, also likely that, because of the small sample in LSMS, many rice producers did not get sampled even though there is rice production. In order to assess the existence of rice production at LGA level, we used the geographical distributions of rice area estimated by Spatial Production Allocation Model (SPAM) developed by IFPRI, and overlaid the map of LGAs to calculate the estimated rice production area in each LGA. We find that rice production actually exists in most LGAs in our sample (Figure 1). This is also consistent with the fact that, in Nigeria rice is widely grown on dryland and rainfed lowland as opposed to some other Sahelian countries where rice is predominantly grown in irrigated area (Ezedinma 2005). We therefore can say that the linkage between fertilizer subsidy and local rice price in each LGA may be through the effect on rice production within each LGA.

[13] Government tractor hiring service, when accessible to farmers, is provided at lower price than by private hiring service.

Sample selection bias

We also assessed whether limiting our focus to LGA's with at least 10 observations (LGA10 hereafter) would significantly change the characteristics of samples. Table 11 and Table 12 present the descriptive statistics of samples in rice regression for the whole region, and for the north, respectively. Sample characteristics are somewhat different between LGAs with less than 5 farmer observations and LGAs with at least 5 farmer observations. However, that is expected since the former LGAs are more likely to be in urban areas. We only focus on the latter LGAs since our interest is the effect in rural agricultural areas. Sample characteristics are quite similar between samples consisting of LGAs with at least 5 observations (LGA5 hereafter), and LGA10, indicating that limiting our sample to LGA10 is unlikely to cause sample selection bias.

Other sources of sample selection may be possible in theory, however, they are unlikely in our case. For example, due to idiosyncratic shocks, more or fewer farmers originally selected in the survey design could have actually been interviewed. This could pose sample selection problems if some unexpected disaster prevented conducting interview in remote areas where more farmers are located, which could also affect the likelihood or amount of subsidy received within the LGA. However, we did not encounter evidence of such occurrences from the LSMS survey team.

Sample selection bias in the first stage can potentially arise in the following scenario: suppose there are two LGAs that are both far away from the governor origin LGA. Among them, only in the LGA with fewer subsidy recipients were sufficient farmers interviewed, while in the LGA with more subsidy recipients, some farmers scheduled to be interviewed were not interviewed, leading to less than 5 farmers being interviewed, and forcing us to drop such LGA from our analysis. Based on the same argument as above, suppose some local disaster (excluding those reported in the LSMS data like flooding etc) prevented enumerators from reaching some farmers to interview but remained unreported (so that they are unobservable to us). If the government were actually responding to such natural disaster by providing subsidized fertilizer as emergency support to this LGA, this LGA actually received more subsidy while fewer than intended farmers were interviewed. However, to the best of our knowledge, no such occurrences were reported. Also, in the event of such disaster, given the capacity of the government, it would also be difficult for the government agents to provide subsidized fertilizer to those farmers. In such case, the error terms are still correlated but the bias is in the positive direction. If our results (negative coefficients) hold even in the presence of such bias, removing the bias would actually further strengthen our results. In general, the incidence of potential disaster was rather rare as are shown in the descriptive statistics, and the bias due to sample selection is expected to be negligible.

Spillover of subsidy to neighboring LGAs

In theory, if fertilizer can be traded across LGAs, food price in LGA j can be also affected by subsidy in the neighboring LGAs. We, however, only focus on the effects of subsidy within the same LGA j on food price in j. First, our definition of ΔS_{jt} in (6) captures some spillover effects that are reflected in the commercial fertilizer price p_j^c that contain the effect of leakage and cross-LGA spillover of subsidized fertilizer. Second, data indicate that farmers are unlikely to travel across LGAs to obtain fertilizer. As shown in Table 13, 83% of farmers who bought fertilizer obtained it within or near the village or town, usually within their LGAs. Quantity bought also does not significantly vary across locations, contrary to the perceptions that farmers travelling long distance would buy larger quantity to exploit economies of scale. These patterns also hold within the Northern region. Third, given that the subsidy effects on food price are generally insignificant and its economic significance is weak, further controlling for spillover effects is unlikely to change the key implications of our results.

5 Potential reasons for weak effects of fertilizer subsidy on local food price

In this section, we discuss several potential reasons why the fertilizer subsidy might have had little effect on local cereal prices. As was discussed above, the direct subsidy portion accounts for a significant share of the effective subsidy farmers received. We therefore focus our discussion here on direct subsidized fertilizer.

First, are farmers receiving subsidized fertilizer actually using it on these crops? The answer is yes. Among subsidized fertilizer recipients, 11%, 61% and 39% used subsidized fertilizer on plots growing rice, sorghum and maize respectively. 83% of the recipients used subsidized fertilizer on at least one of rice, sorghum, maize – so these crops must have captured much of subsidized fertilizer in Nigeria. In addition, 74% of rice producers receiving subsidized fertilizer used subsidized fertilizer on rice growing plots (Table 14). The share is 89% and 83% for sorghum and maize growers. Farmers receiving subsidized fertilizer therefore use most of it on these crops, and therefore its impact should be captured by productions of these crops.

Table 15 shows the relative size of subsidized and unsubsidized fertilizer used on rice-growing plots by sub-regions. In the North Central and South, the share of subsidized fertilizer used on rice- growing plots is very small (less than 2,000 ton compared to more than 80,000 tons of unsubsidized fertilizer used). In the North West and North East, the share is still low, but can be substantial, around 15% of total fertilizer used on rice growing plots. This indicates that, in the North West and North East region, sizes of direct and indirect subsidies might have been large enough to affect the rice supply. The share of subsidized fertilizer used on sorghum plots is similar to that of rice in NW and NE. As is shown below, however, the share of sorghum farmers selling harvest is low, which could lead to insignificant effects of subsidized fertilizer on sorghum price.

Low sales of crops among subsidized fertilizer recipients

Market orientation of fertilizer subsidy recipients has not been often reported in the earlier studies. Our data indicate that, contrary to expectation, farmers using chemical fertilizer are not any more likely to be market-oriented. Table 16 summarizes the share of rice producers using their harvests for various purposes, categorized by their status of fertilizer use and fertilizer subsidy receptions. Among total of 333 rice producers in the sample, 23 received subsidized fertilizer, 198 purchased only non-subsidized fertilizer, and 112 did not use fertilizer. Only 57% of subsidized fertilizer recipients sold rice compared to 61% among rice producers not using fertilizer, though the difference is not statistically significant. Subsidy recipients seem slightly more likely to use their harvests for seeds for the next season. The lower share of rice sellers among subsidy recipients seems common particularly in the northern Nigeria (Table 17). Table 18 provides additional insights, although the statistical significance is generally low due to the small sample size. Generally, rice producers receiving fertilizer subsidy cultivate smaller area, produce and sell less rice, while earning more income from off-farm employment or business. This pattern seems to hold in both northern and southern Nigeria. They indicate that subsidized fertilizer does not necessarily reach farmers with market orientation. Similar patterns hold for sorghum and maize. A slightly lower % of subsidy recipient sorghum farmers sell sorghum (Table 19), and maize (Table 20).

Table 21 and Table 22 summarize the share of households purchasing local rice categorized by their fertilizer use and subsidy status. The shares of purchase are generally low, meaning many of these farmers are autarkic, particularly in the North Central and the South. Therefore use of subsidized fertilizer by subsistence (no-sales) households is generally unlikely to lower local food price through their reduced purchase in the North Central and the South. The share is slightly higher in the NW and NE, particularly among subsidized fertilizer users, indicating that in the NW and NE, their use of fertilizer may slightly affect the local food price.

Crowding out of subsidized fertilizer

Previous studies in SSA generally (Ricker-Gilbert et al 2011; Xu et al 2009; Mason and Jayne 2013) and Nigeria more specifically (Takeshima et al 2013), have demonstrated that subsidy programs tend to crowd out private fertilizer markets. This is partly through poor targeting which reduces the demand for commercially distributed fertilizer. It also occurs through leakages which depress commercial prices (Takeshima et al 2013). Price effects are likely to be larger where subsidies are properly targeted at farmers who would normally not be able to purchase fertilizer (stimulating total fertilizer demand) and where these farmers received a significant amount of fertilizer necessary to boost their yields. This is not the case in Nigeria and may partially explain the limited price effects. Takeshima et al (2013) provide evidence that targeting of subsidized fertilizers is poor in Nigeria and leakages likely to be large. The authors demonstrate that while farmers tended to receive roughly the same quantity of fertilizer from subsidized and non-subsidized sources (which would imply that 70 percent of farmers using fertilizer would have received subsidized fertilizer in 2008), less than 20 percent of those farmers actually received subsidized fertilizer. There is also evidence of leakages in the Nigerian fertilizer subsector. Commercial fertilizer prices have also been shown to be lower in areas where fertilizer subsidy rates are highest irrespective of associated transactions costs that would cause one to expect otherwise[14] (Banful et al, 2010; Liverpool-Tasie and Takeshima 2013; Takeshima et al 2013).

Political influence on subsidy

The results in tables 6 and 7 consistently demonstrate that political influence plays a role in the allocation of subsidized fertilizer in Nigeria. Local governments in close proximity to the local government of origin of the Governor of the state received larger quantities of subsidized fertilizer. Theories of fiscal federalism (Buchanan, 1950; Samuelson, 1954; Musgrave, 1959; Oates, 1972, 1991, 1997, 1999) show that resource allocation based on political incentives are inefficient. In such contexts, the sub optimal allocation of inputs is likely to limit its benefits to direct recipients (including those with significant socio political capital) exacerbating the consequences of poor targeting. In such contexts, price effects are likely to be limited. This may also be partly driving our study results that fertilizer subsidy has limited effects on food price. Even in the north where size of direct and indirect subsidy is much greater, price effects are generally weak

6 Summary and discussion

In the last two decades, many SSA countries have re-introduced fertilizer subsidy programs. The goals of these subsidies are often multi-faceted, ranging from increasing farmers'

[14] Fertilizer prices in Nigeria as a whole are still very high compared to prices in other countries due to factors like higher FOB price, international and domestic transport costs and finance costs (IFDC 2008).

income through higher agricultural productivity, stimulating the growth of private input sector. Since the food price spike in 2008, food price reduction also became one reason for justifying fertilizer subsidy in these countries. Historically, input subsidy had significantly lowered food price and benefited consumers in other developing regions like Asia. Earlier studies find that in many SSA countries (including Malawi, Zambia and Nigeria), fertilizer subsidy crowded out the commercial fertilizer sector. Factors responsible for these outcomes include challenges in properly targeting subsidy beneficiaries and leakages of subsidized fertilizer into the private market (shown to be significant in Nigeria). It was argued that more commercial farmers, who had already been buying fertilizer from commercial market, were benefiting from subsidy, rather than small-scale farmers with less prior access to fertilizer. It is, however, also possible that, these commercial farmers were more efficient in using fertilizer, and this led to greater food production increase and food price reduction. In such cases, spillover effects of fertilizer subsidy programs to local food prices needs to be evaluated as well.

This paper investigated this issue using district level panel data from Nigeria. We employed various measurements of fertilizer subsidies which account for not only its direct effect but also its indirect effect on commercial fertilizer price. We find that fertilizer subsidy generally had no effects on the local price of rice, maize and sorghum. Where significant, price effects were limited to rice prices in the Northern part of the country. We argued that such weak effects are likely due to the following reasons; (1) Likely sub optimal subsidy allocation (from the production perspective) driven partly by political influence captured by a localities closer to the state governors' origin districts.; (2) Subsidy recipients of subsidy were not necessarily market oriented, while they often had greater off-farm income. (3) As in previous studies, subsidy crowded out the demand for commercial fertilizer so much that total fertilizer use did not increase substantially.

Although fertilizer subsidy lowered local rice prices in northern Nigeria, where relatively greater subsidy was provided, its economic impact may be relatively small. Furthermore, any impact is unlikely to be more efficient than alternative measures like direct food subsidy. Previous fertilizer subsidy programs in Nigeria have been shown to be poorly targeted. This study further provides evidence that, the benefit of fertilizer subsidies in Nigeria has translated little into the food market. Much of the subsidy benefit was likely to have been captured by the actual recipients and whoever was connected to them, who could benefit through higher consumption and/or gift exchange of harvests. Consequently the effects of poor targeting persisted, and the large scale fertilizer subsidy program in Nigeria has not been shown to be pro-poor nor efficient.

Reference

Banful A, E Nkonya & V Oboh. (2010). *Constraints to fertilizer use in Nigeria: Insights from agricultural extension service*. IFPRI Discussion Paper 01010. Washington, DC: IFPRI.

Banful AA. (2011). Old Problems in the New Solutions? Politically Motivated Allocation of Program Benefits and the "New" Fertilizer Subsidies. *World. Devel. 39*(7), 1166–1176.

Barrett CB, SM Sherlund & AA Adesina. (2008). Shadow wages, allocative inefficiency, and labor supply in smallholder agriculture. *Agric. Econ. 38*(1), 21–34.

Baum C, ME Schaffer & S Stillman. (2007). Enhanced routines for instrumental variables/generalized method of moments estimation and testing. *The Stata Journal 7*(4), 465–506.

Bazaara, N. & Muhereza, F. (2003). *Agricultural intensification and food security issues in Uganda.* Afrint macro study report. Centre for Basic Research, Kampala, Mimeo.

Bello OB, MS Afolabi, SA Ige, SY Abdulmaliq, MA Azeez & J Mahmud. (2012). Nitrogen Use Efficiency and Grain Yield in a Diallelic Cross of Maize Populations. *International Journal of Plant Research 2*(3), 94–102.Buchanan, J. 1950. Federalism and fiscal equity. *American Economic Review 40*(4), 583–599.

Burke, W. J., Jayne, T. S., Sitko, N. J., 2012a. *Can the FISP more effectively achieve food production and poverty reduction goals?* Food Security Research Project Policy Synthesis No. 51. Accessed March 2013, available at http://fsg.afre.msu.edu/zambia/ps_51.pdf

Chapoto, A., 2012. *The political economy of food price policy: The case of Zambia.* United Nations University-World Institute for Development Economics Research Working Paper No. 2012/100. Accessed May 2013, available at http://www.wider.unu.edu/publications/working-papers/2012/en_GB/wp2012-100/.

Chinsinga, B., 2010. *Seeds and subsidies: The political economy of input programmes in Malawi.* Future Agricultures Working Paper No. 013. Accessed May 2013, available at http://www.future-agricultures.org/publications/research-andanalysis/ working-papers/doc_download/1041-seeds-and-subsidies-the-politicaleconomy-of-input-programmes-in-malawi.

Chinsinga, B., 2012. *The political economy of agricultural policy processes in Malawi: A case study of the fertilizer subsidy programme.* Future Agricultures Working Paper No. 039. Accessed May 2013, available at http://www.futureagricultures. org/publications/research-and-analysis/workingpapers/doc_download/1567-the-political-economy-of-agricultural-policy-processesin-malawi-a-case-study.

Deaton A. (1985). Panel data from time series of cross sections. *Journal of Econometrics 30,* 109-126.

Deaton A. (1995). *Data and econometric tools for development analysis.* In J. Berhman & T. N. Srinivasan (Eds.), *Handbook of development economics* (3rd ed., Vol. Ill, pp. 1785-1882). Amsterdam: North Holland.

Delgado, C. L. 1986. A variance components approach to food grain market integration in northern Nigeria. *American Journal of Agricultural Economics 68*(4): 970–979

Dixon, J., A. Gulliver, and D. Gibbon. (2001). *Farming systems and poverty. Improving farmers livelihoods in a changing world.* Rome and Washington D.C.: FAO and The World Bank.

Dorward, A., E. Chirwa, V. Kelly, T. S. Jayne,R. Slater, and D. Boughton. 2008. *Evaluation of the 2006/07 Agricultural Input SubsidyProgramme, Malawi.* Final Report. Lilongwe, Malawi

Efron B. (1979). Bootstrap methods: another look at the jackknife. *Ann. Statist. 7*, 101–118.

Ezedinma, C. I. (2005). *Impact of Trade on Domestic Rice Production and the challenge of Self-sufficiency in Nigeria.* Ibadan, Nigeria.
Federal Ministry of Agricultural & Rural Development (FMARD). 2011. *Agricultural Transformation Agenda: We Will Grow Nigeria's Agricultural Sector.* Draft. Abuja, Nigeria. Computer Disk, Washington DC.
HarvestChoice. (2012). *Average travel time to nearest town over 20K (hours) (2000)*. Available at http://harvestchoice.org/. Accessed October 10, 2012.
Holden ST & R Lunduka. (2013). Who Benefit from Malawi's Targeted Farm Input Subsidy Program? *Forum for Development Studies 40*(1), 1-25.
Holmén, H. (2005). *The state and agricultural intensification in Sub-Saharan Africa*. In G. Djurfeldt, H. Holmen, & M. Jirstrom (Eds.), *The African food crisis: Lessons from the Asian Green Revolution.* London, UK: CABI Publishing Series.
Horowitz JL. (2001). *The bootstrap.* In JJ Heckman & E Leame, (Eds.), *Handbook of Econometrics,* Vol. 5. North-Holland, Amsterdam, pp. 3159–3228.
Ivanic, M. and W. Martin. 2008. *Implications of Higher Global Food Prices for Poverty in Low-Income Countries.* Policy Research Working Paper 4594. Washington, DC: World Bank.
Johnson M, X Diao, H Takeshima, J Koo, O Kuku, M Malek, A Pradesha, A Ajibola, P Dorosh, K Gyimah-Brempong. (2013). *Assessing the Potential and Policy Alternatives for Achieving Rice Competitiveness and Growth in Nigeria*. Mimeo.
Liverpool-Tasie S, B Olaniyan, S Salau & J Sackey. (2010a). *A Review of Fertilizer Policy Issues in Nigeria*. IFPRI NSSP Working Paper 0019. Abuja: IFPRI-Abuja.
Liverpool-Tasie, L.S. (2013). A paradigm shift in fertilizer in fertilizer distribution: Do vouchers improve on government distribution? Forthcoming in *Agricultural Economics*.
Liverpool-Tasie, L.S. & H Takeshima. (2013). *Moving Forward with Fertilizer in Nigeria: Fertilizer Promotion Strategies within a Complex Fertilizer Subsector.* Mimeo.
Mason, N. M., Ricker-Gilbert, J., 2013. Disrupting demand for commercial seed: Input subsidies in Malawi and Zambia. *World Dev. 45*, 75–91.
Mason, N. M., Jayne, T. S. (2013). Fertilizer subsidies and smallholder commercial fertilizer purchases: Crowding out, leakage, and policy implications for Zambia. *J. Agric. Econ*., in press.
Mason, N. M., Jayne, T. S and N. Van de Walle (2013). *Fertilizer subsidies and voting behavior: Political economy dimensions of input subsidy programs*. Mimeo
Minten B & CB Barrett. (2008). Agricultural Technology, Productivity, and Poverty in Madagascar. *World Development 36*(5): 797–822.
Mogues T, M Morris, L Freinkman, A Adubi & S Ehui. (2012b). *Agricultural Public Spending in Nigeria.*In *Public Expenditures for Agricultural and Rural Development in Africa*, edited by T. Mogues and S. Benin. London and New York: Routledge, Taylor and Francis Group.
Morris, M., Kelly, V., Kopicki, R., & Byerlee, D. (2007). *Fertilizer use in African agriculture: Lessons learned and good practice guidelines.* Washington, DC: World Bank
Mpesi, A. M., Muriaas, R. L., 2012. Food security as a political issue: the 2009 elections in Malawi. *Journal of Contemporary African Studies 30*, 377–383.
Musgrave, R., 1959. *The theory of public finance; A study in public economy*. New York: McGraw-Hill.
Oates W., 1972. *Fiscal federalism.* New York; Harcourt Brace Janovich.
______, 1991. *Studies in fiscal federalism.* Cheltenham: Edward Elgar.

_____, 1997. On the welfare gains from fiscal decentralization. *Journal of Public Finance and Public Choice 2* (3): 83–92.
_____, 1999. An essay on fiscal federalism. *Journal of Economic Literature 37* (3): 1120–1149.
Olayide, S.O. & Idachaba, F.S. 1987. *Input and output marketing systems: a Nigerian case*, in J. Mellor, C.L.Delgado and M.J.Blackie Eds . *Accelerating Food Production in Sub Saharan Africa*. Baltimore. John Hopkins Press.
Pan, L., Christiaensen, L., 2012. Who is vouching for the input voucher? Decentralized targeting and elite capture in Tanzania. *World Dev. 40*, 1619–1633.
Papke LE & JM Wooldridge. (1996). Econometric methods for fractional response variables with an application to 401(k) plan participation rates. *Journal of Applied Econometrics 11*: 619-632.
Ravallion, M. 1990. Rural Welfare Effects of Food Price Changes Under Induced Wage Response: Theory and Evidence for Bangladesh. *Oxford Economic Paper* 42: 574–585.
Ravallion, M. 2000. Prices, Wages and Poverty in Rural India: What Lessons do the Time Series Data Hold for Policy? *Food Policy* 25: 351-364.
Ricker-Gilbert J, TS Jayne & E Chirwa. (2011). Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi. *Amer. J. Agr. Econ. 93*(1): 26-42.
Ricker-Gilbert J, TS Jayne & G Shively. (2013). Addressing the "Wicked Problem" of Input Subsidy Programs in Africa. *Applied Economic Perspective and Policy 35*(2), 322–340.
Sadanandan (2012). "Patronage and Decentralisation: The Politics of Poverty in India", *Comparative Politics*, 44(2): 211–228,
Samuelson, P. 1954. The Pure Theory of Public Expenditures. *Review of Economics and Statistics 36*(4), 387–389.
Smithson, M. and Verkuilen, J. (2006). A better lemon squeezer? Maximum likelihood regression with beta-distributed dependent variables. *Psychological Methods 11*(1):54–71.
Takeshima H & A Winter-Nelson. (2012). Sales location among semi-subsistence cassava farmers in Benin: a heteroskedastic double selection model. *Agricultural Economics 43*(6), 655–670.
Xu Z, WJ Burke, TS Jayne & J Govereh. (2009). Do Input Subsidy Programs "Crowd In" or "Crowd Out" Commercial Market Development? Modeling Fertilizer Use Decisions in a Two-Channel Marketing System. *Agric. Econ. 40*(1): 79-94.
Yanggen D, V Kelly, T Reardon & A Naseem. (1998). *Incentives for fertilizer use in Sub-Saharan Africa: A review of empirical evidence on fertilizer response and profitability.* International Development Working Paper No. 70, Michigan State University, East Lansing, Mich., U.S.A.

Table 1. Estimated import parity price of NPK (USD / ton) in each geopolitical zone (2010)

North West	North Central	North East	South West	South South	South East
689	666	706	653	695	668

Source: Takeshima et al. (2013).

Table 2. Explanatory variables and descriptive statistics

Variables	Min	Mean	Max
Flood: Share of farmer experienced harvest loss due to flood in 2010 rainy season	0	.13	1
Poor rain: Share of farmer experienced harvest loss due to poor rain in 2010 rainy season	0	.11	1
Disttown: Distance to towns of 20 thousand inhabitants (hours)			
Road: Road density (km / km^2 of LGA area)	2	13	45
Farming system zones			
22 (Irrigated)	0	.06	1
23 (Tree crop)	0	.06	.1
28 (Root crop)	0	.27	1
29 (Cereal-root crop mixed)	0	.34	1
32 (Agro-pastoral – millet / sorghum)	0	.20	1
33 (Pastoral)	0	.02	1
35 (Coastal artisanal)	0	.06	1
Asset: total value of assets not including land (LGA average, USD)	11	836	8034
Wage: LGA median wage of land clearing / preparation (USD / day)	1	4	20
Tractor: Share of farmers using tractors	0	.07	1
Extension: Share of farmers receiving extension service in 2010 ?	0	.03	.40
Excluded instruments (Z_j)			
distance from LGA j to governor origin LGA (G_j) (geographical minute)	.10	.78	2.10
distance from LGA j to the state capital (D_j) (geographical minute)	.02	.71	1.96
Changes in other factors (ΔY_j)			
Growth rate (%) in imported rice price in LGA j	-37	23	114
Growth rate (%) in bread price in LGA j	-192	-13	212
% of farmers losing harvested from **wild fire** in 2010 in LGA j	0	0.5	10
% of farmers losing harvested from **pest infestation** in 2010 in LGA j	0	0.8	30
% of farmers losing harvested from **flood** in 2010 in LGA j	0	2.6	40
% of farmers losing harvested from **poor rain** in 2010 in LGA j	0	1.9	50

Source: Authors.

Table 3. LGA median price of subsidized fertilizer and commercial inorganic fertilizer (USD / ton) (2010)

	North West	North Central	North East	South West	South South	South East
Subsidized fertilizer	267	333	293		540	453
Commercial fertilizer	600	533	533	567	600	667

Source: Authors' calculations from LSMS data.

Table 4. First stage (rice equation)[abc]

Dependent variable	Share of direct subsidy recipients in LGA *j*				Average subsidy amount in LGA *j*			
Sample	All		North		All		North	
Specification	2SLS	3SLS	2SLS	3SLS	2SLS	3SLS	2SLS	3SLS
LN(Distance to governor origin LGA – within state)	√	-.033*	√	√	-505**	-594**	-328†	-272†
LN(Distance to governor origin LGA - global)	√	√	√	-.029†	√	√	√	√
LN(Distance to state capital LGA)	√	√	√	√	-646†	-400†	-532†	√
% change in imported rice price	√		√		√		√	
% change in bread price	√		√		√		√	
Flood incidence	√		√		-5921*		-5100*	
Poor rain	√		√		√		√	
Road density	√	√	√	√	√	√	√	√
Distance to nearest 20k town	√	√	.053*	√	√	√	√	√
LN (Distance to nearest dam)	.066*	√	.202*	√	√	√	√	√
Extension contact	√	.450*	√	√	√	√	√	√
Government tractor	√	√	√	√	√	√	√	√
Farm labor wage	√	√	√	√	√	1.062**	√	√
state dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
farming system dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
North	Yes	Yes			Yes	Yes		
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	122	122	66	66	122	122	66	66
p-value (H_0: overall insignificance)	.000	.000	.000	.000	.000	.000	.000	.000

Source: Authors. ** 1%; * 5%; † 10%

[a]Symbols (√) indicate statistically insignificant coefficients. Blank cells indicate that those regressors were excluded.

[b]Standard errors are adjusted for state level cluster effects. Due to the presence of singleton dummies, the statistics for overidentification test is calculated by partialling out state and farming system dummy variables, as suggested in Baum et al. (2007).

[c]Underidentification test and overidentification test are based on Kleibergen-Paap rk LM statistic and Hansen J statistics, respectively.

Table 5. First stage (samples in maize and sorghum equation) – results only for 3SLS[abc]

Dependent variable	Share of direct subsidy recipients in LGA *j*				Average subsidy amount in LGA *j*			
Crop	Maize		Sorghum		Maize		Sorghum	
Sample	All	North	All	North	All	North	All	North
LN(Distance to governor origin LGA – within state)	√	√	-.028†	√	-503†	√	-587*	√
LN(Distance to governor origin LGA - global)	√	√	√	√	√	√	√	-838*
LN(Distance to state capital LGA)	√	√	√	√	1433**	-1248†	710*	√
Road density	√	√	√	√	√	√	√	√
Distance to nearest 20k town	√	√	√	.039†	-470†	√	√	√
Distance to nearest dam	√	√	√	√	√	√	√	√
Extension contact	.655**	1.029†	.515*	√	18755*	√	√	√
Government tractor	√	√	√	√	5184*	4333**	3649**	3665*
Farm labor wage	√	√	√	√	√	√	√	√
state dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
farming system dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
North	Yes		Yes		Yes		Yes	
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	115	46	120	80	115	46	120	80
p-value (H_0: overall insignificance)	.000	.000	.000	.000	.000	.000	.000	.000

Source: Authors. ** 1%; * 5%; † 10%

[a]Symbols (√) indicate statistically insignificant coefficients. Blank cells indicate that those regressors were excluded.

[b]Standard errors are adjusted for state level cluster effects. Due to the presence of singleton dummies, the statistics for overidentification test is calculated by partialling out state and farming system dummy variables, as suggested in Baum et al. (2007).

[c]Underidentification test and overidentification test are based on Kleibergen-Paap rk LM statistic and Hansen J statistics, respectively.

Table 6. First stage using all sample

Dependent variable: Share of direct subsidy recipients in LGA *j*								
Specification		OLS				Beta regression		
Sample	All	All	North	North	All	All	North	North
Ln(Distance to governor origin LGA – within state)	-.019*	-.019*	√	√	√	-.161*	-.215†	-.185†
LN(Distance to state capital LGA)	√	√	√	√	√	√	√	√
% change in imported rice price	√		√		√		1.113**	
% change in bread price	√		√		√		√	
Flood incidence	√		√		√		√	
Poor rain	√		√		√		√	
Road density	√	√	√	√	√	√	√	√
Distance to nearest 20k town	√	√	√	.028†	√	√	.374**	.313**
Distance to nearest dam	√	√	√	√	√	√	√	√
LN(Distance to nearest dam)			†	†				
Extension contact	-.384†	-.383†	√	√	√	√	√	√
Government tractor	√	√	√	√	√	√	√	.572†
Farm labor wage	√	√	√	√	√	√	-.681*	-.613†
state dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
farming system dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
North	Yes	Yes			Yes	Yes		
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	227	227	94	94	227	227	94	94
p-value (H_0: overall insignificance)	.000	.000	.000	.000	.000	.000	.000	.000

Source: Authors. ** 1%; * 5%; † 10%

[a]Symbols (√) indicate statistically insignificant coefficients. Blank cells indicate that those regressors were excluded.

[b]Standard errors are robust to heteroskedasticity.

[c]For Beta regression, we transformed the 0 and 1 observations into non-zero and one values using the method suggested by Smithson & Verkuilen (2006).

Table 7. First stage using all sample (OLS)

Dependent variable: Average subsidy amount in LGA *j*				
Sample	All	All	North	North
Ln(Distance to governor origin LGA – within state)	-357*	-375*	-320†	-331†
Ln(Distance to governor origin LGA - global)	√	√	√	√
LN(Distance to state capital LGA)	√	√	√	√
% change in imported rice price	√		√	
% change in bread price	√		√	
Flood incidence	√		√	
Poor rain	√		√	
Road density	√	√	√	√
Distance to nearest 20k town	√	√	√	√
Distance to nearest dam	√	√	√	√
LN(Distance to nearest dam)				
Extension contact	√	√	√	√
Government tractor	√	√	√	√
Farm labor wage	√	√	√	√
state dummy	Yes	Yes	Yes	Yes
farming system dummy	Yes	Yes	Yes	Yes
North	Yes	Yes		
Constant	Yes	Yes	Yes	Yes
Number of observations	227	227	94	94
p-value (H_0: overall insignificance)	.000	.000	.000	.000

Source: Authors. ** 1%; * 5%; † 10%

[a]Symbols (√) indicate statistically insignificant coefficients. Blank cells indicate that those regressors were excluded.

[b]Standard errors are robust to heteroskedasticity.

Table 8. Effects of fertilizer subsidy on local rice price[abc]

Dependent variable: Growth rate in local rice price in LGA *j*								
Sample	All		North		All		North	
Specification	2SLS	3SLS	2SLS	3SLS	2SLS	3SLS	2SLS	3SLS
Share of subsidized farmers in the LGA	√	√	√	√				
Average subsidy received in LGA					√	√	-.00022†	-.00025*
LN(Distance to state capital LGA)	√	√	√	√	√	√	√	√
% change in imported rice price	.313†	√	√	√	.279†	.243†	√	√
% change in bread price	√	√	√	√	√	√	√	√
Flood incidence	√	√	√	√	√	√	√	√
Poor rain	√	√	√	√	√	√	√	√
Road density	√	√	√	√	√	√	√	√
Distance to nearest 20k town (hours)	√	√	√	√	-047†	√	√	√
LN (Distance to nearest dam)	√	√	√	√	-.138†	√	√	√
Extension contact	√	√	√	√	√	√	√	√
Government tractor	√	√	√	√	√	√	-.256†	√
Farm labor wage	√	√	√	√	√	√	√	√
state dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
farming system dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
North	Yes	Yes			Yes	Yes		
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	122	122	66	66	122	122	66	66
p-value								
H_0: overall insignifcance	.000	.000	.000	.000	.000	.000	.000	.000
H_0: Underidentified[b]	.141		.404		.009		.033	
H_0: Not overidentified[b]					.852		.266	

Source: Authors. ** 1%; * 5%; † 10%

[a]Symbols (√) indicate statistically insignificant coefficients. Blank cells indicate that those regressors were excluded.

[b]Standard errors are robust to heteroskedasticity. Due to the presence of singleton dummies, the statistics for overidentification test is calculated by partialling out state and farming system dummy variables, as suggested in Baum et al. (2007).

[c]Underidentification test and overidentification test are based on Kleibergen-Paap rk LM statistic and Hansen J statistics, respectively.

Table 9. Effects of fertilizer subsidy on local rice price (OLS)[ab]

Dependent variable: Growth rate in local rice price in LGA *j*				
Sample	All	All	North	North
Share of subsidized farmers in the LGA	√		√	
Average subsidy received in LGA		√		√
LN(Distance to state capital LGA)	√	.120*	.093†	.098†
% change in imported rice price	.304†	.289†	√	√
% change in bread price	√	√	√	√
Flood incidence	√	√	√	√
Poor rain	√	√	√	√
Road density	√	√	√	√
Distance to nearest 20k town	-.050†	-.056*	√	√
Distance to nearest dam	√	-.134†	√	√
Extension contact	√	√	√	√
Government tractor	√	√	√	√
Farm labor wage	√	√	√	√
state dummy	Yes	Yes	Yes	Yes
farming system dummy	Yes	Yes	Yes	Yes
North	Yes	Yes		
Constant	Yes	Yes	Yes	Yes
Number of observations	126	126	68	68
p-value (H_0: overall insignificance)	.000	.000	.000	.000

Source: Authors. ** 1%; * 5%; † 10%

[a]Symbols (√) indicate statistically insignificant coefficients. Blank cells indicate that those regressors were excluded.

[b]Standard errors are robust to heteroskedasticity.

Table 10. Effects of fertilizer subsidy on maize and sorghum price (results for 3SLS only)[abc]

Dependent variable: Growth rate in crop prices in LGA *j*	Maize		Sorghum		Maize		Sorghum	
	All	North	All	North	All	North	All	North
Share of subsidized farmers in the LGA	√	√	√	√				
Average subsidy received in LGA					√	√	√	√
LN(Distance to state capital LGA)	√	√	√	.126*	√	√	√	√
% change in imported rice price	√	√	√	√	√	√	√	√
% change in bread price	√	√	√	√	√	√	√	√
Flood incidence	√	√	√	√	√	√	√	√
Poor rain	√	√	√	√	√	√	√	√
Road density	-45**	√	√	√	-69**	√	√	√
Distance to nearest 20k town (hours)	√	√	√	√	√	√	√	√
LN (Distance to nearest dam)	√	√	√	√	√	√	√	√
Extension contact	√	√	-1.534*	√	√	√	√	√
Government tractor	√	√	√	√	√	√	√	√
Farm labor wage	√	√	√	√	.649**	.355†	√	√
state dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
farming system dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
North	Yes		Yes		Yes		Yes	
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	115	46	120	80	115	46	120	80
p-value (H_0: overall insignificance)	.000	.000	.000	.000	.000	.000	.000	.000

Source: Authors. ** 1%; * 5%; † 10%

[a]Symbols (√) indicate statistically insignificant coefficients. Blank cells indicate that those regressors were excluded.

[b]Standard errors are robust to heteroskedasticity. Due to the presence of singleton dummies, the statistics for overidentification test is calculated by partialling out state and farming system dummy variables, as suggested in Baum et al. (2007).

[c]Underidentification test and overidentification test are based on Kleibergen-Paap rk LM statistic and Hansen J statistics, respectively.

Table 11. Explanatory variables and descriptive statistics – by type of LGAs in the sample

Variables	Excluded LGA (farmer obs less than 5) (many are likely urban)	Used LGA (5 or more obs, excluding LGA with missing values)
Growth rate (%) of imported rice price in LGA *j*	18	23
Growth rate (%) of bread price in LGA *j*	-18	0
Flood: % experienced harvest loss due to flood in 2010 rainy season	1.2	2.5
Poor rain: % experienced harvest loss due to poor rain in 2010 rainy season	1.1	2.4
Disttown: Distance to towns of 20 thousand inhabitants (hours)	2.29	2.42
Distance to the nearest dams	-.15	-.63
Road: Road density (km / km^2 of LGA area)	.001	.001
Asset: total value of assets not including land (LGA average, USD)		
Wage: LGA median wage of land clearing / preparation (Naira / day)	1000	500
Tractor: Share of farmers using tractors	4.4	7.4
Extension: Share of farmers receiving extension service in 2010 ?	1.4	3.7
distance from LGA *j* to the state capital (D_j) (geographical minute)	-1.01	-.44
Excluded instruments (Z_j)		
distance from LGA *j* to governor origin LGA (G_j) (geographical minute)	.54	.87
distance from LGA *j* to governor origin LGA (G_j) (geographical minute)	-.68	-.68
% of farmers losing harvested from **wild fire** in 2010 in LGA *j*	0.1	0.4
% of farmers losing harvested from **pest infestation** in 2010 in LGA *j*	0.7	1.0

Source: Authors.

Table 12. Explanatory variables and descriptive statistics – by type of LGAs in the sample (North) in rice regression

Variables	Excluded LGA (farmer obs less than 5) (many are likely urban)	Used LGA (5 or more obs, excluding LGA with missing values)	10 obs LGA
Growth rate (%) of imported rice price in LGA *j*	64	15	15
Growth rate (%) of bread price in LGA *j*	0	0	0
Flood: % experienced harvest loss due to flood in 2010 rainy season	3.4	4.2	3.8
Poor rain: % experienced harvest loss due to poor rain in 2010 rainy season	2.6	3.0	3.5
Disttown: Distance to towns of 20 thousand inhabitants (hours)	2.67	2.23	2.21
Distance to the nearest dams	-.57	-.71	-.72
Road: Road density (km / km^2 of LGA area)	.001	.001	.001
Asset: total value of assets not including land (LGA average, USD)			
Wage: LGA median wage of land clearing / preparation (Naira / day)	500	388	350
Tractor: Share of farmers using tractors	8.4	10.6	9.8
Extension: Share of farmers receiving extension service in 2010 ?	1.6	4.2	4.3
distance from LGA *j* to the state capital (D_j) (geographical minute)	-.48	-.24	-.25
Excluded instruments (Z_j)			
distance from LGA *j* to governor origin LGA (G_j) (geographical minute)	1.06	1.27	1.27
distance from LGA *j* to governor origin LGA (G_j) (geographical minute)	-.28	-.23	-.22
% of farmers losing harvested from **wild fire** in 2010 in LGA *j*	0.0	0.5	0.6
% of farmers losing harvested from **pest infestation** in 2010 in LGA *j*	1.0	1.2	1.4

Source: Authors.

Table 13. Purchase of inorganic fertilizer from different locations (among all farmers who obtained new fertilizer in 2010; excluding composite manure)[a]

	Within the village	Near the village	Within the town	Near the town	Urban center	Others
proportion of farmers (%)	26	33	17	7	15	6
by locations	[23, 29]	[29, 36]	[15, 20]	[5, 9]	[12, 17]	[4, 8]
Average quantity bought	144	181	149	156	190	159
(kg / household)	[119, 168]	[155, 206]	[114, 184]	[112, 200]	[154, 226]	[93, 225]

Source: Authors' calculations from LSMS data.

[a]Shares do not add up to 100 because some farmers obtained fertilizer from multiple locations. Others include any other locations within / outside the states. Figures are adjusted for sample weights. Figures in brackets are 95% confidence intervals.

Table 14. % of growers of each crop receiving subsidized fertilizer and using subsidized fertilizer on the crop

		Rice	Sorghum	Maize	All three crops
Number of observations	Grower of this crop + Subsidized fertilizer recipients	*23*	*106*	*64*	*139*
	Those using subsidized fertilizer on plots growing this crop	*17*	*94*	*53*	*124*
% of growers of each crop, and recipient of subsidized fertilizer, using subsidized fertilizer on the crop		74	89	83	89

Source: Authors.

Table 15. Total quantity of fertilizer used on plots in Nigeria in 2010 rainy season (1,000 ton)[a]

Type of plots		Subsidized fertilizer		Un-subsidized fertilizer	
	Regions		95% CI		95% CI
Rice grown plots	NC + South	1.9	[1.1, 2.8]	85.1	[48.4, 121.8]
	NC	1.4	[1.4, 1.4]	79.1	[43.8, 114.4]
	South	0.5	[0, 4.6]	6.0	[2.4, 9.6]
	NE + NW	17.7	[6.4, 29.0]	106.5	[77.3, 135.7]
Sorghum grown plots	NC + South	8.9	[3.5, 14.3]	45.3	[27.7, 63.0]
	NC	8.9	[3.5, 14.3]	45.3	[27.7, 63.0]
	South	–	–	–	–
	NE + NW	57.0	[44.3, 69.6]	406.6	[360.2, 452.9]
Maize grown plots	NC + South	16.3	[6.7, 26.0]	83.5	[66.9, 100.1]
	NC	13.3	[4.3, 22.2]	37.8	[27.4, 48.1]
	South	3.1	[2.1, 4.0]	45.8	[33.1, 58.4]
	NE + NW	27.0	[19.2, 34.8]	309.4	[265.9, 353.0]

Source: Author.

[a]Adjusted for sample weights. Multiple crops can be grown on these plots, and thus figures may be double-counted.

Table 16. Rice sales / uses by fertilizer users, subsidy recipients (rice growers)[a]

	Did not use fertilizer	Used only non-subsidized fertilizer	Used subsidized fertilizer
No of obs	*112*	*198*	*23*
Sold rice (%)	66	57	62
Gave harvest as gift (%)	35	54	49
Sold or gift (%)	77	80	93
Processed harvest (%)	51	61	65
Kept harvest as seed (%)	66	77	90
Used harvest as payment for labor (%)	2	5	7
Lost some of harvest (%)	16	33	22

Source: Authors.
[a]Percentage adjusted for sample weights.

Table 17. Share of rice sellers and fertilizer subsidy by region[a]

Regions		Did not use fertilizer	Used only non-subsidized fertilizer	Used subsidized fertilizer
NC + South	No of obs	*53*	*68*	*6*
	% selling rice	68	82	75
	% selling or gifting rice	69	90	100
NE	No of obs	*41*	*76*	*6*
	% selling rice	53	33	20
	% selling or gifting rice	78	72	84
NW	No of obs	*18*	*54*	*11*
	% selling rice	79	52	69
	% selling or gifting rice	98	76	92
NE + NW	No of obs	*59*	*130*	*17*
	% selling rice	64	44	58
	% selling or gifting rice	86	75	90

Source: Author.
[a]Percentage adjusted for sample weights.

Table 18. Rice production characteristics – by fertilizer recipient status

	All		North	
	Direct subsidy recipient	Non-recipient	Direct subsidy recipient	Non-recipient
No of obs (rice producing households)	*23*	*310*	*17*	*168*
Median production (kg)	775	950	1404	1392
Average sales (kg)	428	751	752	451
Median sales (kg)	5	100	5	0
Average share of sales to production (%)	28	27	29	27
Median share of sales to production (%)	1	7	0	0
% using irrigation on rice grown plots	39**	10	49**	7
% purchasing seed	30	24	42	27
% at least one household member was engaged in non-agricultural work in the past 7 days	83*	61	77	58
Non-farm business sales from previous month (USD) - median	57†	0	57†	0
Literacy	57	53	69	51
Household asset (USD) - median	404	347	563	349
Livestock asset (USD) – median	767†	202	473	260
% owning at least some plots	22	21	33	26
Non-food item expenditure per capita/year (USD) - median	87	53	89	53
Total farm size cultivated (ha)	0.8	1.1	0.7	0.7

Source: Authors.

[a]Asterisks (** 1%; * 5%; † 10%) indicate the statistically significant difference from non-recipients. Tests are based on non-weighted sample.

Table 19. Sorghum sales / uses by fertilizer users, subsidy recipients (sorghum growers)[a]

Category	Did not use fertilizer	Used only non-subsidized fertilizer	Used subsidized fertilizer
No of obs	*526*	*524*	*106*
Sold sorghum (%)	18	20	13
Gave harvest as gift (%)	48	51	52
Sold or gift (%)	57	61	56
Processed harvest (%)	65	74	61
Kept harvest as seed (%)	78	83	73
Used harvest as payment for labor (%)	2	3	1
Lost some of harvest (%)	17	18	18

Source: Author.
[a]Percentage adjusted for sample weights.

Table 20. Maize sales / uses by fertilizer users, subsidy recipients (Maize growers)[a]

Category	Did not use fertilizer	Used only non-subsidized fertilizer	Used subsidized fertilizer
No of obs	*798*	*559*	*65*
Sold sorghum (%)	32	30	27
Gave harvest as gift (%)	28	36	38
Sold or gift (%)	44	53	49
Processed harvest (%)	42	50	34
Kept harvest as seed (%)	51	63	58
Used harvest as payment for labor (%)	3	5	7
Lost some of harvest (%)	19	14	22

Source: Author.
[a]Percentage adjusted for sample weights.

Table 21. Share (%) of farm households buying local rice by subsidy recipient status (NW and NE)[a]

Type of farmers	All			Among rice producers			Among rice sellers		
	No of obs.	Share (%)		*No of obs.*	Share (%)		*No of obs.*	Share (%)	
		p	h		p	h		p	h
Did not use fertilizer	*529*	43	50	*59*	33	32	*33*	36	37
Used only non-subsidized fertilizer	*620*	53	54	*130*	46	36	*53*	50	47
Used subsidized fertilizer	*114*	57	58	*17*	64	52	*8*	70	62
All	*1263*			*206*			*94*		

Source: Authors.
[a]p = post-planting data; h = post-harvesting data. Percentage adjusted for sample weights.

Table 22. Share (%) of farm households buying local rice by subsidy recipient status (NC and South)[a]

Type of farmers	All			Among rice producers			Among rice sellers		
	No of obs.	Share (%)		*No of obs.*	Share (%)		*No of obs.*	Share (%)	
		p	h		p	h		p	h
Did not use fertilizer	*1244*	33	29	*53*	49	25	*35*	62	30
Used only non-subsidized fertilizer	*401*	37	33	*68*	35	22	*51*	30	20
Used subsidized fertilizer	*45*	24	22	*6*	14	14	*5*	18	18
All	*1690*			*127*			*91*		

Source: Authors.
[a]p = post-planting data; h = post-harvesting data. Percentage adjusted for sample weights.

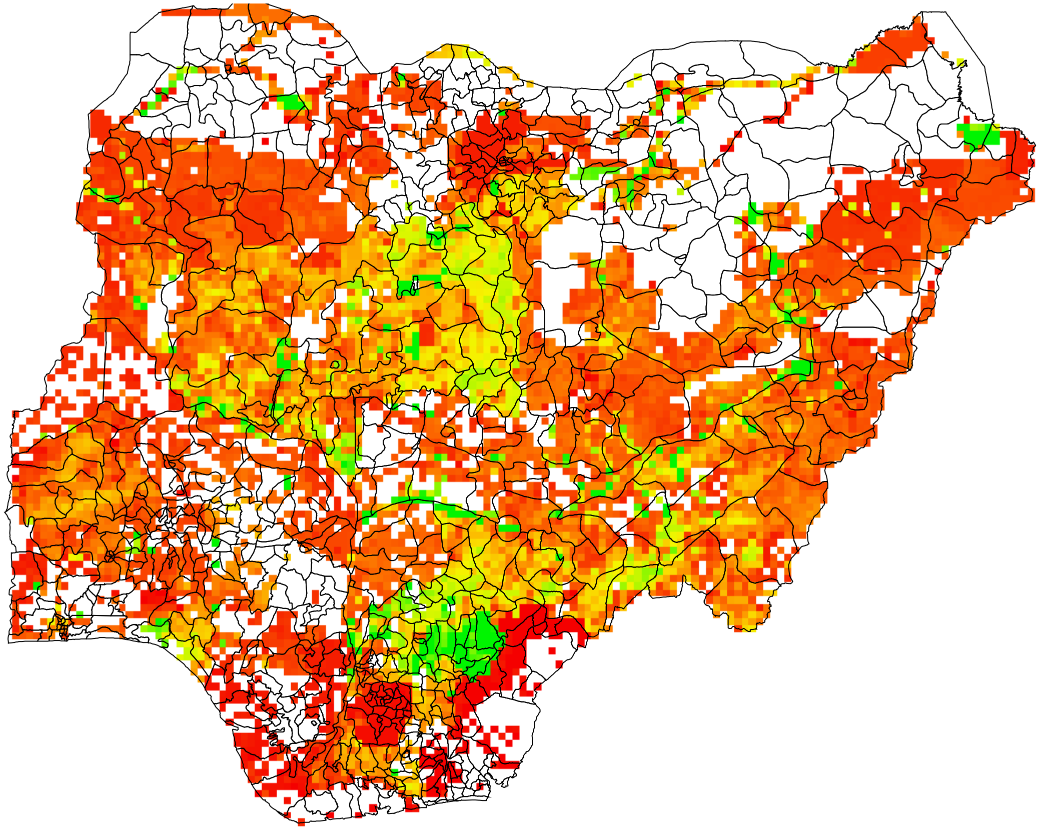

Figure 1. Rice production area in Nigeria (green = more rice area, red = less rice area, white = no rice area)
Source: Authors based on Spatial Production Allocation Model (SPAM).