The Impact of Fertilizer Subsidies on National Fertilizer Use: An Example from Malawi

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Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, FL, July 27-29, 2008.

Abstract

This paper examines the impact of government funded fertilizer subsidies on national level fertilizer use. We use panel data to investigate how the 2006/07 fertilizer subsidy program in Malawi impacted farmer decisions to purchase commercial fertilizer. Using a fixed effects estimator to control for time invariant unobservables, we find that when farmers' ability to acquire subsidized fertilizer is treated as exogenous, it has a significant negative impact on commercial fertilizer purchases but the coefficient is small. We also find that wealth and social networks have a significantly positive impact on who receives subsidized fertilizer. We then use instrumental variables (IV) to control for the endogeneity of subsidized fertilizer acquisition affecting commercial purchases. Using this IV fixed effects estimator demonstrates that when we control for the endogeneity of subsidized fertilizer, it again has a significant negative impact on commercial purchases. However the coefficient on subsidized fertilizer is ten times greater when using IV to control for endogeneity than when subsidized fertilizer is treated as exogenous. These findings indicate that policy makers must be aware of potential displacement of commercial sales when they introduce an input subsidy program. Furthermore, government programs should be designed to target households without effective demand in order to ensure that fertilizer subsidy programs maximize their impact on total fertilizer use and hence contribute to their cost-effectiveness.

Introduction

Food production is the major component of incomes for the vast majority of rural African households, so increasing yields is essential for reducing poverty and improving livelihoods. There is widespread agreement that increased use of fertilizer and other productivity-enhancing inputs is a precondition for rural productivity growth and poverty reduction. After phasing out fertilizer subsidy programs in the 1990s, several African countries have re-introduced fertilizer subsidies as a means to boost grain yields and rural incomes. However, the economic rationale for fertilizer subsidies continues to be controversial. In addition to crop/fertilizer response rates, crop prices, and fertilizer prices, the economics of subsidies depends on the extent to which they displace commercial fertilizer use and hence affect total fertilizer use. However, there is limited evidence on this topic, and this study is motivated by the need to develop a framework for

analyzing the magnitude of "displacement" in a two-channel input system and to generate empirical estimates to inform important policy debates.

The objective of this paper is to determine the extent to which government fertilizer subsidies affect farmer purchases of commercial fertilizer and total fertilizer use. We use the term displacement to define the extent to which subsidized fertilizer crowds out the purchase of fertilizer that a farmer would otherwise have made from a private retailer. The magnitude of displacement obviously affects the benefits and costs of fertilizer subsidy programs compared to other approaches for stimulating fertilizer use.

In the next section, we briefly describe the dual fertilizer marketing channels in Malawi and why this market structure gives rise to problems in specifying and estimating typical input demand functions. We then present a conceptual framework for modeling smallholder farmer input purchase decisions in a two-channel marketing system. We then present a fixed-effects model to measure the potential displacement of commercial fertilizer purchases by government subsidy programs, using household panel data from 2003 and 2007 in Malawi. Because receipt of subsidized fertilizer is likely to be endogenous, we first model the government's behavior in distributing fertilizer to households, and use an instrumental variables approach for modeling households' commercial fertilizer demand. We then present the results of the estimation, and lastly discuss their implication for policy.

Fertilizer Distribution in Malawi

Like many countries in sub-Saharan Africa, the majority of Malawi's population earns a living through agriculture, growing maize as their staple crop. In 2007 90% of Malawi's population was engaged in farming and agricultural contributed 36% of GDP (CIA World Factbook 2008). Furthermore, 86% of Malawian farmers cultivate less than 2.0 hectares of land.

Because many farmers cultivate small parcels, purchasing fertilizer may be beyond their means, which provides an important rationale for fertilizer subsidy programs.

The Malawian government actively controlled fertilizer distribution channels from the 1970's into the 1990's, in order to make fertilizer accessible to the population. Under the government controlled system, smallholders received discounted fertilizer on loan from government. This system began to break down in the 1990's under budget pressure and associated pressure for reform (Dorward et al. 2008). These factors along with new multi-party elections caused the system to collapse by the mid 1990's.

Between the mid 1990's and early 2000's, donors and the Malawian government implemented a series of smaller-scale subsidy programs such as TIP and starter pack. During the early to mid-2000s, the private fertilizer distribution industry in Malawi grew, with one estimate indicating that there were over 1,000 private fertilizer retailers operating in the country by 2005 (IFDC 2008). However in 2005 the government announced that it would subsidize maize inputs again which raised concerns among private distributors and retailers. The Malawian government distributed 131,803 metric tons of maize fertilizer vouchers (requiring farmers to pay 25% of the full cif cost of fertilizer) to households during 2005/06 and 174,689 metric tons in 2006/07. Meanwhile, commercial fertilizer sales by private retailers fell from an estimated 186,354 mt. in 2003/04 to 117,719 mt in 2006/07 (Dorward et al. 2008). Dorward et al. (2008) sampled fertilizer dealers in Malawi and found that many of them feel they have been set back by this subsidy. However, an accurate estimate of displacement must control for other factors affecting fertilizer use such as input and output prices as well as the potential endogeneity of fertilizer subsidy acquisition.

In recent years, the government criteria for providing subsidized fertilizer to households have been households considered vulnerable but capable of using fertilizer efficiently and producing a grain surplus (Ministry of Agriculture 2007).

Conceptual Framework

Traditional models of input demand tend not to account for the fact that in many cases, inputs may be available from both market and non-market channels, and that the interplay between these channels influences farmer behavior. Our analysis focuses on this interaction and attempts to quantify how the existence of a government channel affects private sales.

When government and commercial input distribution systems operate together, three different outcomes are possible: (1) Government subsidized fertilizer compliments private sector fertilizer and sales increase in both input channels. In this scenario the government fertilizer program "crowds in" commercial fertilizer purchases by farmers, and this might occur over time if additional crop income from use of subsidized fertilizer in year 1 alleviates farmers' budget constraint in subsequent years; (2) the subsidy program has no impact on commercial sales; (3) government fertilizer displaces national level sales and the total amount of fertilizer used by the farmer does not increase proportionally to the amount of subsidized fertilizer that enters the market. Some degree of displacement might be expected, but if displacement becomes too high, the incremental fertilizer used and its contribution to output may be insufficient to outweigh the costs of the program.

Scenario 1
($\Delta Qtotal / \Delta Qgov$) > 1: Government fertilizer compliments commercial fertilizer

Scenario 2
($\Delta Qtotal / \Delta Qgov$) = 1: No displacement (1)

Scenario 3
($\Delta Qtotal / \Delta Qgov$) < 1: Government fertilizer displaces commercial fertilizer

Where Qtotal is total fertilizer use, and Qgov is the quantity distributed via government subsidy programs.

In order to understand the affect of subsidized fertilizer acquisition on commercial fertilizer use, it is essential to understand how farmers make decisions to purchase inputs in a two channel system. In a scenario where two channels exist, a farmer makes his or her decision on whether or not to acquire commercial fertilizer based on the following factors.

$$Y_{it} = f(I_{it}, O_{it}, C_{it}) \quad (3)$$

where Y_{it} is the demand for commercial fertilizer by household i in year t, I is the amount of fertilizer obtained from government channels (exogenous from the standpoint of the household), O is the vector of household level explanatory variables such as income, landholdings, dependency ratio and age of household head, and C is the vector of exogenous community variables that may influence whether and how much fertilizer he or she purchases. Such variable include price of input at time of application, perceived view of output prices at time of harvest, soil quality etc.

The quantity of subsidized fertilizer by household i (I in equation 3), is likely to be a function of the following factors.

$$I_{it} = O_{it} + \Phi_{it} \quad (4)$$

O is the same set of socio-economic factors that influence purchase commercial fertilizer. Φ is the vector of variables which might be expected to influence government allocation of fertilizer to recipients. This could include "social capital" factors such as influence in the community, years living in a village, or political patronage variables, such as whether a Member of Parliament resides in the area. The vector of variables in Φ does not have any direct impact on commercial fertilizer purchases, and would therefore make for potentially appropriate instruments for receipt of government fertilizer, *I,* as in equation (3).

Methods

There are two major challenges in modeling the demand for commercial fertilizer in a two channel input distribution system. The first problem is dealing with time invariant unobservable factors that may bias the model and the second is accounting for the endogeneity of any explanatory variables in our model.

Use of a fixed-effects estimator with panel data allows us to control for the time invariant unobservable factors that may influence farmers' decision to purchase commercial fertilizer. Consider the model that is a linear version of equation (3) in the conceptual framework

$$Y_{it} = \beta I_{it} + \upsilon O_{it} + \phi C_{it} + \mu_i + e_{it} \quad (5)$$

Where Y is the amount of commercial fertilizer acquired by household (i) at time (t). (I) is the amount of commercial fertilizer acquired by household (i) at time (t) and (O) is the vector of socio-economic factors of household (i) at time (t) which affect commercial purchases. C represents the vector of variables outside the farmer's control that influences his or her decision to purchase commercial fertilizer. μ represents the vector of time invariant variables that may affect fertilizer purchases such as soil quality and community infrastructure. (e) represents the

unobservable factors vary over time that may influence fertilizer use. B, υ, ſ represent the respective parameters.

The fixed effects estimator subtracts (Y_{it} – mean of Y_i) creating the time de-meaned average of these variables. The outcome, called the fixed effects transformation can be seen in the equation below.

$$\acute{Y}_{it} = в\acute{I}_{it} + υ\grave{O}_{it} + ſ\acute{C}_{it} + \acute{e}_{it} \quad (6)$$

The transformation removes time invariant μ variables from the regression, effectively preventing time invariant unobservable factors such as soil quality from affecting the model. Under an assumption of strict exogeneity, the fixed effects estimator can be considered unbiased (Wooldridge, 2003). This implies that all explanatory variables are uncorrelated with all unobservable factors in the residual.

While the fixed effects estimator effectively removes all time invariant unobservable factors from the model, it can not remove time varying observables and is therefore unbiased only under strict exogeneity. The problem we face in modeling commercial fertilizer acquisition is that, there is legitimate reason to believe subsidized fertilizer acquisition, one of the explanatory variables is correlated with the time varying unobservables (ie: $cov(I,e) \neq 0$ in equation (6). This violates the strict exogeneity assumption and biases the fixed effects estimator.

In order to control for the endogeneity of subsidized fertilizer use, we need to use instrumental variables (IV) that are correlated with subsidized fertilizer acquisition but uncorrelated with the error term. In addition the IV must not influence commercial fertilizer use themselves. With desirable IV we can then estimate a two stage least squares model where stage 1 is given below

Stage 1: $\acute{I}_{it} = \upsilon \grave{O}_{it} + \varsigma Z_{it}$ (7)

Where Í represents the fixed effects transformed subsidize fertilizer acquisition, Ò represents the transformed vector of explanatory household variables and Z represents the IV that affects subsidized fertilizer acquisition. (υ) and (ç) represent parameters.

Equation (7) can be used to obtain an estimated value for subsidized fertilizer use (Ĭ). This estimated value can be used in the following model of commercial fertilizer to control for endogeneity of subsidized fertilizer use.

Stage 2: $\acute{Y}_{it} = \beta \breve{I}_{it} + \upsilon \grave{O}_{i} + \varsigma Z_{it}$ (8)

Equation (8) means that in the second stage of the OLS estimate, commercial fertilizer (Y) is being regressed on the part of subsidized fertilizer acquisition (I) that is uncorrelated with the error term. (Y) is also regressed on the socio-economic factors (O) and the instrumental variables (Z) (Wooldridge 2002). The two stage least squares purges subsidized fertilizer acquisition (I) of its correlation with the error term and the model can be treated as unbiased.

Data

Data used in this analysis come from the Government of Malawi's statistical Service. They conducted the first round of household surveys called the Integrated House Hold Survey 2 (IHHS2) after the 2002/03 growing season. Due to the timing of the study, the IHHS2 survey was not completed after the 2003/04 growing season was completed. For this reason the first year of the panel has farmers interviewed during the 2002/03 and 2003/04 growing season. The second year of our panel comes from the Agricultural Input Subsidy Survey (AISS) which Malawian government conducted during after the 2006/07 growing season, in order to evaluate the impact of the fertilizer subsidy program, which had been implemented a year earlier. We

were able to create a balanced panel of 2,591 households for our analysis from the IHHS2 and AISS surveys.

While the percentage of household purchasing fertilizer ranged from 45% in 202/03 to 17% in 2006/07, the distribution of the dependent variable using fixed effects (subtracting the mean from each yearly observation) was reasonably normally distributed with a median of zero.

Instrumental Variables

We use two instrumental variables to control for the endogeneity of amount of subsidized fertilizer on amount commercial fertilizer purchased. The instruments chosen are the years that the household head lived in village and a categorical variable indicating whether a Member of Parliament resided in the community. These variables are highly correlated with subsidized fertilizer use and have low correlation with commercial fertilizer use. These simple diagnostics indicate that both instruments make appropriate instrumental variable in our analysis.

Results

The findings in our estimation provide interesting insights into the impact of fertilizer subsidies on farmers' decisions to purchase commercial fertilizer. We first present descriptive statistics and bi-variate scatter plots of the relationship between commercial fertilizer and subsidized fertilizer acquisition. We then move to the regression analysis and first present results from a fixed effects estimator on factors influencing farmer demand for commercial fertilizer without controlling for the endogeneity of subsidized fertilizer acquisition. Finally we present a two-stage least squares model looking at determinants of factors that affect the quantity of subsidized fertilizer acquired by farm households, followed by the IV model of commercial fertilizer controlling for the endogeneity of acquiring subsidized fertilizer, using fixed effects. All of these findings present insight into the interaction between the government and private

input markets. It should be noted that our initial estimation included dummy variables for the year in the sample. Unfortunately, these variables were highly correlated with other variables in the model so to avoid multicollinearity, we excluded them from the final estimation.

Table 1 presents the distribution of the variables used in the analysis. The fertilizer use variables for commercial and subsidized fertilizer show that the majority of farmers in the survey did not use fertilizer with the median value being zero kg per household for both variables. The majority of farmers in the survey were small farmers with the median farm having less than one hectare. One of the instrumental variables years household head lived in village had a wide ranging distribution from 4 years at 10% of the distribution to more than 62 years at 90% of the distribution. The other IV, the binary MP variable, indicates that only 20% of the respondents had a member of parliament living in their community.

Table 2 displays the percentage of respondents in the different years of the survey who used commercial and subsidized fertilizer. The results indicate that a significantly higher number of respondents used commercial fertilizer in 2002/03 and 2003/04 compared to 2006/07 after the government scaled up the subsidy program. Not surprisingly a higher percentage of farmers used subsidized fertilizer in 2006/07 than they did in earlier years before the large scale subsidy began. These results provide some initial indication of the negative relationship between subsidized fertilizer acquisition and commercial fertilizer purchases.

Figures 1 and 2 provide further evidence about the negative correlation between subsidized and commercial fertilizer. These figures are the empirical results of equation (2) in the conceptual framework. This bivariate analysis shows the change in quantity of commercial fertilizer purchased given a change in subsidized fertilizer. The negative coefficients (-0.49) between 2002/03 & 20006/07 and (-0.62) between 2003/04 & 2006/07 indicate that a one kg

increase in subsidized fertilizer acquired leads to a 0.49 and 0.62 kg decrease in commercial fertilizer purchases respectively. This simple bivariate analysis does not control for other factors that may affect commercial fertilizer purchases over time, but it does provide further evidence that government fertilizer distribution channels crowd out private sector sales.

Table 3 displays the results of the fixed effects estimator on the factors influencing commercial fertilizer purchases. It is important to note that these results do not control for the potential endogeneity of subsidized fertilizer acquisition. These findings indicate that subsidized fertilizer acquisition has a significant negative impact on commercial fertilizer purchases. The coefficient on subsidized use is small (-.06), indicating that every kg of subsidized fertilizer displaces 0.06 kg of commercial fertilizer. Household assets and landholdings have a significant positive impact of commercial fertilizer purchases. This indicates that wealthier farmers are more likely to purchase fertilizer through commercial channels, as we would expect. Price of NPK fertilizer has a significant negative effect on commercial purchases, meaning the higher the price of fertilizer, the less likely farmers are to purchase it. The price of maize has a significant positive effect on commercial fertilizer purchases. This indicates that farmers will invest in fertilizer if they believe the returns from growing will be worth the cost of the input.

Table 4 displays the results of the fixed effects estimator on factors that determine how much subsidized fertilizer farmers receive. The variable for land holdings is marginally significant with a positive coefficient and the asset value variable is almost significant with a positive coefficient. This indicates hat wealthier farmers with more land may be able to obtain the subsidized fertilizer intended for farmers with more limited resources. Local maize price is also significant with a positive coefficient as is the number of female adults over 65 in the household.

The two instrumental variables that will be used in the second stage of the regression, years lived in the village, and if a member of parliament resides in the village are both highly significant and positively impact the amount of subsidized fertilizer acquired in Table 4. These findings indicate that social capital matters in terms of who receives subsidized fertilizer. For example, people with longer tenure in the village are better connected and more likely to be influential in the community and therefore be able to obtain subsidizes more easily that less well connected people. The significance of the parliament member variable indicates that subsidies are political in nature and politicians seem to be rewarding their own constituents with fertilizer subsidies. The significance of these two variables on amount subsidized fertilizer received raises questions as to the effectiveness of the program at targeting the people who truly need the fertilizer rather than those who are well connected.

As mentioned earlier, years lived in village and if a member of parliament lives in the village make excellent instrumental variables because they significantly impact subsidized fertilizer acquisition but to not directly impact farmers' decisions to purchase commercial fertilizer. Table 5 presents the results from the IV fixed effects estimator on factors influencing how much commercial fertilizer farmers purchase, while controlling for the endogenous factors that affect subsidized fertilizer acquisition. The results indicate that in the fixed effects IV estimation, subsidized fertilizer has significant negative impact on commercial fertilizer purchases. The coefficient on subsidized fertilizer purchases is (-0.61), ten times larger than the coefficient on subsidized fertilizer in Table 3 when subsidized fertilizer use is treated as exogenous. These results provide evidence that after controlling for the endogeneity of subsidized fertilizer with the instrumental variables, subsidized fertilizer seriously displaces commercial sales. According to these results, every kg of subsidized fertilizer a farmer receives

causes him or her to reduce commercial purchases by 0.61 kg. Asset value and land holdings are also significant with positive coefficients, indicating that large farmers with more assets buy greater quantities of commercial fertilizer. In addition, maize price has a positive and significant impact on commercial fertilizer use. The price of fertilizer in the IV regression is not significant.

Conclusions

In many developing countries, farmer input demand is affected by the interplay of public and commercial input distribution systems. There are concerns that the demand for commercial inputs may be displaced by the operation of government programs. This paper develops a modeling framework to empirically estimate the degree of displacement of farmers' purchase of fertilizer, taking explicit account of dual input marketing channels. Second, the paper identifies the factors influencing the probability of households acquiring fertilizer from alternate distribution channels as well as the amount acquired from each channel. In so doing, we estimate the degree of displacement of private fertilizer sales due to government subsidized fertilizer programs. Third, we identify the potential to increase fertilizer use through public policy tools.

Our main findings are as follows: First, when subsidized fertilizer purchases are treated as exogenous as in Table 3, then acquiring subsidized fertilizer is found to have a significant negative impact on commercial fertilizer, but the coefficient (-0.06) is very small. This may cause some policy makers to believe that implementing a fertilizer subsidy program will have minimal negative impact on commercial sales. However, when considering the likely endogeneity of subsidized fertilizer acquisition, the displacement effect is ten times larger with a coefficient of (-0.61). Controlling for endogeneity will generally produce more accurate model

estimates, and hence the analysis would indicate, therefore, that the government subsidy program in Malawi has had a major negative impact on demand for fertilizer through commercial channels. This finding means that government must pay close attention to potential displacement. Furthermore, government programs should be designed to target households without effective demand in order to ensure that fertilizer subsidy programs maximize their impact on total fertilizer use and hence contribute to their cost-effectiveness.

The results also indicate that wealthy farmers are more likely to purchases commercial fertilizer, as expected. Acquisition of subsidized government fertilizer is also correlated with household wealth, years that the household head lived in the village, and whether a Member of Parliament resided in the community. The statistical significance of these variables in the government fertilizer acquisition model reflect the importance of social capital between the household and village authorities determining who the allocation of subsidized fertilizer as well as the importance of political representation in subsidy allocation. In our model in Table 3 which treats subsidized fertilizer as exogenous, we found the price of fertilizer is significantly correlated with commercial purchases, having a price elasticity of demand of -0.73. However using the model in Table 5, which treats subsidized fertilizer as exogenous, we find that price of fertilizer does not significantly impact commercial purchases.

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Table 1: Distribution of the Variables

variable	description	Value at the different percentiles of the Distribution					mean
		10	25	50	75	90	
Age of household head	Age of household head in years	26	32	43	59	72	46
Asset value	2006/07 Value of all durable assets in 1,000 Malawian Kwacha	0.4	1.4	5.24	12.38	36.82	24.15
Children under 12 yrs old	Number of children under the age of 12 living in the household	0	1	2	3	4	1.91
Commercial fertilizer	Quantity of fertilizer purchased through commercial channels (in kg)	0	0	0	20	100	42.23
Female adults under	Number of females under the age of 65 living in the household	1	1	1	2	3	1.46
Female headed household	Binary (1 if household headed by female)	0	0	0	1	1	0.26
Females over 65 yrs old	Number of females over the age of 65 living in the household	0	0	0	0	1	0.13
Fertilizer price	District level price of NPK fertilizer per kg in Malawian Kwacha, in 2006/07.	47.9	51.6	56.7	70	74	60.9
Land holdings	Number of hectares owned by the household	0.32	0.55	0.91	1.61	2.43	1.24
Maize price	District level price of Local maize per kg in Malawian Kwacha, in 2006/07.	10	10.72	10.72	12.86	15	11.62
Male adults under 65 yrs old	Number of males under the age of 65 living in the household	0	0	1	2	3	1.4
Males over 65 yrs old	Number of males over the age of 65 living in the household	0	0	0	0	1	0.11
Mortality	Binary (1 if household member died in past three years)	0	0	0	0	1	0.12
MP in Community	Binary (1 if member of parliament lives in the community)	0	0	0	0	1	0.2
Rainfall	Rainfall in cm by district between October and December (planting season)	148.8	208.9	276.3	358.9	405.5	282.47
Subsidized fertilizer	Quantity of fertilizer acquired through government channels (in kg)	0	0	0	50	100	37.55
Years lived in Village	Years household head has lived in the village in 2002/03 base year value	4	12	28	44	62	30.45

Table 2
Percentages of Respondents Who Used Subsidized and Commercial Fertilizer in Different Years of the Survey

	2002/03	2003/04	2006/07
Percent of Respondents Using Commercial Fertilizer	42	35	16
Percent of Respondents Using Subsidized Fertilizer	24	35	56
Percent of Respondents Using Both Commercial and Subsidized Fertilizer	96	109	169
Sample Number	**1186**	**1405**	**2591**

(Note: The fertilizer subsidy program was scaled up before and during the 2006/07 growing season)

Table 3
Factors Influencing Commercial Fertilizer Purchases (Without Controlling for Endogeneity of Subsidized Fertilizer)

Fixed-effects (within) regression	Number of obs	=	5182
Group variable (i): case	Number of groups	=	2591
R-sq: within = 0.1209	Obs. per group: min	=	2
between = 0.1734	avg.	=	2
overall = 0.1525	max	=	2
	F(14,2577)	=	25.30
corr(u_i, Xb) = 0.1134	Prob > F	=	0.0

Variable	Commercial Fertilizer Purchases
Subsidized fertilizer	-0.06***
	(0.00)
Asset value	0.04**
	(0.02)
Land holdings	32.72***
	(0.00)
Female headed household	-9.55
	(0.54)
Household head age	-0.90
	(0.14)
Males over 65 yrs old	-1.33
	(0.94)
Female over 65 yrs old	-0.25
	(0.99)
Male adult under 65 yrs. old	-4.92
	(0.31)
Female adult under 65 yrs. old	1.71
	(0.71)
Child under 12 yrs. old	5.18
	(0.09)*
Mortality	1.77
	(0.83)
Maize price	3.15**
	(0.03)
Fertilizer Price	-0.73***
	(0.00)
Rainfall	-0.03
	(0.29)
Constant	58.81***
	(0.10)

Note: Dependent variable is the amount of commercial fertilizer purchased (in kgs.);
*, **, *** indicate coefficients are significant at the 10%, 5% and 1% level, respectively;
p-values in parenthesis

Table 4

Factors Influencing Government Subsidized Fertilizer Acquisition

Fixed-effects (within) regression	Number of obs.	=	5182
Group variable (i): case	Number of groups	=	2591
R-sq: within = 0.0521	Obs per group: min	=	2
between = 0.0052	avg	=	2
overall = 0.0155	max	=	2
F(13,2578) = 10.90			
corr(u_i, Xb) = -0.2801	Prob > F	=	0.0

Variable	Subsidized Fertilizer Acquired
Asset value	0.04
	(0.13)
Land holdings	5.28*
	(0.10)
Female headed household	-9.15
	(0.71)
Household head age	0.46
	(0.63)
Male over 65 yrs. old	31.42
	(0.26)
Female over 65 yrs. old	0.71
	(0.98)
Male adult under 65 yrs old	6.35
	(0.41)
Femal adult under 65 yrs. old	11.90*
	(0.10)
Chlld under 12 yrs. old	2.00
	(0.68)
Mortality	24.26*
	(0.07)
Maize price	8.59***
	(0.00)
MP lives in community	21.11*
	(0.06)
Years lived in village	1.59***
	(0.00)
Constant	-201.95***
	(0.00)

Note: Dependent variable is the amount of subsidized fertilizer acquired (in kgs.);
*, **, *** indicate coefficients are significant at the 10%, 5% and 1% level, respectively;
p-values in parenthesis

Table 5
Factors Influencing Commercial Fertilizer Purchases (Using IV to Control for Endogeneity of Subsidized Fertilizer Acquisition)

Fixed-effects (within) IV regression	Number of obs	=	5182
Group variable: case	Number of groups	=	2591
R-sq: within = .	Obs per group: min	=	2
between = 0.0344	avg	=	2
overall = 0.0362	max	=	2
Wald chi2(14) = 491.83			
corr(u_i, Xb) = -0.3122	Prob > chi2	=	0.0

Variables	Commercial Fertilizer Purchases
Subsidized fertilizer	-0.61***
	(0.00)
Asset value	0.06**
	(0.01)
Landholdings	36.02***
	(0.00)
Female headed household	-17.15
	(0.41)
House hold head age	-1.13
	(0.16)
Male over 65 yrs. old	13.11
	(0.58)
Female over 65 yrs. old	4.29
	(0.83)
Male adult under 65 yrs old	-2.26
	(0.73)
Femal adult under 65 yrs. old	6.93
	(0.27)
Chlld under 12 yrs. old	4.75
	(0.23)
Mortality	12.64
	(0.28)
Maize price	8.28***
	(0.00)
Fertilizer price	0.78
	(0.16)
Rainfall	-0.02
	(0.63)
Constant	-0.82
	(0.21)

Note: Dependent variable is the amount of commercial fertilizer purchased (in kgs.);
Instrumental variables are (1) Yrs. lived in village, (2) If MP lives in village;
*, **, *** indicate coefficients are significant at the 10%, 5% and 1% level, respectively;
p-values in parenthesis

Figure 1

Change in Fertilizer Acquisition Between 2002/2003 & 2006/2007 at HH Level For HH that Experienced Changes in Fertilizer Use

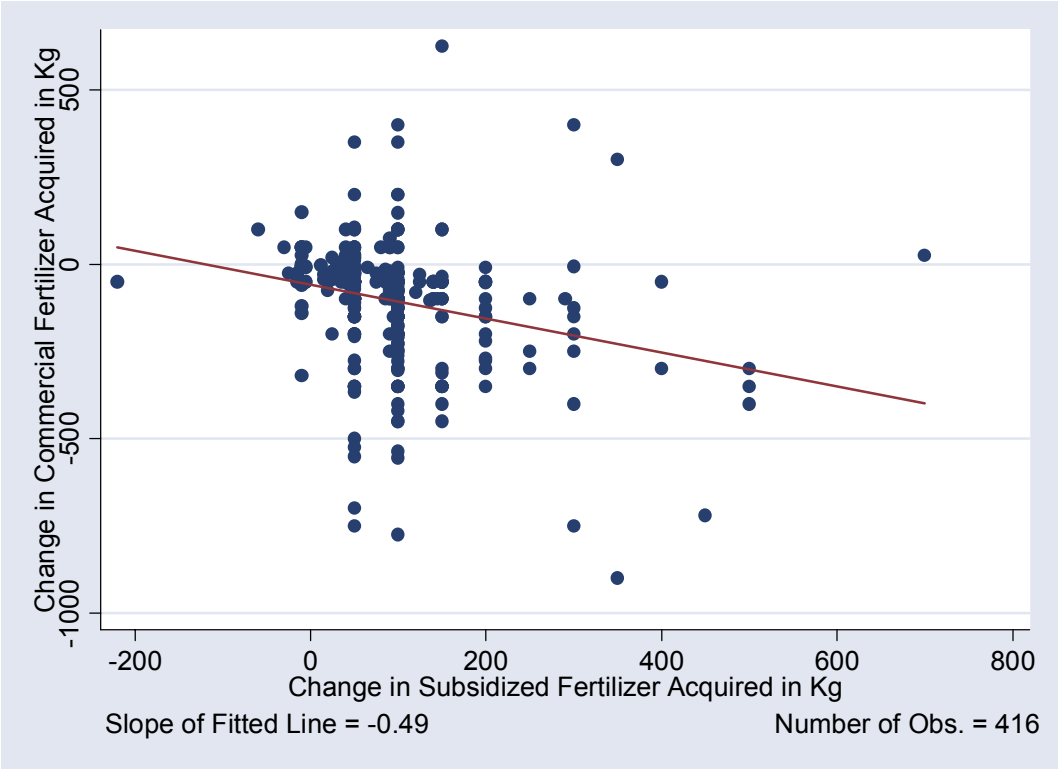

Figure 2

Change in Fertilizer Acquisition Between 2003/04 & 2006/07 at HH Level
For HH that Experienced Changes in Fertilizer Use