Measuring the impacts of Malawi's farm input subsidy programme

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Abstract

We measured the farm-level impacts of Malawi's Farm Input Subsidy Programme (FISP) on fertiliser use and maize yields in central and southern Malawi. Using multiple rounds of panel data and an instrumental variable regression strategy to control for endogenous selection into the subsidy programme, we found positive and statistically significant correlations between participation in the FISP and fertiliser-use intensity. The results are broadly robust to the inclusion of previous fertiliser intensity to control for household-specific differences in fertiliser use. We combined these results with those from a maize production function to calculate programme-generated changes in average maize availability, accounting for estimated subsidy-induced changes in crop area. Our findings have implications for the way input subsidy programmes are designed and implemented.

Key words: farm input subsidy programme; maize yields; fertiliser use; Malawi

1. Introduction

Agricultural input subsidies have long been used to promote smallholder farmers' use of inputs, to increase wages, to reduce food prices and to promote economic growth (Crawford *et al*. 2003). The implicit justification for doing so has often been a concern that market failures preventing private transactions in inputs undermine overall economic performance, which has public good characteristics (e.g. Kydd & Dorward 2004). In Malawi, general price subsidies coupled with subsidised credit were used in the 1970s and 1980s to stimulate the production of food crops, resulting in a high degree of self-reliance in maize, Malawi's main staple. Following donor pressure to abolish state-led interventions, the government eliminated subsidies in the early 1990s. Fertiliser costs rose sharply and constrained the uptake of fertiliser by poor farmers, causing severe and persistent food crises. Partly in response to these food shortages, agricultural subsidies were reintroduced in 1998, through the Starter

Pack Scheme (SPS), which evolved into a Targeted Inputs Programme (TIP). Early evaluation studies suggested that the SPS succeeded in increasing food production, thereby helping to promote national food security in the short term (Levy & Barahona 2002). However, critics argued that the SPS and TIP crowded out commercial supplies of chemical fertilisers and seed (Dorward *et al*. 2008). Despite the perceived benefits of the SPS, most of Malawi's donors were opposed to the programme, which they criticised for undermining private sector development, perpetuating overdependence on maize and creating welfare losses due to resource use, administrative burden and operational problems (Harrigan 2008).

Despite the perception of shortcomings, Nyirongo (2005) found no evidence of crowding out of private traders for fertiliser, although he did document some degree of crowding out of private suppliers for maize seed. One argument is that, at the time the SPS was implemented, there was virtually no private market for fertiliser and seed, and very little effective demand for agricultural inputs. Nyirongo *et al*. (2003) also found that purchases of fertiliser were higher by beneficiaries of the TIP than they were for non-beneficiaries. Supporters used these findings to argue that the SPS and TIP strengthened weak demand by providing inputs to inexperienced farmers, creating "learning by doing" and subsequently stimulating commercial demand (Harrigan 2008).

Poor weather in 2004 and 2005, coupled with a scaling down of the TIP, resulted in very low national maize production, acute food shortages and very high maize prices in 2005 and 2006. In the hope of avoiding a recurrence of this crisis, the government reintroduced large-scale input subsidies for maize. A total of 147 000 tonnes of fertiliser (of which 22 000 tonnes were for tobacco) and 6 000 tonnes of improved maize seed were distributed to farmers, boosting production by 670 000 tonnes (Denning *et al*. 2009). Evaluation studies have shown that this Farm Input Subsidy Programme (FISP) increased food production and promoted food security at the national level. Despite its high implementation cost, estimated at US$72 million, 3.44 million tonnes of maize were harvested in 2006/2007, generating an estimated surplus of 1.34 million tonnes above national requirements (Dorward *et al*. 2008).

While past studies have strengthened the rationale for continued support for the programme as a strategy to enhance fertiliser uptake by poor farmers to enhance food production, the question of whether fertiliser subsidies have boosted fertiliser use and/or intensity has not been investigated fully in Malawi, or elsewhere (see Ricker-Gilbert *et al*. 2013).[1] The present study uses panel data collected from central and southern Malawi to investigate the extent to which the subsidy programme induced fertiliser use among smallholder farmers in the period 2002 to 2009.

Although designed as a programme targeting vulnerable farmers, Malawi's FISP has been criticised for uneven rollout and widespread leakage (Dorward *et al*. 2008; Ricker-Gilbert & Jayne, 2008). This means that, from a research design point of view, programme participation cannot be interpreted as being exogenously determined, because in some instances the criteria for selecting beneficiary households seem to have been ignored or adjusted at the local level. In addition, subsidy amounts have been heterogeneous, consisting of either seed or fertiliser or some combination of the two that does not accurately reflect programme design guidelines. For these reasons we used a two-stage, instrumental variables regression approach to analyse the effect of the FISP on fertiliser use. In the first stage, participation in the subsidy programme was treated as endogenous and conditional on household- and village-specific factors. In the second stage, we estimated the parameters of a series of regression

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[1] At the time of writing, a collection of papers on input subsidies in Africa was being prepared for publication elsewhere; see Jayne and Rashid (2013).

models, using fertiliser intensity per hectare as the dependent variable, conditioned on observables and the latent characteristics of programme participants. The two-stage approach provides some perspective on the pathway by which the FISP had an impact on fertiliser use. Using lagged indicators, we also attempted to control for prior, baseline levels of fertiliser use. We concluded the analysis by estimating a production function for maize to measure sample average differences in maize yields between households that did and did not receive subsidised fertiliser. The results suggest that farmers who obtained subsidised inputs used more fertiliser for maize production than those who did not. After adjusting for observed land-use changes, we found that the fertiliser subsidy was associated with an average annual increase in maize output of approximately 250 kg per household.

2. Background

2.1 An overview of agricultural policy in Malawi

Agriculture employs about 80% of Malawi's total workforce, accounts for 39% of GDP and contributes more than 80% of foreign exchange earnings (Malawi Government 2009). The sector is divided into smallholder and estate sub-sectors, which contribute about 70% and 30% to agricultural GDP respectively (Malawi Government 2006). Malawi's initial policy stance following independence in 1964 included significant government involvement in production, extension, technology development and marketing. The government established the Agricultural Development and Marketing Corporation (ADMARC) to sell inputs, buy outputs and provide agricultural credit. Most of the resulting profits were channelled into the development of the estate sub-sector, which at the time was considered the engine of growth. Maize prices were kept low to reduce food prices and encourage the production of cash crops for export.

These early policies had limited success. The collapse in the terms of trade towards the end of the 1970s (by up to 35%), drought in 1979/1980, and an influx of refugees from civil war in neighbouring Mozambique highlighted the failure of the estate-led export strategy. By the mid-1980s, most Malawian households could not afford to buy the maize that filled ADMARC's warehouses (Harrigan 2003). The country experienced a food crisis in 1987 as a result of declining per capita maize production and the inability of ADMARC to purchase maize (Sahn *et al.* 1990). Chronic and widespread malnutrition resulted, and nearly half of Malawi's children were affected (Malawi Government 2009).

In 1990, the Government adopted World Bank and IMF recommendations to reform agriculture in order to improve macroeconomic conditions in the country. Legislation that barred smallholder farmers from growing commercial crops was repealed and a series of adjustment programmes was instituted to remedy the policy bias against smallholders. Maize prices were deliberately kept low to safeguard the rural population that was reliant on maize as their main staple. Overall, smallholder output temporarily grew by 15.8% in 1995 as a result of increased tobacco production, as well as a bumper maize harvest (Harrigan 2001).

The recovery was temporary. Severe drought struck in 1992 and 1994, refugees continued to enter from Mozambique, and Western non-humanitarian aid was frozen in 1992/1993 in protest against President Banda's suppression of the pro-democracy movement (Harrigan 2003). The sequencing of policies during this period exacerbated poverty (Sahn *et al.* 1990; Sahn & Arulpragasam 1991; Cromwell 1992;

Harrigan 1988, 1997; Kherallah & Govindan 1999), and the removal of fertiliser subsidies for maize reduced maize profitability vis-à-vis cash crops (Harrigan 1995).[2]

During the period 1994 to 2000, Malawi registered positive growth in per capita GDP, per capita agricultural GDP, and per capita smallholder agricultural GDP, largely due to an increase in production of root crops (cassava and sweet potato) and other cash crops (Dorward & Kydd 2004). Growth was also attributable, in part, to the US$23.5 million Starter Pack Scheme (SPS), which was introduced in 1998 to provide free seed and fertiliser to all Malawian smallholders. The SPS was scaled down in 2001, and implemented as the Targeted Inputs Programme (TIP). Smallholder maize production declined sharply, although some of this decline may have resulted from bad weather conditions between 2000 and 2005. Regardless of the cause, smallholder per capita GDP declined from 2000 to 2005. The SPS and TIP were ultimately criticised for creating and perpetuating widespread dependency on maize, based on the concern that this could eventually lead to a maize poverty trap (Harrigan 2008) and/or increase smallholder vulnerability to drought (Holden & Mangisoni 2013). Nevertheless, by 2008/2009, the subsidy programme was targeted primarily at maize production, with a small provision for tobacco fertiliser and pesticides for cotton.

2.2 Malawi's Farm Input Subsidy Programme (FISP)

The FISP has been administered via a series of coupon vouchers that enable households to purchase fertiliser, hybrid seed and/or pesticides at greatly reduced prices (Dorward & Chirwa, 2009). Four main criteria were used to identify beneficiaries in 2007/2008 and 2008/2009: (1) that the household owned land being cultivated during the relevant season; (2) that the household was a bona fide resident of the village; (3) that only one beneficiary would be eligible in a household; and (4) that vulnerable groups, especially households headed by children and women, would be given priority.

In 2008/2009, each voucher entitled a household to 50 kg of maize fertiliser at 8% of market price, and free seed – either 2 kg of hybrid maize seed or 4 kg of open pollinated variety (OPV) seed.[3] The Ministry of Agriculture distributed coupons to the districts. Traditional authorities (TAs) then allocated coupons to villages. Village heads and Village Development Committees (VDCs) identified beneficiary households within their jurisdictions. A total of 150 000 tonnes of maize fertiliser and 20 000 tons of tobacco fertiliser were distributed in 2008/2009 at a cost of MK31 billion (MK140 = US$1). Of this, 95% was financed through the government budget and 5% was financed by Malawi's development partners.

One objective of the subsidy was to remedy the weak demand for inputs by increasing smallholder farmers' access to and use of chemical fertilisers and improved maize seed. We pick up the thread of this argument, asking whether, in the context of our sample, the programme boosted smallholder farmers' use of chemical fertiliser and whether the programme lifted maize yields over time. We answer these questions using field data collected in Kasungu and Machinga Districts in central and southern Malawi over the period from 2002 to 2009. These data catalogue the experiences of 375 farm

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[2] Although the displacement of maize raised numerous concerns, Sahn *et al.* (1994) argued at the time that a shift towards tobacco could potentially raise incomes and reduce levels of malnutrition among smallholder farmers who adopted tobacco as a crop. More recently, Binswanger *et al.* (2010) have argued that Malawi's comparative advantage vis-à-vis neighbouring countries rests with tobacco and other cash crops, rather than with maize.

[3] Some households also received coupons entitling them to 50 kg of tobacco fertiliser. This subsidy was subsequently dropped due to a steep decline in tobacco prices.

households in 2009. When combined with data from the 2002 and 2006 surveys in the same villages, we are able to examine the outcomes in greater detail from somewhat smaller two- and three-round panels.

3. Empirical approach

3.1 Participation in the FISP

Our empirical approach relies on a series of instrumental variable regressions to examine the impacts of the FISP on fertiliser use.[4] Selection into the FISP is treated as endogenous and conditional on a range of household- and village-specific factors. A number of strategies were analysed to arrive at an appropriate indicator of coupon receipt. One approach, not used here, would be to treat coupon receipt in a simple binary fashion, with 1 indicating receipt of a coupon of any kind and 0 indicating otherwise. However, a binary approach ignores the considerable heterogeneity observed among households in terms of what combinations of coupons went to individual households. Instead, we compute the aggregate value of all coupons received by a household. This constructed variable has the virtue of providing a household-specific, scalar measure of the magnitude of programme treatment. It also can be incorporated easily into standard IV estimation methods. The programme treatment regression takes the form:

$$T_i = \beta_0 + \beta_1 \mathbf{Z}_i + \beta_2 IV_i + \varepsilon_i \qquad\qquad (1)$$

where $\mathbf{T}$ represents household i's programme treatment, $\mathbf{Z}$ is a vector of household socio-demographic and economic control variables, IV represents instrumental variables, and ε represents random and unobservable measurement error.

Estimating programme effects on fertiliser use requires that we include at least one identifying variable in the participation equation that does not enter the fertiliser use equation. In terms of programme design, the subsidy programme was targeted specifically at (i) female-headed households, (ii) the poor and (iii) permanent residents. Although we have suitable control variables for these variables, it seems inappropriate to assume the first two are exogenous to the fertiliser use decision, since poor and female-headed households face numerous challenges associated with agricultural production that could simultaneously have an impact on programme participation and fertiliser use. To identify the first-stage regression we therefore combined two variables that we believed affected programme treatment, but not fertiliser use: (1) the number of years the head had been residing in the village at the time of the survey, and (2) the population of the household's village. We hypothesise that length of residency would have influenced the village chief and the VDC during coupon distribution. Also, beginning with the inception of the FISP in 2005, a number of new villages have arisen, many as breakaways from larger villages. While some growth in the number of villages might be expected, the rate of village formation has been much higher than before the subsidy programme. Some new villages consist entirely of families of new village heads who attempt to use the coupon distribution to benefit themselves. Most of these new villages are small, and not officially recognised. As a result, we hypothesise that residents of larger villages were more likely to receive FISP benefits. To account for non-linear influences between these variables and our participation variable, we constructed two instrumental variables, namely the interaction of residency and village size and the square of this term.

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[4] Using propensity score-matching techniques, Chirwa (2010) evaluates the FISP and a previous programme in Malawi and finds mixed results, with negative impacts in 2006 and positive impacts in 2009.

The relevance of these instruments is indicated by their pair-wise and group-wise correlation with the participation indicator. The instruments were excluded from the subsequent stage fertiliser regression on the grounds that they exerted no independent influence over fertiliser use decisions, except through the impact on coupon receipt. The results from over-identification tests confirm the validity of our instruments.

3.2 Fertiliser use regression

Previous studies have attempted to understand the factors affecting fertiliser-use decisions by smallholder farmers (Green & Ng'ong'ola 1993; Nkonya *et al.* 1997; Isham 2002; Abdoulaye & Sanders 2005; Chirwa 2005). We estimate the subsidy's influence on fertiliser use via the regression:

$$Q_i = \phi_0 + \phi_1 \mathbf{J}_i + \phi_2 \hat{T}_i + \phi_3 \mathbf{L}_i + \mu_i \qquad (2)$$

where Q_i is the total amount of fertiliser (in kg/ha) applied to both improved and traditional maize in the 2008/2009 agricultural season by household i.[5]

Vector $\mathbf{J}$ represents variables that describe the household's socio-demographic and economic characteristics (age and education of the household head; number of household residents; farm size; household's poverty status). We included age of household head because younger household heads have been found to be more inclined to experiment with fertiliser (Feder *et al.* 1985; Feder & Umali, 1993; Doss & Morris, 2001). We also expect educated household heads to be more inclined to use fertiliser than the less educated (Feder *et al.* 1985; Feder & Umali, 1993; Doss & Morris, 2001). We used household size to proxy labour availability, and included a control variable for household poverty status on the assumption that wealthier households may have a greater capacity to purchase fertiliser than poor households. We also included a variable for farm size (and its square). Farmers with more land might use more fertiliser (Feder 1980; Doss & Morris 2001), but incentives to use purchased or non-purchased inputs more intensively might be greater for land-constrained households.

$\hat{T}$ represents the instrumented value of the household's FISP benefits in the 2008/2009 agricultural season. We expect the treatment to be positively correlated with fertiliser use in the current season. Finally, we included in some of the reported regressions one or more lagged variables (**L**), corresponding to household use of fertiliser in the 2002/2003 and 2006/2007 growing seasons. Including these variables reduced our sample size because the three-round balanced panel is smaller than the remaining sample. However, regressions with lagged variables provided us with additional checks of robustness, and helped to ensure that the observed pattern of greater fertiliser use among FISP beneficiaries did not simply reflect greater rates of coupon receipt among households that would have had high rates of fertiliser use anyway.

3.3 Impacts of the FISP on maize yields

To measure productivity we estimated a plot-level yield response function for maize. Farmers in the sample planted either traditional maize or improved maize or both. For this analysis, we stacked

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[5] Twelve households in the sample did not apply any fertiliser. We include these zeroes in our regressions, but the results are insensitive to whether we used OLS or a censored model to account for the lower truncation of the fertiliser variable.

observations for traditional and improved maize. The yield (in kg/hectare) for household i on plot j is estimated using a linear-in-logs production function, as follows:

$$y_{ij} = \beta_0 + \beta_1 f_{ij} + \beta_2 H_{ij} + \beta_3 I_{ij} + v_{ij} \tag{3}$$

where f_{ij} is the amount of fertiliser applied (in kg/ha), which is expected to have a positive, but diminishing, effect on yield. Previous studies have found diminishing returns with fertiliser use (Traxler & Byerlee 1993; Kouka *et al.* 1995; Ricker-Gilbert & Jayne 2008). H_{ij} is a binary indicator of whether the plot was intercropped with another crop; we expect its estimated coefficient to be negative. I_{ij} is a binary indicator of whether improved maize was used on the plot. Given differences in the genetic potential of the two varieties, plots planted with improved maize should produce higher yields than those planted with traditional maize. v_{ij} is a random term for unobserved plot-level heterogeneity. We excluded labour from the estimation due to insufficient plot-level data on labour allocation.[6] Table 1 presents the descriptive statistics for the variables used in the regressions.

4. Model results and discussion

4.1 Participation in the FISP

Results from a Tobit regression for coupon value are presented in Table 2. Variables are grouped such that our two instrumental variables appear for reference at the bottom of the table. Contrary to programme design and targeting guidelines, the most vulnerable households – those who are net buyers of maize – were less likely to have received FISP benefits during 2008/2009. Those headed by females, one of the target groups, were also less likely to have received benefits. Similarly, poor households in the sample were less likely to receive vouchers than non-poor households. This pattern is consistent with reports by Ricker-Gilbert and Jayne (2008) and Xu *et al.* (2009) for Malawi and Zambia respectively.

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[6] In the absence of labour allocation data we attempted to approximate labour use for maize production from household composition, but obtained unreliable results. The estimated regression coefficients are robust to the inclusion of this excluded labour variable.

Table 1: Descriptive statistics for the dataset

Variable	Description	Mean	SD
Age	Age of household head (years)	46.8	14.9
Female-headed	Female-headed household (1 = yes; 0 = no)	0.15	0.35
Education	Education of household head (1 = some; 0 = none)	0.85	0.35
Household size	Number of residents in the household	6.33	2.77
Farm size	Total land owned by household (hectares)	1.61	1.44
Farm size squared	Square of total land owned by household (hectares^2)	4.77	12.4
Adults	Number of adults (aged 15 years and older)	3.34	1.67
Net buyer of maize	Household was a net buyer of maize in 2008 (0 = no, 1 = yes)	0.57	0.50
Poor	Asset-poor household (0 = no, 1 = yes)	0.47	0.50
Residency	Number of years head has been resident in the village	35.7	17.2
Value of coupons received	Total value of coupons for maize seed and fertiliser in 2009	10,098	425
Maize seed coupon 2008	Received maize seed coupon in 2008 (0 = no, 1 = yes)	0.05	0.21
Maize fertiliser coupon 2008	Received maize fertiliser coupon in 2008 (0 = no, 1 = yes)	0.26	0.44
Maize seed & fertiliser 2008	Received maize seed & fertiliser coupons in 2008 (0 = no, 1 = yes)	0.51	0.50
Kasungu	Household resides in Kasungu District (0 = no, 1 = yes)	0.56	0.50
Village size	Number of households in the village	117	79
Improved maize	Household planted improved maize (0 = no, 1 = yes)	0.44	0.50
Distance to market	Distance from village to market for agric. inputs (walking minutes)	64	49
Maize fertiliser price	Price of maize fertiliser (MK/kg)	53.3	54.5
Fertilisation rate	Quantity of fertiliser applied per hectare of maize (kg/ha)	184	161
Seed per hectare	Quantity of maize seed used (kg/hectare)	19.7	15.1
Intercrop	Maize was grown as an intercrop (1 = yes; 0 = no)	0.45	0.50
Number of observations		375	

Older and better-educated household heads received greater FISP benefits. They might have been perceived as better and more deserving farmers, or they may have had more bargaining power with village chiefs. In general, larger families did not receive more benefits. One explanation might be that larger households were perceived as having enough labour to support off-farm work during the agricultural off-season. We found a positive but diminishing effect of farm size on FISP benefits received.

Exploratory analysis indicated no substantial district-level differences in the administration of the subsidy programme: FISP benefits in Kasungu district did not differ substantially from those in Machinga. The two districts received roughly equal amounts of fertiliser relative to the size of their target populations. Point estimates for the instruments indicate a strong predictive value for the non-linear influence of the interaction between length of residency and village size in determining coupon receipt.

Table 2: Tobit regression results for receipt of FISP benefits

Variable	Value of all coupons received (in Malawi Kwacha)
Constant	-33.823
	(26.015)
Age	1.079***
(years)	(0.377)
Education	25.505***
(0 = none, 1 = some)	(8.720)
Household size	0.781
(number)	(1.968)
Female-headed	-6.109
(0 = no, 1 = yes)	(23.151)
Poor	-18.521*
(0 = no, 1 = yes)	(9.801)
Farm size	30.465*
(hectares)	(18.574)
Farm size squared	-6.429*
(hectares)	(3.885)
IV: Residency × village size	0.195**
(years, # households)	(0.080)
IV: Residency × village size (squared)	-0.002**
(years, # households)	(0.001)
N	375
F (9, 371)	11.10
Log-likelihood	-1985.48

Note: Robust standard errors, adjusted for 35 village clusters, are presented in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Results for impacts of coupon receipt on fertiliser use conditional on FISP receipt

Table 3 presents results for three fertiliser-use IV regressions. We used the interaction between length of residency and village size, as well as its square, as instruments, excluding them from the second-stage fertiliser-use regression. Test statistics reported in the final row of the table weakly support the exclusion restrictions. Fertiliser use was measured as intensity: total kg applied to a hectare of maize. Model 1 was estimated using 2009 data only. Models 2 and 3 incorporate lagged fertiliser use information from 2006 and 2002. Broadly speaking, the regressions perform fairly well in this small sample. Controlling for household characteristics, FISP benefits are positively correlated with intensity of fertiliser use at statistically significant levels. Each 100 Kwacha increase in the value of the subsidy increased fertiliser-use intensity by 0.50 to 0.60 kg/ha.

We found that, in general, larger households used significantly more fertiliser per hectare for maize production than smaller households. This is consistent with previous research that showed that the use of improved maize technology (hybrid maize and chemical fertilisers) accentuates seasonal peaks in labour demand and is therefore more easily adopted in households with surplus labour (Byerlee & Heisey, 1996). Smaller farms used more fertiliser per hectare for maize production than larger farms, suggesting an inverse farm size-farm productivity relationship (rather than wealth effects in accessing inputs).

Overall, the FISP increased fertiliser use, consistent with the findings of Ricker-Gilbert and Jayne (2008). However, while Model 1 provides evidence of a positive correlation between the FISP and

fertiliser use, the result does not imply causality. To reach more robust conclusions regarding the programme's causal effects, we introduced indicators of per-hectare fertiliser use in previous growing seasons in Models 2 and 3 (2006/2007 in the case of Model 2, and 2002/2003 and 2006/2007 in the case of Model 3). These data come from earlier surveys conducted in the same area by the Centre for International Forestry Research (CIFOR). Although there was complete geographic overlap between the CIFOR survey and our own, we did not have a completely matched panel of observations at the household level going back to 2002. Model 3 therefore is based on a subset of 175 households that were visited in all three rounds of the survey. The logic behind including these lagged variables in the regressions is that they should help control for household-specific unobservables, such as soil quality or farmer attitudes and experience.

The results reported in the final rows of Table 3 reveal no strong pair-wise correlations between average levels of fertiliser use in the 2002, 2006 and 2009 surveys. However, including both indicators for previous levels of fertiliser use diminishes the magnitude of the estimated coefficient on the FISP variable somewhat – reducing its size by approximately 20%, from approximately 0.60 to 0.50. This strongly suggests that, to some extent, fertiliser-use intensity in 2009 can be explained by past levels of fertiliser-use intensity rather than the FISP. Controlling for past fertiliser use leaves a smaller proportion of the observed intensity to be explained by coupon receipt.[7] Including lagged fertiliser use has little or no impact on the signs, magnitudes or significance of most of the control variables of interest. Overall, these results increase our confidence that the FISP impacts on fertiliser use reported in Table 3 are likely to be causal, rather than reflections of shared correlation with past fertiliser use.

4.3 Results for impacts of the FISP on maize yields

Table 4 presents results for a parsimonious production function for maize, estimated for plot-level data. As expected, we found a positive and statistically significant correlation between the amount of fertiliser used and maize yield, but diminishing returns to fertiliser use. Maize plots that were intercropped registered yields that were significantly lower (by about 18%) than those that were mono-cropped. The production function intercept for farmers producing improved maize is higher than for those producing traditional varieties: plots with improved maize registered yields that were 17% higher than those planted with traditional maize.

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[7] When we estimate simple OLS (non-IV) regressions that do not account for the sample selection bias that arises from ignoring the latent characteristics of adopters, we obtain a corresponding coefficient of approximately 1.5, suggesting more than half of the observed fertiliser use is explained not by FISP participation *per se*, but by latent characteristics of the FISP beneficiaries.

Table 3: Regression results for the effect of coupon receipt on maize fertiliser use

	Model 1 IV 2009 variables only	Model 2 IV 2006 fertiliser	Model 3 IV 2002 and 2006 fertiliser
Constant	64.691***	65.930***	77.451***
	(17.882)	(18.938)	(22.730)
Age	-0.456	-0.540	-0.683**
(years)	(0.447)	(0.421)	(0.287)
Education	2.538	2.426	6.173
(0 = none, 1 = some)	(10.201)	(10.258)	(13.955)
Household size	2.479**	2.423*	1.470
(number of persons)	(1.202)	(1.323)	(1.790)
Female-headed household	4.542	2.761	-10.731
(0 = no, 1 = yes)	(13.275)	(13.765)	(13.571)
Poor	-10.688	-7.899	1.055
(0 = no, 1 = yes)	(10.689)	(11.089)	(12.480)
Farm size	-81.978***	-86.591***	-76.121**
(hectares)	(23.573)	(24.421)	(22.826)
Farm size squared	15.250***	16.226***	13.659**
(hectares)	(4.996)	(5.028)	(5.703)
Value of all coupons received[†]	0.573*	0.615**	0.501*
(100 Mk)	(0.351)	(0.313)	(0.299)
Fertiliser use in 2006/2007	—	-0.008	0.039
growing season (kg/ha)		(0.007)	(0.041)
Fertiliser use in 2002/2003	—	—	0.041
growing season (kg/ha)			(0.097)
N	375	375	176
Anderson LR statistic	6.25**	5.89**	2.74

Notes: Dependent variable is the total quantity of fertiliser used per hectare of maize (kg/ha); District-clustered robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; [†] denotes instrumented value based on model presented in Table 2. Test of identification/IV relevance for the pair of instruments (years of residency and village population) are reported in the final row of the table.

Table 4 Production function for maize, dependent variable is natural log of yield (kg/ha)

	Estimated coefficient
Constant	4.94**
	(0.090)
Fertiliser per hectare	0.293**
(natural log of kg/hectare)	(0.021)
Intercrop	-0.185**
(0 = no, 1 = yes)	(0.051)
Improved maize seed	0.167**
(0 = no, 1 = yes)	(0.050)
N	562
R^2	0.28

Note: District-clustered robust standard errors in parentheses; ; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1 sketches the estimated average relationships between fertiliser intensity and maize yields in the sample. Consistent with the sample data and regression results, households producing improved maize are placed at a higher intercept than those producing traditional maize. Points A and C on the diagram show yields from traditional maize and from improved maize respectively, at average fertilisation rates for farmers who did not access subsidised fertiliser. Points B and D represent yields from traditional maize and improved maize respectively, at mean fertilisation rates for farmers who used subsidised fertiliser. Access to subsidised fertiliser but not to improved seed moves a traditional

maize producer from point A on the input response curve to B. The fertiliser subsidy moved producers of improved maize from C to D. Access to a complete FISP package of coupons (for improved seed *and* fertiliser) shifts production from A to D.
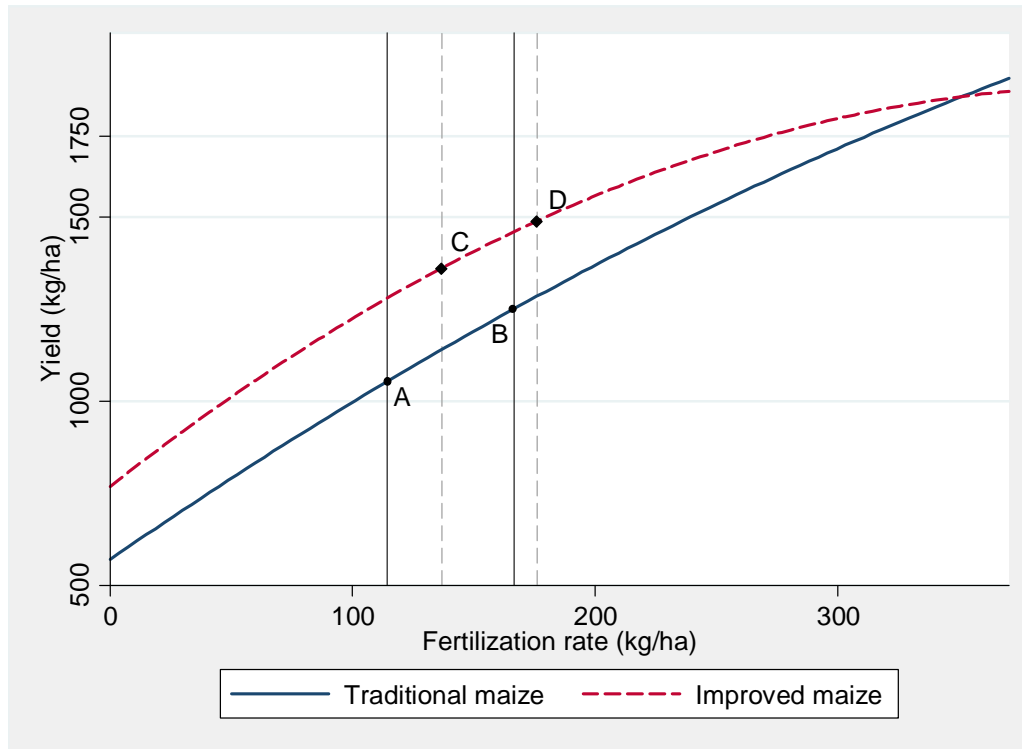

Figure 1: Maize yield response to fertiliser
Note: Marked points on the graph correspond to the following fertiliser-yield combinations: A [114 kg/ha, 1302 kg/ha];
B [165 kg/ha, 1245 kg/ha]; C [136 kg/ha, 1373 kg/ha]; D [175 kg/ha, 1477 kg/ha]

The estimated total yield gain from the subsidy can be calculated as

$$\Delta y = y_D - y_A \tag{4}$$

where Δy represents the yield gain from the subsidy programme per hectare. We observed a 447 kg/ha gain from accessing subsidised maize seed and fertiliser. Fertiliser without seed (i.e. the shift from A to B in Figure 1) is associated with an average gain of 249 kg/ha, or approximately half that associated with the combination of improved seed and fertiliser. In terms of impact, therefore, including improved maize seed in the FISP results in the highest net benefit, because yields from improved maize are higher at each level of fertilisation than the yields from traditional maize.

In a related study of the land allocation impacts of the FISP, Chibwana *et al.* (2012) found for the same sample of farmers that each complete set of subsidy coupons was associated with a 16% increase in the area that farmers allocated to maize during the 2008/2009 agricultural season. Using results from the production function represented in Figure 1, the total direct impact of receiving a complete FISP fertiliser and seed subsidy can be calculated as:

$$(Y_D - Y_A) * \left[\partial L /_{\partial C} * L_m \right] \tag{5}$$

where Y_D (= 1 510 kg) represents the yield per hectare from improved maize obtained by farmers who applied chemical fertiliser obtained through the subsidy programme, and Y_A (= 1 063 kg) represents the yield per hectare from traditional maize for farmers who received no coupon.[8] $\partial L /_{\partial C}$ (= 1.16) is the partial change in maize area resulting from receiving coupons for maize seed and fertiliser, and L_m is the average amount of land planted to maize (0.88 hectares). The average farm-level impact on maize production, accounting for both yield and area changes, therefore is 456 kg for each complete set of coupons (seed and fertiliser). However, we noted that output from other crops would likely decline as a result of a shift toward maize. The size of this decline is not derived here, but Chibwana *et al.* (2012) reported that farmers who received coupons for maize seed and fertiliser allocated about 20% less land to other crops than those who did not receive any coupon. Valuing this reduced crop area based on average areas and yields for cassava (the representative crop most likely displaced), and using the prevailing farm-gate price of cassava and the retail price of maize, we calculate that the maize-equivalent value of offset production was roughly 250 kg of maize on average, or slightly more than half of the observed maize gain.[9]

5. Conclusions and policy implications

The FISP was intended to benefit both the most vulnerable farm households, as well as those having sufficient land to make use of the subsidised seed and fertiliser. However, the results suggest that the most vulnerable people in the communities were not the main recipients of the coupons. Female-headed households were intended to be targeted, but were less likely to benefit from the programme than male-headed households. In addition, poor households were less likely to participate in the FISP compared to non-poor households. The selection of beneficiaries appears mainly to have reflected other factors, including whether a household received coupons in the previous year, length of residency, and whether the village had been established for long.

Critics argue that, to be effective, subsidies must be targeted. The FISP has been widely cited as a smart subsidy success story (Minot & Benson 2009).[10] However, given that the poor and vulnerable in the two communities were not the primary beneficiaries of subsidised inputs, questions remain about the FISP's targeting effectiveness. One goal of the FISP has been to jumpstart the use of improved maize technologies among resource-poor smallholder farmers. To achieve this goal, the poor and vulnerable need to be the primary targets of the input vouchers. A revision of the system for distributing the coupons to households could help to achieve this. A conservative approach would be to target production incentives at those with capabilities to produce, and to provide safety nets for those most vulnerable and least likely to make productive use of the inputs. However, such targeting raises the thorny question of whether subsidies should ignore those who, by virtue of current resource endowments, are likely to remain poor (even with subsidies). Furthermore, our production function

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[8] As a point of reference, Malawi's national average maize yield in 2009 was 1 483 kg/ha.

[9] Chibwana *et al.* (2013) conclude that maize subsidies appear to have reduced agricultural expansion modestly, although tobacco subsidies delivered as part of the FISP generated a derived demand for timber (to construct tobacco drying sheds) and therefore may have had a small detrimental impact on forest cover.

[10] Minot and Benson (2009) define "smart subsidies" as mechanisms to provide subsidised goods and services designed both to promote market development and to enhance the welfare of the poor. Such subsidies are often phased out once the market infrastructure has been developed and markets for the supply of the relevant goods and services are functioning.

estimates suggest diminishing responsiveness to fertiliser, which adds to the logic of targeting small producers.

Targeting concerns notwithstanding, the results suggest that the FISP probably helped to increase the intensity of fertiliser use among benefiting households. This finding is consistent with previous research by Ricker-Gilbert and Jayne (2008) on the effects of the Malawi subsidy programme on fertiliser use. Fertiliser-use intensity is negatively correlated with farm size and positively correlated with the planting of improved maize. The FISP affects maize yields through fertiliser use and varietal choice. Farmers planting improved maize obtained higher yields than those producing traditional maize. The results show that the average increase in maize yields from accessing a standard FISP package of maize seed and fertiliser was 447 kg/ha, about twice the yield gain from receiving coupons for fertiliser only. This suggests the programme may be placing too much emphasis on fertiliser and not enough emphasis on improved seed. Under the FISP, farmers were given a choice between 2 kg of hybrid maize seed or 4 kg of OPV seed in addition to 100 kg of fertiliser (50 kg basal and 50 kg side dressing). Given the yield differentials between the two varieties, shifting emphasis to promoting the use of hybrid seed in the subsidy programme could help to improve outcomes. In the future, therefore, effort might be best directed at policies that seek to improve the delivery of improved seed to farming communities in Malawi.

Acknowledgements

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