Smart Subsidy? Welfare and Distributional Implications of Malawi's FISP

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ABSTRACT

It is often argued that subsidizing fertilizer and other inputs is desirable both to boost agricultural production and to help poor farmers. This analysis of Malawi's huge Farmer Input Subsidy Program highlights a tension between these two objectives: The more FISP increases fertilizer use and thereby raises output, the greater the distortion and hence the *lower* the welfare gains from the program. Indeed, the empirical results indicate that up to 59% of every Kwacha spent on the FISP is wasted, in the sense that the fertilizer is not sufficiently valued by the beneficiaries. Cashing out the program is shown to have desirable distributional implications.

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Malawi's Farmer Input Subsidy Program or FISP is undoubtedly the largest such scheme relative to GDP in sub-Saharan Africa. Perhaps as a result it has become something of a cause célèbre (e.g., Denning et al. 2009). What sets FISP apart is its vast coverage—around 1.4 million (44% of) agricultural households by 2012/13—combined with its use of vouchers to target subsidies to poor farmers, a so-called "smart" subsidy. Since FISP alone accounts for around 9% of Malawi's government budget, it is important to understand its welfare and distributional implications.

To do so, the analysis described in this note hews closely to the welfare economics tradition. That is, it assumes, at least as a starting point, that demand reflects marginal valuation and thus can be used to measure the benefits (and costs) of policy interventions. The empirical application, therefore, involves first estimating a demand curve for fertilizer using micro-data and then simulating "consumer surplus" changes implied by the smart subsidy scheme. In an extension, the possibility that credit constraints distort fertilizer use decisions is taken seriously. In this case, demand may understate marginal valuation. Nonetheless, the analysis can be adapted to 'adjust' demand for the presence of credit constraints and recover the true benefits of fertilizer subsidies.

Conceptual framework

Smart ISPs typically provide farmers with vouchers to purchase small quantities of fertilizers and seeds. The quantity limitation, often combined with explicit targeting of vouchers, is designed to reduce the share of benefits going to larger, wealthier, farmers for whom the subsidy is likely to be inframarginal. Insofar as the subsidy is not inframarginal, thereby changing the quantity of fertilizer procured, the critical question is: What is a voucher worth to farmers? If vouchers can be costlessly resold at the market price, then a voucher is, of course, equivalent to a cash grant of the subsidy amount. Since FISP voucher resale is rare in Malawi (Kilic et al. 2013 and more recent evidence cited below), the remainder of this discussion presupposes that vouchers are not equivalent to cash.

Figure 1 displays four smart subsidy scenarios based on four different levels of demand for fertilizer. Suppose that, as in FISP, a voucher is provided that can be redeemed for a single 50 kg. bag of urea (an identical argument applies to the NPK voucher). Upon redemption, farmers must pay some fraction of the market price p_m; i.e., $p_s > 0$. It is also assumed, plausibly in the context of Malawi, that p_m is given on world markets. Thus, none of the subsidy benefits are dissipated in the form of producer surplus.

Taking the four scenarios in turn, case 1 shows a demand for fertilizer so low that none would be purchased at the subsidized price *even if it were possible to purchase in fractions of 50 kg bags.* Case 2 shows a demand just high enough to make it worthwhile to redeem the voucher. Note that redemption forces the farmer to purchase a whole 50 kg bag at a price of p_s, even though in this case the farmer would want to purchase only a fraction of a bag. The net welfare gain to the farmer from the subsidy is represented by the area of the solid blue triangle *minus* the area of the solid red triangle. As in case 2, in case 3 the subsidy induces the farmer to procure more fertilizer than he otherwise would. However, the marginal value of these additional units to the farmer is less than the cost of providing them. This difference is represented by the dotted blue triangle in Figure 1. Lastly there is the purely inframarginal subsidy, represented by case 4. Here, the subsidy does not change farmer behavior at all and, as a consequence, the welfare gain, the entire blue rectangle, is equal to the cost of the subsidy. In other words, case 4 is the only situation where the subsidy benefits the farmer *and* does not entail a deadweight loss.

Thus far, the analysis takes the stand that demand reflects marginal value. But what if farmers are constrained from making optimal input use decisions? For example, by lack of credit. Returning to case 3, suppose that unconstrained demand is D_3' as illustrated in Figure 2. While the constrained demand D_3 indicates how much quantity of fertilizer procured would increase in response to the subsidy, it would, in general, understate the welfare gain from this quantity increase. For an unconstrained farmer, the value of additional fertilizer use is given precisely by the value of the additional crop it produces. But for a credit constrained farmer, the value of additional fertilizer also depends on the shadow price of transferring resources from the present to the future. In other words, credit constraints raise the shadow price of fertilizer at any given value of the monetary price.[2] Thus, D_3' reflects the true productivity benefits of an increase in fertilizer use and, correspondingly, the solid blue area in Figure 2 represents the *additional* benefit to the household (i.e., above and beyond that reflected by D_3) from a non-inframarginal subsidy.

[2] This can be seen most easily in a model where households have preferences over a single consumption good in both a pre and post-harvest period. Given that post-harvest consumption is always greater than pre-harvest consumption, the shadow price of fertilizer, which must be purchased before harvest, always exceeds the monetary price.

Empirical framework

The empirical model is described by three equations (see technical appendix for details): (i) a demand curve for each type fertilizer relating quantity procured to the effective price; (ii) a price equation relating per unit effective price to distance to fertilizer source;[3] (iii) a voucher redemption equation. A combination of equations (i) and (ii) is estimated on a sample of households that do not receive fertilizer vouchers and equation (iii) is estimated on a sample of voucher recipients.

The key problem the model is designed to solve is the lack of good data on commercial fertilizer prices faced by each household. Even if such data were available, *including for households that choose not to purchase any fertilizer and for communities where no fertilizer is sold*, the exogeneity of prices would be an issue. To work around this lacuna, the analysis uses distance between household and source of fertilizer (i.e., fertilizer plant or port of entry into Malawi), which is plausibly exogenous and available for every household whether purchaser or not. However, absent direct information of prices, the price elasticity or slope of the demand is not identified from equations (i) and (ii) alone. Since without this demand elasticity it is impossible to do welfare analysis, an auxiliary relationship between voucher uptake and household characteristics is required; hence equation (iii). The technical appendix describes how all three equations fit together to identify the price elasticity of demand.

Finally, note that credit or cash-in-hand constraints are incorporated in the model by including a measure of household income (in practice, per capita expenditures) in the fertilizer demand equation (i). In the absence of credit constraints, fertilizer use should be unrelated to income, conditional on prices and productivity.[4]

Data and preliminary analysis

Data come from Malawi's 2013 ISA survey, a nationally representative survey that includes information on FISP voucher receipt and redemption. In addition, GPS coordinates are available for all dwellings of the roughly 4000 surveyed households, allowing construction of the appropriate distance variables.

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[3] Effective price means the relative price of a kg of fertilizer in terms of a kg of, say, maize at the farm-gate.
[4] Strictly speaking, separability between production and consumption decisions also requires a complete set of factor markets as well as, in the presence of uncertainty, complete contingent claims markets.

Table 1 provides descriptive statistics on fertilizer voucher receipt and redemption in the ISA sample. On the whole, households receiving vouchers used them, but around 10% of recipients nationally did not redeem *at least one* voucher. Only a handful, however, reported selling the voucher.

Demand estimation

Table 2 presents tobit estimates of the relationship between fertilizer use (separately for NPK and urea) and household characteristics, including most importantly log distance of household from fertilizer source (nearest of fertilizer plant or port of entry into Malawi) and log per capita expenditures. The regressions also control for household demographics, landholdings, indicators of soil productivity based on the household's GIS coordinates, and district dummies.[5] In addition, to deal with the concern that log per capita expenditures is endogenous with respect to household fertilizer purchase, this covariate is instrumented with the leave-one-out mean of log per capita expenditures in the enumeration area.

Note that the distance coefficients are negative and per capita expenditure coefficients are positive for both fertilizer types. Thus fertilizer use of voucher non-recipient households declines with distance to the production point or port of entry for this input. And, wealthier households purchase more fertilizer, conditional on soil productivity, which is consistent with a model of cash-on-hand constraints (see Duflo et al., 2011). These demand estimates along with the probit estimates for voucher redemption on the sample of voucher recipients (not reported), provide estimates of the underlying demand parameters as discussed in the technical appendix.[6]

Smart subsidy?

Consumer surplus is computed for each household based on their predicted demand for the two types of fertilizer under the smart subsidy scheme relative to the counterfactual of commercial purchase. Table 3 breaks down voucher recipient households into the four cases discussed in reference to Figure 1. Only a few households are predicted to be in the inframarginal category (case 4). Most are predicted to

[5] The large set of controls is a way of addressing possible selection bias due to the fact that voucher non-recipients are not randomly chosen.

[6] Following the notation in the technical appendix, this procedure yields $\beta_{NPK} = -.174$ and $\beta_{urea} = -.099$.

purchase less than one bag commercially in the absence of the subsidy; hence, for them FISP increases the quantity of fertilizer acquired.

If one takes consumer surplus, summed across fertilizer types, as a measure of the benefit of FISP and the difference between the effective price (i.e., inclusive of transport costs)[7] and the subsidized price (times the number of vouchers redeemed) as the cost of FISP, then a benefit to cost ratio can be computed, for both the overall population and for different sub-populations. The results of this exercise are reported in Table 4.

Recall that consumer surplus can be computed in two ways: First, by assuming that each household's actual or 'constrained' demand schedule reflects their marginal valuation of fertilizer; second, by assuming that the household's marginal valuation is represented by their demand 'as if' they did not face a binding cash constraint. 'Unconstrained' demand in Table 4 uses household fertilizer demand evaluated at the 90th percentile of per capita consumption (rather than at actual household per capita consumption); farmers in the top 10% of the wealth distribution are unlikely to be cash constrained in their purchase of fertilizer.

The key finding is that benefit cost ratios are well below 1, the upper bound achieved when all households are inframarginal with respect to the FISP. For consumer surplus computed based on constrained demand, the national benefit/cost ratio is only 0.41, which means that 59% of every Kwacha spent on FISP is wasted. The poor account for much more of this deadweight loss than the non-poor for the simple reason that the poor have a lower demand for fertilizer. If consumer surplus is computed based on unconstrained demand, however, the national benefit/cost ratio rises to 0.62, a significant improvement, but still indicative of a highly inefficient transfer (relative to cash). Obviously, moving from constrained to unconstrained demand as a basis for computing consumer surplus attenuates the difference in benefit/cost ratios between poor and non-poor.

As a final step, figures 3 and 4 show benefit incidence curves for FISP. In each figure, the naïve BIC is plotted, which is just the share of vouchers going to the bottom *kth* percentile of the per capita expenditure distribution. Evidently, FISP voucher distribution does not target the poor particularly well; indeed, there is no discernable progressivity in the distribution of vouchers. However, when the actual benefit (consumer surplus) due to the voucher is taken into account, FISP appears much more

[7]FISP reduces the effective price in two ways: by fixing a low pan-territorial subsidized price and by actually delivering fertilizer to local shops for sale at this price, which, of course, entails a sizeable transport cost.

regressive, which again is attributable to the low demand for fertilizer among the poor. Using the more generous (to FISP) definition of consumer surplus, in figure 4, improves progressivity, but the program remains more regressive than the naïve BIC would suggest.

Conclusions and policy implications

It is often argued that subsidizing fertilizer is desirable both to boost agricultural production and to help poor farmers. The lesson here is that there is a tension between these two objectives: The more FISP increases fertilizer use and thereby raises output (i.e., the less crowd-out), the greater the distortion and hence the *lower* the welfare gains from the program. Indeed, the results of this analysis of Malawi's FISP suggest that the magnitude of this distortion is high. Up to 59% of every Kwacha spent on the FISP is wasted, in the sense that the fertilizer is not sufficiently valued by the beneficiaries. Even in the rosiest scenario considered, the estimates indicate that 38% of FISP expenditures are deadweight loss.

Allocating the FISP budget through a targeted cash transfer program avoids these welfare costs and would still stimulate the demand for fertilizer among smallholders in Malawi to some extent; i.e., by alleviating the credit constraint. The predicted distributional impact of such a program 'cash-out' under different assumptions about fertilizer demand (i.e., constrained versus unconstrained) are illustrated in figure 5.[8] In either case, a cash-out is evidently a highly progressive policy change, in absolute terms benefitting households in the bottom quintile far more than households in the top quintile.

References

Denning, G., Kabambe, P., Sanchez, P., Malik, A., Flor, R., Harawa, R., ... & Sachs, J. (2009). Input subsidies to improve smallholder maize productivity in Malawi: Toward an African Green Revolution. *PLoS Biol*, *7*(1), e1000023.

Duflo, E., Kremer, M., & Robinson, J. (2011). Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya. *American Economic Review*, *101*(6), 2350-90.

Kilic, T., Whitney, E., & Winters, P. (2013). Decentralized beneficiary targeting in large-scale development programs: insights from the Malawi farm input subsidy program. *World Bank Policy Research Working Paper*, (6713).

[8]The policy simulations assume that the cash transfer would include the value of the costs otherwise incurred by the program in transporting the fertilizer to beneficiaries.

Technical Appendix

The demand for fertilizer type *j* for farmer *i* f_{ij}^* is assumed to take the form

$$\ln\left(f_{ij}^* + 1\right) = \alpha_{ij} + \beta_j\, p_{ij} + \varepsilon_{ij} \qquad (1)$$

where p_{ij} is the farm-gate price of fertilizer in real terms (i.e., in terms of crop output). The parameter α_{ij} is the intercept, which can depend on farmer characteristics (e.g., land holdings), and $\beta_j < 0$ is the price-elasticity of demand for fertilizer *j*. In what follows, the *j* subscript is suppressed for convenience.

The farm-gate price depends on cost of transport from port/production source. Thus, p_i is a function of market price at source, p_m, and the distance d_i to source as follows

$$p_i = p_m + \delta \ln(d_i) + u_i \qquad (2)$$

where $\delta > 0$ is a parameter to be estimated .

Combining (1) and (2) yields

$$\ln(f_i^* + 1) = \alpha_i{}' + \beta' \ln(d_i) + \varepsilon_i' \qquad (3)$$

where $\alpha_i{}' = \alpha_i + \beta p_m$, $\beta' = \beta\delta$, and $\varepsilon_i' = \varepsilon_i + \beta u_i$. Equation (3) can be estimated by tobit to account for censoring at zero.

Next, consider the decision to redeem vouchers by voucher recipients. The price they face for a 50 kg bag is assumed to be

$$p_{si} = (1 - \mathrm{s})\, p_m \quad + u_i$$

where s is the subsidy rate. Note that, since Malawi effectively has pan-territorial pricing of subsidized fertilizer, the cash price of fertilizer purchased with a voucher is the same at every location up to random noise u_i (i.e., think of this as a 'hassle' cost). This delivers a probability of voucher redemption of the form

$$\Pr(\text{redeem}) = \Pr[\, \tilde{p}_i(\, \hat{\alpha}_i{}' \,, \hat{\beta}'/\delta) > p_{s,i}\,]$$
$$= \Pr[\ u_i \ < \ \tilde{p}_i(\, \hat{\alpha}_i{}' \,, \hat{\beta}'/\delta) - (1 - \mathrm{s})p_m]$$

where $\tilde{p}_i$ is the take-it-or-leave-it price of a 50 kg bag. Equation (1) implies that $\tilde{p}_i = -\,(\alpha + 1 - \frac{51}{50} * ln51)/\,\beta = p_m - \delta\theta_i$, where $\theta_i = \frac{1}{\beta'}[1 - \frac{51}{50} * ln51 + \hat{\alpha}_i{}']$. From this it follows that

$$\Pr(\text{redeem}) = \Phi\left[\, \frac{p_m - \delta\theta_i - (1-\mathrm{s})p_m}{\sigma} \,\right] = \Phi\left[\, \frac{sp_m - \delta\theta_i}{\sigma} \,\right]$$

where Φ is the standard normal CDF and σ is the standard deviation. Thus, the slope coefficient from this voucher redemption probit identifies -$\delta/\,\sigma$ and the constant term identifies sp_m/σ. Since sp_m is a known constant, both σ and δ follow directly, as does β and, finally, α_i.

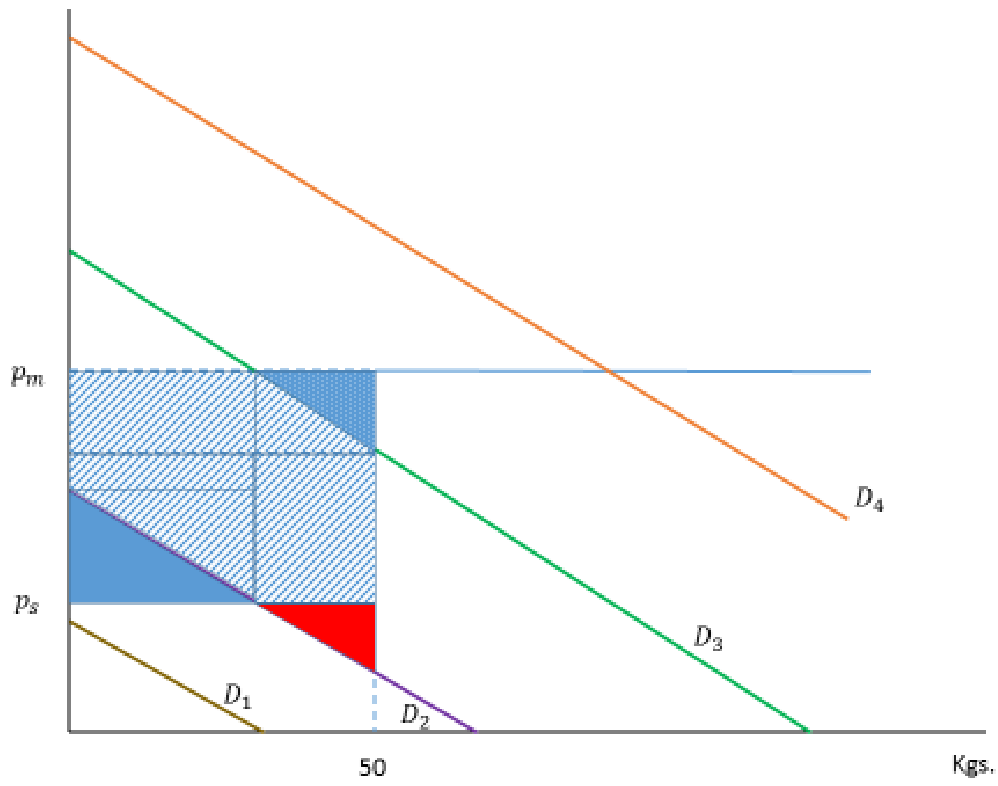

Figure 1. Four smart subsidy scenarios

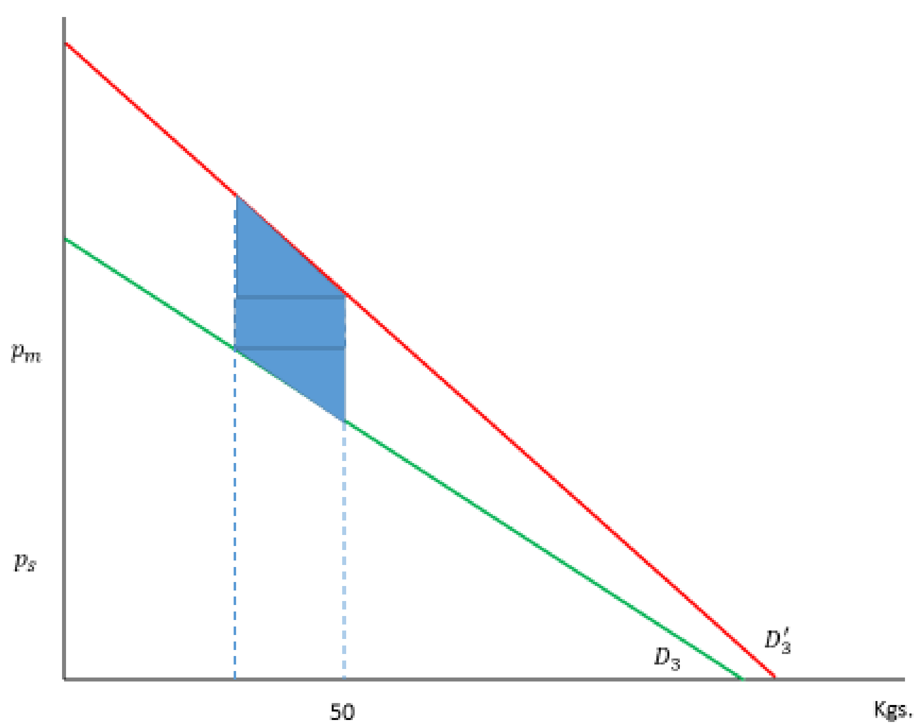

Figure 2. Additional welfare gains based on unconstrained demand

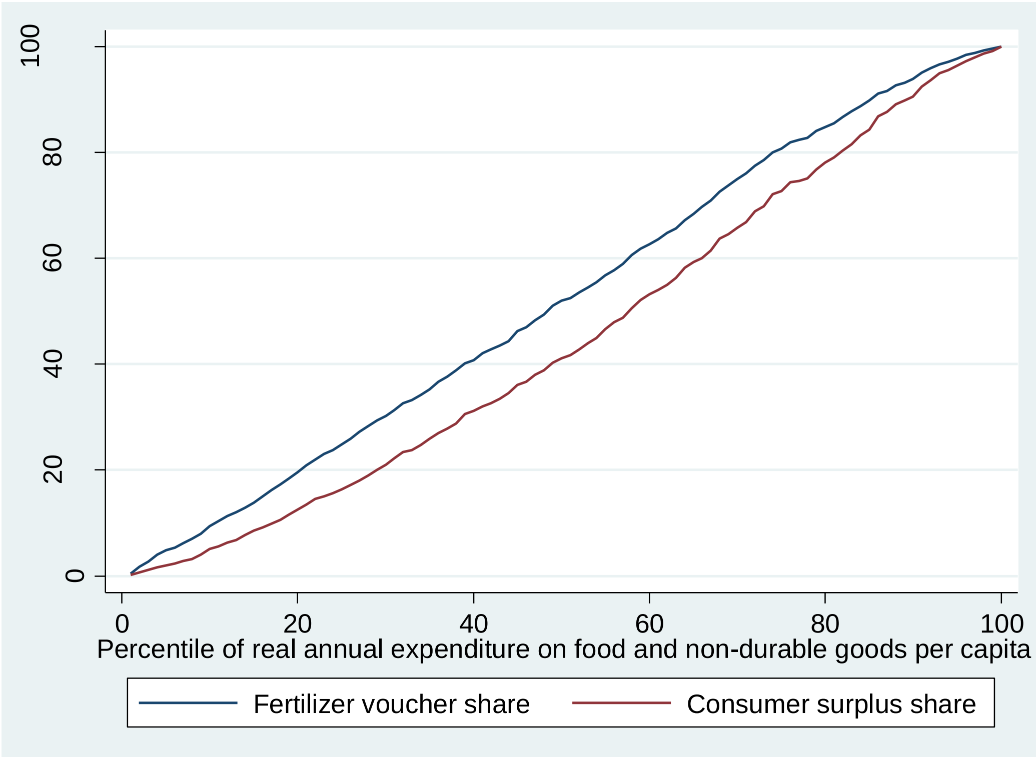

Figure 3. Benefit incidence based on constrained demand (ag. households)

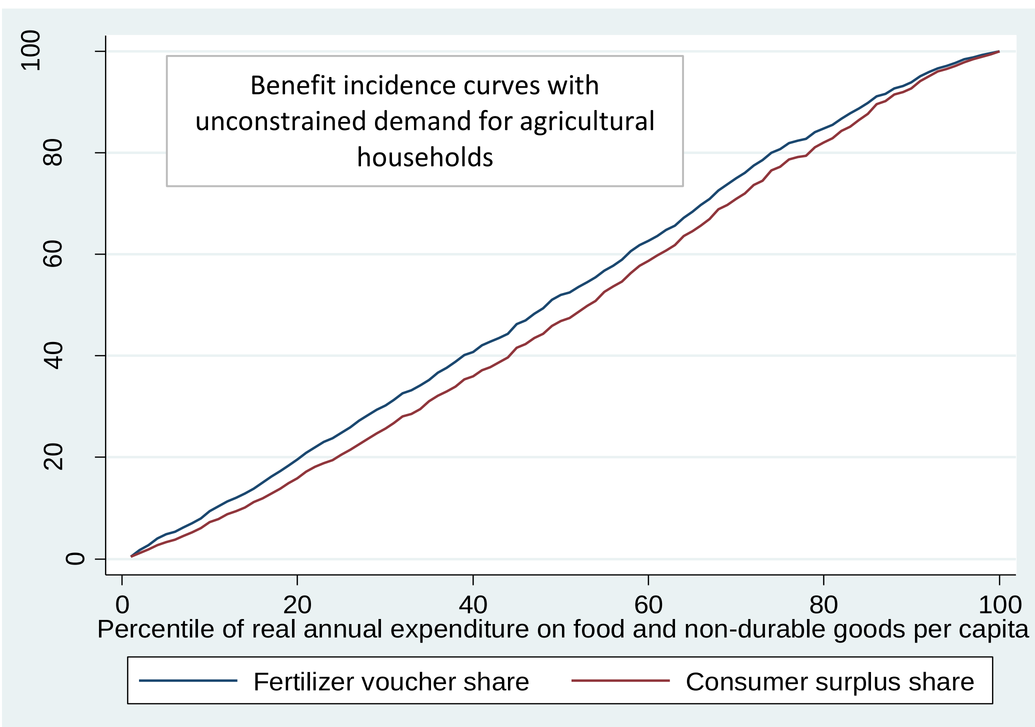

Figure 4. Benefit incidence based on unconstrained demand (ag. households)

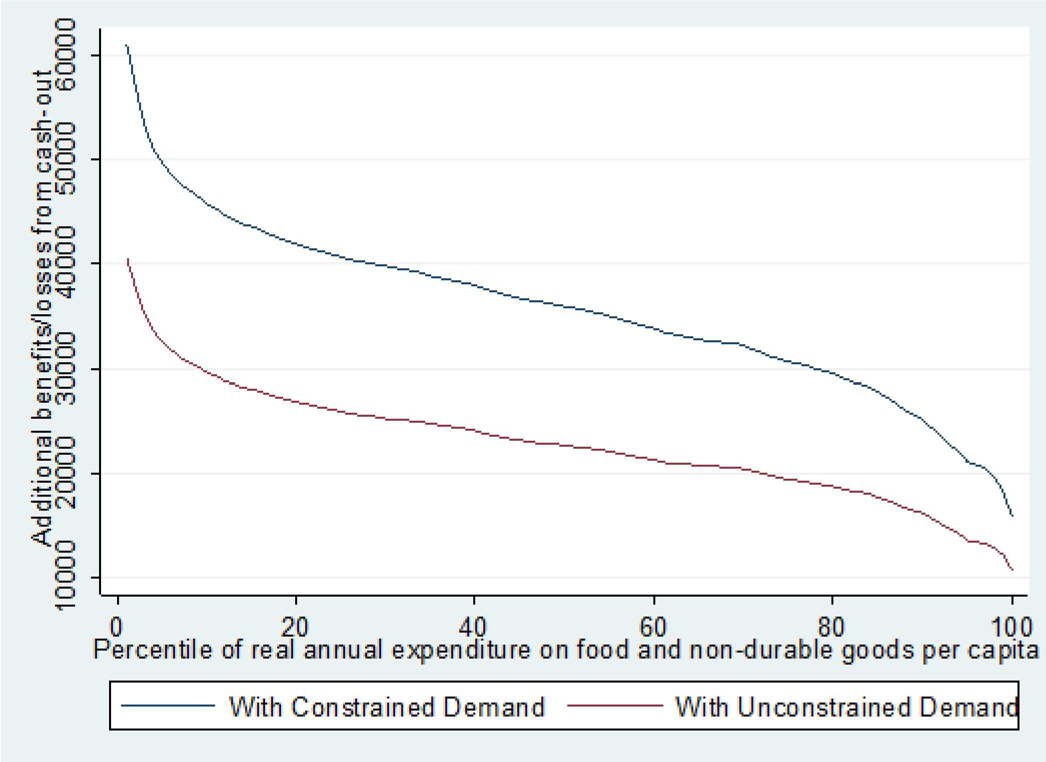

Figure 5. Benefit distribution of a FISP cash-out

Table 1: Number of households receiving and redeeming vouchers in Malawi ISA 2013

	North		**Central**		**South**		**National**	
	NPK	Urea	NPK	Urea	NPK	Urea	NPK	Urea
Voucher recipients	246	244	315	348	512	489	1073	1081
Full redeemers	236	234	268	295	465	432	969	961
Non-redeemer	5	7	32	46	36	47	73	100
Partial or non-redeemers	10	10	47	53	47	57	104	120
Of whom, no. who sold	1	4	4	5	3	3	8	12

Table 2: Tobit estimates of demand for commercial fertilizer for non-recipients of vouchers

Variables	Log (kg NPK + 1)	Log (kg urea +1)
Log(km from HH to nearest main border port or local fertilizer plant)	-0.931	-0.722
	(2.71)**	(2.21)*
log(annual HH per capita consumption)	2.350	2.122
	(6.46)**	(6.00)**
log (ha cultivated by HH)	0.442	0.408
	(4.28)**	(4.06)**
Household size (adult equivalent)	0.391	0.421
	(7.02)**	(7.82)**
Female headed HH (=1)	-0.536	-0.586
	(2.10)*	(2.40)*
Age of household HH head	-0.028	-0.023
	(3.84)**	(3.26)**
Plot conditions		
Workable soil (=1)	-0.211	0.169
	(0.37)	(0.31)
Non-toxic soil (=1)	-0.525	-0.500
	(0.61)	(0.63)
Oxygen available to crop roots (=1)	0.337	-0.398
	(0.61)	(0.78)
Good rooting condition (=1)	-0.245	-0.304
	(0.49)	(0.64)
Good soil nutrient retention capacity (=1)	0.248	0.808
	(0.44)	(1.50)
Good soil nutrient availability (=1)	-1.058	-0.860
	(1.96)*	(1.67)
Average elevation (meters)	0.004	0.003
	(5.26)**	(4.34)**
1st stage residual	-0.245	-0.297
	(0.64)	(0.79)
Observations	1700	1700

Notes: Absolute value of t statistics in parentheses (* significant at 5%; ** significant at 1%). District dummies included but not reported. Log per capita consumption is assumed to be an endogenous variable. Thus, the residual from a first-stage regression of log per capita consumption on (leave-one-out) mean of log per capita consumption for the enumeration area and the other exogenous variables is included in the tobit specifications.

Table 3: Number of households in each demand category based on predicted demand

Cases (see figure 1)	**NPK**	**Urea**
1 : no demand at p_s	9	7
2 : marginal willingness to pay for one bag < p_s	267	242
3 : p_m > marginal willingness to pay for one bag > p_s	776	809
4 : marginal willingness to pay for one bag > p_m (inframarginal)	13	17
Total	1065	1075

Table 4: Benefit/Cost ratios for FISP

	Constrained demand	Unconstrained demand
Region	All Ag. households	
North	0.65	0.78
Central	0.52	0.68
South	0.26	0.54
National	0.41	0.62
	Poor Ag. households	
North	0.55	0.74
Central	0.37	0.61
South	0.14	0.41
National	0.29	0.53
	Non-poor Ag. households	
North	0.71	0.81
Central	0.59	0.71
South	0.31	0.60
National	0.46	0.66

Notes: See text for details. Unconstrained demand assumes all households value fertilizer as though they were in the 90th percentile of the per-capita expenditure distribution.