Input Subsidies, Cash Constraints and Timing of Input Supply:

-Experimental Evidence from Malawi

Stein Holden and Rodney Lunduka

School of Economics and Business

Norwegian University of Life Sciences

P. O. Box 5033, 1432 Ås, Norway

Corresponding author email: *stein.holden@umb.no*

Tel: +47-64965699

Fax: +47-64965701

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Abstract

The study investigated the demand for fertilizer among rural farm households in Malawi that have been exposed to high fertilizer subsidy levels. Subsidies and cash constraints may limit their demand but their cash constraint may be less severe at harvest time than at planting time when they normally get their inputs. Three different experiments were used to assess the demand for fertilizer at harvest time and at planting time, to elicit farm gate shadow prices for fertilizer and to assess the gap between WTA and WTP prices for a standard input package The experiments demonstrated significant effects of timing and of cash constraints.

Key words: Malawi, input subsidies, fertilizer, cash constraints, time inconsistency, input delivery timing.

JEL Classification codes: Q12, Q18

Malawi has implemented a large-scale agricultural input subsidy program since 2005 after a period with severe food shortages and the program has contributed to increased food availability, higher real wages, economic growth and poverty reduction (Dorward and Chirwa, 2011). The targeted input subsidy program distributes coupons (providing more than 90% subsidy in the 2008/09 season) to about two million of about two and a half million smallholder farm households where priority should be given to poor and vulnerable households (Dorward et al. 2008; Ricker-Gilbert and Jayne 2008; 2009; MoAFS 2008).

Important reasons for the reintroduction of large-scale subsidies were that the inputs were not affordable for the poor smallholder farmers because of liquidity constraints and that it was cheaper to import fertilizer than to import food. The fact that the country managed to quickly switch from being a "beggar for food" to becoming a net exporter has also been very important for the national pride. While the program contributed to national and household food security and maize export to neighboring countries, the costs of the program also rose sharply with the increasing international fertilizer and oil prices. The budgetary costs of the input subsidy program therefore increased from 50 million US$ in 2005/06 to 360 million US$ in 2008/09 or close to 15% of Malawi's total government expenditure. There is therefore a need to reduce the costs of the program without reducing the food production. This paper investigates one possible approach to reducing such costs without affecting the food production negatively.

An important reason for advocacy of fertilizer subsidies is that rural households in Malawi are very poor and typically lack cash resources to buy profitable inputs and this causes too low input use. Poverty in combination with liquidity constraints may cause high discount rates and this may lead to low investment (Holden et al. 1998). Time inconsistent behavior in form of present bias has been observed in many social experiments and may also contribute to explain low input use and investment levels in developing countries (Duflo et al. 2011). Another reason for low adotion of improved technologies may be fixed costs that limit market access (Suri 2011). The main novel contributions of our study are as follows. First we assess how demands for fertilizer and food at harvest time and planting time are associated with the price of maize, access to input subsidies market access, and household poverty. Second, we assess the unconstrained farm gate shadow prices for small amounts of fertilizer and how they vary between harvest time and planting time and their correlation with maize prices, access to input subsidies, market access and poverty. Third, we assess the gap between the share of households Willing to sell and Willing to buy a standard input package at varying prices and how this gap is affected by the price of the package, the timing of the offers (harvest time or planting time), the price of maize, and other covariates.

The seasonality of rain-fed agricultural production which dominates in Malawi make food shortages seasonal and food has to be stored from one harvest season and up to the next harvest season. More than 60% of the rural households in Malawi are still net buyers of maize (the main staple food) after the introduction of the subsidy program. At planting time they may face a dilemma between using scarce cash resources to buy food to meet more immediate needs or to buy inputs to meet next year's needs. Time inconsistent behavior may then cause too low investment in inputs. The two standard approaches to deal with this problem have been to provide credit for input purchase or to subsidize the inputs. Input credit programs have had greater success in reaching net sellers than net buyers of agricultural outputs, however, as payback has often been in form of production output. Input credit programs have also faced large moral hazard problems contributing to high default rates and covariate risk has made it hard to sustain such programs in environments with substantial weather risk. It was after two years with droughts in 1992 and 1994 that the Malawian input credit program collapsed (Zeller et al., 1997).

Use of subsidies could then be a way of internalizing the externality related to sub-optimal input use and such subsidies could enhance both productivity and equity. One may, however, question whether such subsidies are the most appropriate and cost-effective instrument to address this market failure. Duflo et al. (2011), based on a study and social experiments in Kenya, found that poor households are willing to invest in response to small, time-limited discounts in form of free delivery of fertilizer just after harvest. A 50% subsidy on fertilizer at planting time did not enhance fertilizer use more than a discount in form of free delivery of fertilizers at harvest time. Their finding may indicate that distribution and selling of fertilizer just after harvest can be a better system than selling fertilizers at planting time when households may no longer have sufficient cash from the selling of their harvest. Buying of inputs at harvest time for the next growing season may then serve as an commitment device (DellaVigna 2009) and reduce the need for subsidies. It could also reduce the pressure on the input delivery system at planting time and reduce to risks of too late delivery of inputs with subsequent productivity losses.

This study investigates the willingness of rural households in Malawi to allocate funds for input purchase at harvest time and whether this willingness is as high or higher at harvest time than at planting time. Rural households do not face food shortages at harvest time and may then be more willing and able to spend funds on inputs. On the other hand, net buyers of food may still prefer to buy additional food at harvest time when food prices are at their lowest. More than 60% of rural households in Malawi are net buyers of food also after the input subsidy program has been implemented (Holden and Lunduka 2010a). It is therefore not obvious that the willingness to buy inputs at harvest time is high or higher than at planting time. While our study investigates some of the same issues as Duflo et al.(2011) studied in Kenya, our study is substantially different wrt the policy context as well as the types of experiments used and therefore provides novel complementary insights. We also apply a different theoretical model although the basic idea of presence bias is the same. One important value added of our study is an assessment of the effect of seasonal maize price variation that can bias the analysis of seasonal input demand if ignored. We show that in the case of Malawi maize prices are almost double at planting time as compared to harvest time. Furthermore, our study is in a country with very high fertilizer subsidies and where a large share of farmers use fertilizers but are net buyers of maize, while the study of Duflo et al. (2011) was in a country without fertilizer subsidies and where a small share of the farmers used fertilizers.

There may be reasons to worry that the large scale input subsidy program in Malawi has undermined household incentives to spend funds on inputs. On the other hand, access to subsidized inputs is constrained and the subsidized prices may therefore not reflect the true shadow prices of inputs for the households. Another novel contribution of this paper was to use an experimental approach to elicit shadow prices for fertilizers in a context where actual prices paid were endogenous and dependent on unobservable household characteristics.

Cash constraints may limit the ability of households to purchase inputs. Our first two experiments were designed to control for this as they did not require any out of the pocket expenses and were used to obtain estimates of marginal expenditure shares and unconstrained shadow prices for fertilizer inputs. A third experiment was conducted to assess the gap between the share of households that were Willing to sell versus Willing to buy a standard input package at alternating prices varying from full subsidy (90%) to no subsidy.

The results showed that households were willing to allocate a significantly larger share of the given budget to fertilizer purchase at planting time than at harvest time. Previous access to input subsidies was not negatively associated with fertilizer demand but was negatively associated with food demand. A large share of the households had very high shadow prices for small amounts of fertilizer when relieved from their cash constraint. However, only 20-25% of the households were willing to buy the input package at the commercial price while only 10-20% of households who were lucky to win the input package were willing to resell the package at the commercial price if it first were given to them. The gap may be explained as a cash constraint rather than as an “endowment effect” as the share of households that were willing to buy the package reduced rapidly as the price increased while the share willing to sell increased much more slowly with increasing price (Plott and Zeiler 2005; 2007; Horowitz and McConnel 2002).

The setting

Malawi is a small landlocked country in Southern Africa where more than 80% of the households depend on agriculture for their livelihood. Weather risk and inappropriate policies have contributed to severe household and national food insecurity. The last severe food shortages occurred in 2004/05 with the consequence that the newly elected president, Bingu wa Mutharika, embarked upon a comprehensive input subsidy program quite contradictory to the recommendations from IMF and the World Bank. Arguments for the subsidy program were that it is cheaper to import fertilizer than to import food. Food production in the country increased dramatically and Malawi became a net exporter of food (maize) in the following years and the program has been coined a success story (Denning et al. 2009).

The rural population in Malawi constitutes 88% of the total population and the country has one of the highest rural population densities in Africa of about 2.3 persons per ha. The average farm size is about 1.12ha. Farm sizes are smaller in the southern region of the country where population density is higher (SOAS 2008). The incidence of poverty is also higher in the southern region where 64% of the households are estimated to fall below the poverty line against 52% at the national level. Maize is the main staple crop grown by 97% of the rural households (SOAS 2008). Some households also grow cash crops such as tobacco, sugarcane and cotton but such crops are on average grown on less than 10% of the farm area while maize covers 65-70% of the farm area (Holden and Lunduka 2010a).

More than 60% of the rural households in the central and southern regions of the country are net buyers of maize even with the input subsidy program (Holden and Lunduka 2010b). Access to input subsidies has, however, reduced the food deficit of net buyers of food and more households have become self-sufficient or even net sellers (ibid.). Most of the agricultural production is rain-fed and the rainfall is uni-modal with a rainy season from December to April. This implies that the planting season is in December and harvesting season is in May-June for the main staple crop, maize.

The Government of Malawi has increased its budget share for agriculture from 6.1% in the period 2000-2005 to 15.9% in 2006-2009 and is aiming to increase it further to 24% by 2015 with the implementation of the Agricultural Sector Wide Approach (ASWAp) (GoM 2010).

The Ministry of Agriculture and Food Security (MoAFS) in Malawi has developed targeting criteria for the distribution of input subsidies that emphasize targeting land-owning rural resident households and particularly poor and vulnerable households (MoAFS, 2008). The MoAFS is issuing and distributing free coupons through their local staff in collaboration with local leaders to identified beneficiary households. Households receiving the coupons can take the coupon to the nearest depot where inputs are sold and pay a small amount (MK1500 per 50 kg bag in the 2009/10 season) to get the inputs. The depots can be quite far from the home of the households and they risk having to wait for long time in line before they get the inputs. This implies that rural households in Malawi face higher transaction costs in the market than typical households surveyed by Duflo et al.(2011) in Kenya. There was no easily available market that sold small amounts of fertilizers. In the 2008/09 season about 2 million input packages were distributed to the about 2.5 million rural households in the country, indicating coverage of close to 80% of the households. A recent study (Holden and Lunduka 2012) has identified substantial leakages of coupons, secondary (illegal) markets for coupons and cheap fertilizers, and substantial targeting errors. They found that very few households had resold their fertilizers or fertilizer coupons. Access to inputs and the actual prices paid therefore depend on household characteristics, including households' social capital in terms of social networks, access to information and ability to negotiate. Wealthier households have been found to be more successful while female-headed households have been less successful in obtaining subsidized inputs (Dorward et al. 2008; Holden and Lunduka 2012).

1 1 US$=140 Malawi Kwacha(MK).

The costs of fertilizer subsidies to the Malawian government have increased with the increase in international fertilizer prices. In 2006/07 the fertilizers represented 40% of the agricultural budget (Dorward et al. 2008). With the very high fertilizer prices in 2008/09 the spending on fertilizer imports and the fertilizer subsidy program exceeded the initial budget by more than 100% (Logistic Unit 2009). Table 1 gives an overview of the costs of the input subsidy program versus some benchmarks. After the 2008/09 the country has experienced shortages of foreign exchange which also have led to fuel shortages. Tobacco is the main export crop but tobacco export is also limited by international agreements. Maize exports have to some extent compensated for the fertilizer import cost.

The donor community sees the input subsidy program as a temporary solution to the food insecurity problems of the country and provides conditional support to the program as general budget support or through funding of particular elements of the program such as the seed component.

Malawi's late president argued that the subsidies have come to stay and became the chairman of the African Union and other African countries have been looking to Malawi and considered implementing similar policies. Ghana, Tanzania and Zambia are among the countries that have scaled up similar input subsidy programs. International fertilizer prices are again on the increase, however, and there is a need to keep the budgetary costs down. Shortages of foreign exchange have started to bite the Malawian economy after the 2008/09 season through frequent fuel shortages that slow down the economy. The main argument for the program is that rural households cannot afford to buy the inputs if they are not subsidized and their removal will lead to new food shortages. Provision of credit has been an alternative approach that also has given mixed results due to high default rates. Up to the early 1990s, fertilizer use and maize production was stimulated through provision of credit for this drought-sensitive crop in Malawi. Droughts in

1992 and 1994 combined with political promises to write off loan debt during the election year (1994), led to widespread loan defaults and eventually to the collapse of the Smallholder Agricultural Credit Administration (SACA) parastatal in 1994 (Zeller et al. 1997). The input subsidy program came as a substitute for the credit program that collapsed. It is in this perspective that this study explores the alternative proposal to sell inputs at harvest time to reduce the need for subsidies and provide a commitment devise that can reduce the need for credit as well. However, it is an open question whether net buyers of maize should buy fertilizer or maize at harvest time when maize prices are at their lowest.

Theoretical framework

Duflo et al. (2011) found that small investments in fertilizers generated annualized rates of return between 52 and 85 in their study in Kenya. They were puzzled that farmers invested so little in fertilizers when profits were so large and the technology is well known and divisible. One possible explanation could be fixed costs related to buying and learning about the technology but they found that these could not be large enough to provide an explanation. They therefore looked for a behavioral explanation in form of present-bias such as has been observed also in relation to investments in pension plans in the United States (Choi et al. 2008) and drew on models of procrastination in psychology and economics. Strong presence bias has been observed among poor rural households in developing countries and is related to liquidity constraints and poverty (Holden et al. 1998). Empirical evidence shows that the discounted utility model (Samuelson 1937) represents a poor fit to the reality of inter-temporal choices (Frederick et al. 2002).

Laibson (1997) and O'Donoghue and Rabin (1999) have formulated an alternative (β, δ) preference model

1) $U_t = u_t + \beta\delta u_{t+1} + \beta\delta^2 u_{t+2} + \beta\delta^3 u_{t+3} + ...$

where the difference from the standard discounted utility model is the parameter $\beta \leq 1$ which captures self-control problems. The model has also been expanded by O'Donoghue and Rabin (2001) to handle naïve expectations (overconfidence) related to future self-control. We argue that the same parameter may reflect a current period liquidity constraint and apparent irrational presence bias may rather reflect a rational response to short-term constraints and needs in a stochastic environment (Holden et al. 1998).

With this perspective we take this alternative (β, δ) preference model as a basis for analyzing behavior of poor rural producer-consumer households who make consumption and investment decisions facing cash constraints and imperfections in factor markets. Liquidity constrants could cause the timing of offering of investment opportunities to rural households to matter for how much they are willing to invest, or it could be due to self-control problems like suggested by Duflo et al.(2011). This could cause households to be willing to invest more if offered to buy inputs at harvest time rather than waiting and offering them to buy the inputs at planting time when the inputs are to be used but when also more of the cash resources have been spent on other items. Purchase of inputs at harvest time may thus be a self-control device leading to higher investments.

The model covers three points in time, first harvest time (t=1), planting time (t=2), and second harvest time (t=3). Households are offered to allocate a fixed budget, Y, for food consumption, C, input investments, F, or other goods expenditure, X, such that $Y=p_cC+p_fF+p_xX$. This offer is made either at harvest time (t=1) or at planting time (t=2) and the budget offered at the two points in time is the same, $Y^1=Y^2$. For a household i that receives the offer at harvest time (t=1), it will allocate the budget as $Y^1=p_cC^1+p_fF^1+p_xX^1$ such that it maximizes expected utility. An important assumption in our model is that producer-consumer households do not have an immediate need to buy food at harvest time. If they prefer to spend extra funds on food at this point in time it is done in order to save the food and consume it later, e.g. at planting time. With (β,δ) preferences, the expected utility of the food expenditure at first harvest time (t=1) may be formulated as: $U^1(C^1)=\beta\delta u_2(C^1)$. On the other hand, if the offer is made at planting time, food expenditure may be for immediate consumption and the utility may be formulated as: $U^2(C^2)=u_2(C^2)$. The expected utility of the allocation of the budget for inputs when the offer is made at harvest time (t=1) and when inputs only can be used in the following planting time and yield benefits after the next harvest time (t=3), can be formulated as: $U^1(F^1)=\beta\delta^2 u_3\left\{\left(1+r^F\right)F^1\right\}$ where r^F is the expected return to input investment. When the budget offer is made at planting time the expected utility may be formulated as: $U^2(F^2)=\beta\delta u_3\left\{\left(1+r^F\right)F^2\right\}$. Optimal budget allocations (interior solutions while allowing prices to vary over time) at the two points in time imply:

2) $\frac{\partial U^1(p_c^1C^1)}{\partial Y^1}=\frac{\partial U^1(p_f^1F^1)}{\partial Y^1}$ and $\frac{\partial U^2(p_c^2C^2)}{\partial Y^2}=\frac{\partial U^2(p_f^2F^2)}{\partial Y^2}$

Substituting in the expected utilities with (β,δ) preferences yields

$$\frac{\beta\delta\partial u_2(p_c^1C^1)}{\partial Y^1}=\frac{\beta\delta^2\partial u_3\left\{\left(1+r^F\right)p_f^1F^1\right\}}{\partial Y^1}$$ which reduces to

3) $$\frac{\partial u_2(p_c^1C^1)}{\partial Y^1}=\frac{\delta\partial u_3\left\{\left(1+r^F\right)p_f^1F^1\right\}}{\partial Y^1}$$

for harvest time budget allocation decisions and to

4) $$\frac{\partial u_2(p_c^2C^2)}{\partial Y^2}=\frac{\beta\delta\partial u_3\left\{\left(1+r^F\right)p_f^2F^2\right\}}{\partial Y^2}$$

for planting time budget allocation decisions. Note that the β coefficient cancelled out for the harvest time allocation as it is assumed that food purchase at this point in time is not for immediate consumption.

It follows that, *ceteris paribus* (assuming no change in consumption of other goods or prices), $C^1 < C^2$ and $F^1 > F^2$ if $\beta < 1$. Offering of inputs at harvest time may then be a commitment devise that enhances input expenditure and use.

But what if food prices vary systematically across seasons and typically are much lower at harvest time than at planting time such that $p_c^1 < p_c^2$ while fertilizer prices are assumed not to change? We then get

5) $$\frac{\partial u_2(p^1C^1)}{\partial Y^1} = \frac{\delta\partial u_3\left\{\left(1+r^F\right)p_f^1F^1\right\}}{\partial Y^1}$$

6) $$\frac{\partial u_2(p^2C^2)}{\partial Y^2} = \frac{\beta\delta\partial u_3\left\{\left(1+r^F\right)p_f^2F^2\right\}}{\partial Y^2}$$

It then follows that $C^1 < C^2$ and $F^1 > F^2$ only if $\beta < \frac{p_c^1}{p_c^2}$ and $p_f^1 = p_f^2$ and households with rational price expectations and who are net buyers of food will allocate more of a given budget for inputs relative to food at planting time than at harvest time when $\frac{p_c^1}{p_c^2} < \beta \leq 1$. Likewise, net sellers would prefer to store the food crop (maize) and sell it at planting time in order to buy fertilizer at that point in time. We must add that storage losses could be an additional explanation for the maize price gap between harvest time and planting time and that could pull in direction of selling maize earlier or buying later.

But what if a household expects to access cheap fertilizers through the subsidy program at planting time? This would imply that the expected fertilizer price at planting time is lower than the fertilizer price offered at harvest time, $\mathrm{E}\left(p_f^2\right) < p_f^1$. Such an expectation should reduce the demand for fertilizer at harvest time and may explain a higher demand at planting time. Transaction costs in commodity markets cause selling prices to be lower than buying prices and this is likely to be the case both for food and inputs. However, transaction costs are typically relatively larger in input markets than in food markets (Binswanger and Rosenzweig 1986). Rural households are therefore likely to be hesitant to sell inputs and food that they have bought and they are not likely to do so unless they have been exposed to some form of shock because

$$7)\ \frac{\partial u_2(p^1C^1)}{\partial Y^1} = \frac{\delta \partial u_3\left\{\left(1+r^F\right)p_{fb}F^1\right\}}{\partial Y^1} > \frac{\partial u_2(p_{fs}F^1)}{\partial Y^1}$$

where $p_{fs} < p_{fb}$ and represent the selling and buying prices of inputs. Such a gap between selling and buying prices is sufficient for input expenditures to be "sticky". This could also facilitate higher input investments if inputs are offered at harvesting time when food prices are lower than if inputs only are offered at planting time when also the available cash budget may have become lower, $Y^2 < Y^1$. A severe shock may, however, destabilize the inter-temporal balance and cause households to resell the inputs at a lower price. The risk that they would do so depends on how the shock would affect a number of the parameters that become household-specific in the reformulated model. This implies that the discount factor, δ_i, the expected return to inputs, r_i^F, and the present bias parameter, β_i, are household specific and may be affected by shocks. Shocks may cause the discount rate and the present bias parameter to increase and the expected return to inputs to decrease. A possible consequence of a shock could then be distress sales of assets or inputs that were bought at harvest time and before the shock occurred and this may further affect expected returns.

The discount rate, the present bias parameter and the expected return functions cannot be directly observed but experiments are constructed to assess the existence of presence bias and whether this can be utilized to design a commitment device something which also depends on the transaction costs in the input market. It is commonly assumed that poor people have high discount rates and have a tendency towards stronger presence bias and are more vulnerability to shocks and empirical evidence is also in line with this (Holden et al. 1998). Wealth accumulation substitutes for missing markets and alleviates constraint sets (Yesuf and Bluffstone 2009). This implies that risk aversion that is related to wealth also can affect input decisions as poorer households tend to be more risk averse and less able and willing to go for risky investments. Loss aversion may also cause households to be willing to take less risk when they face a downside risk versus a situation where they do not face such downside risk (Binswanger 1980; Wik et al. 2004; Yesuf and Bluffstone 2009). Risk and risk aversion may therefore also affect input demand and the responses in our experiments but this was not directly tested in our experiments. Risk aversion, including loss aversion, could lead to a positive correlation between wealth variables and investment in inputs for net sellers of food (Finkelshtain and Chalfant 1991). Theoretically, higher risk aversion and higher risk could, however, also lead to higher input demand by net buyers of food (ibid.) and may imply a negative relationship between marketed surplus and input demand. We are able to assess this latter effect.

Experimental methods and data

The survey covered a random sample of 450 households in two districts in Central Malawi (Kasungu and Lilongwe) and four districts in Southern Malawi (Chiradzulu, Machinga, Thyolo, and Zomba) (Lunduka, 2010). About 89% of the Malawian population lives in Central and

Southern Malawi. Our survey should therefore be fairly representative of a large share of the population. The data were collected in three rounds, in 2006, 2007 and 2009. Only 378 of the initial 450 households were found and interviewed in the third round. The experiments were added to the survey instrument in the 2009 survey round. The three experiments are outlined below

Experiment 1: Budget allocation "experiment". The budget allocation "experiment" was hypothetical. The households were asked to allocate a cash amount of MK 10 000[2] that they were free to decide on how to use among a) buying fertilizer, b) buying food, c) buying other important/urgent commodities, d) investing or saving for later use. The households were exposed to this experiment either at harvest time (June) or at planting time (December) for a part of the sample. The choice of locations for the planting time experiments was not random but determined by poor quality data in the first round survey in some locations causing a need for a resurvey in part of the locations. It is possible that the resurveyed villages are statistically different from the other villages. To test for this they were compared for key variables. The comparison tests are included in Table A1 in the appendix. There were statistical differences for some of the endowment variables. These have been included in the regressions to control for these differences. We therefore do not think that this has affected the key results in this study.

Experiment 2: 5 kg fertilizer experiment. A real experiment was conducted where the households had the choice between 5 kg ($1/10^{th}$ of a bag) basal fertilizer and a varying amount of money determined by the throw of a die. The amount of money varied between MK 200 and 1500. These amounts range from 50 to 375 percent of the commercial price of fertilizer at the time of the experiments. Households had equal opportunity to choose between fertilizer and cash and

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2 The daily wage in unskilled rural employment was about MK 300 at the time of the survey. An input package of 2 bags of fertilizer and seeds costed about MK 9 000.

therefore did not have to take cash out of their pocket in order to get the fertilizer allowing us to assess unconstrained farm gate shadow prices for fertilizer.

Experiment 3: WTA/WTP Input package experiment. This experiment was also hypothetical and involved randomly allocating the households with an input package for maize production consisting of one bag of basal fertilizer, one bag of urea, and one bag of hybrid maize seeds, or if they were not lucky to “win” the package, they were offered the opportunity to buy the same package. The allocation of the package for free was determined by the toss of a coin. The lucky winners were then offered the possibility of reselling the package at an amount determined by throwing a die. Similarly, those that were not lucky were offered to buy the package at an amount determined by throwing the die. The price range for the package was from MK1000 (full subsidy) to MK9000 (no subsidy) based on the price and subsidy rates decided by the Malawian government for the 2009/10 growing season. The experiment should establish whether there is a gap between WTP and WTA prices when households’ cash constraints are affecting the WTP. However, the cash constraint effect may be confounded with an “endowment effect” such that we have to be careful with the interpretation here (Plott and Zeiler, 2005; 2007; Horowitz and McConnell, 2002). However, we do not expect the endowment effect to vary with the randomly determined package price. A significant cash constraint should imply that the share of household that are willing to buy the package is falling much more rapidly with increasing price than the share of households that are willing to sell it as the price increases. The experiment investigates the incentives to buy or resell an input package when prices are known and exogenously given.

Analysis of experimental data. To assess the factors affecting budget allocation priorities in the budget allocation “experiment”(Experiment 1), Tobit models were used because there were many zero responses for each commodity (demands for fertilizer and food). The fertilizer and food demands were regressed on an aggregate variable capturing fertilizer subsidy access in the previous four years (counting the number of years with access), maize price in the nearest market at the time of the survey experiment, a dummy for planting time observations, distance to nearest large market, marketed surplus of maize in the previous season (2008/09), household wealth variables, farm size and other household characteristics, and district dummies. As sensitivity analysis a varying number of control variables were included related to access to fertilizer in the informal market, maize price and marketed surplus of maize in the previous year.

To further investigate factors that are correlated with households' choices between cash and fertilizer the data from the 5 kg fertilizer experiment (Experiment 2) were regressed on the random cash price, the location and time-specific maize prices, the timing dummy for the experiment, distance to market, access to subsidies and informal input markets, household characteristics, including land and livestock endowments, and geographical location (district). We also included the interaction between timing of the experiment and the random cash price in one specification (Logit 3) and predicted its outcome across observations in the non-linear logit model (Figure 2).. Furthermore, wee also tested two shock variables, capturing households' exposure to shocks and a credit market participation variable but these were not significant. Credit was not available for purchase of farm inputs, possibly explaining its insignificant effect. Because several of the variables are potentially endogenous and correlated with unobserved heterogeneity, while we do not have access to good instruments for their prediction, we resorted to running a range of models by step-wise adding more of the suspect variables to assess their effects on the sign and significance of the key variables. Random effects logit models were used for this. Similar econometric analysis was also made for the Willingness to sell(WTA) and Willingness to buy(WTP) experiments for the input package (Experiment 3). The basic findings from the experiments are presented in the next section.

Experimental results and discussion

Experiment 1. In the hypothetical budget allocation experiment households were asked how they would allocate a cash amount of MK 10 000 that they were free to decide on how to use among; a) buying fertilizer; b) buying food; c) buying other important/urgent commodities; and d) saving and investing in business. Summary statistics by type of expenditure and time of the experiment are summarized in Table 2. It can be seen that the allocation for fertilizer was significantly higher at planting time than at harvest time while the opposite was the case for food. Econometric analyses (Tobit models with district dummies) of the factors associated with household budget allocation for fertilizers and food are presented in Table 3. The numbers in the table are the average partial effects.

We see from Table 3 that the willingness to allocate money for fertilizer out of a given budget in December (planting time) was significantly higher than at harvest time in June-July. The difference was as large as about 30% of the total budget. The willingness to allocate money for food was not significantly affected by the timing of the experiment but allocation of budget for food was significantly (at 0.1% level) lower for households with better access to fertilizer subsidies in the previous four years.

Significant wealth effects are also observed. Households with better quality houses and higher asset values allocated significantly more cash for fertilizer. This is in line with the general theory that poverty can reduce the willingness and ability to invest and result in higher discount rates as immediate needs are given higher priority. There was a weak indication that households with smaller farm sizes were willing to allocate a larger share of the budget for fertilizers as farm size was negative and significant at 10% level in two of the models. Land shortage may increase the need to intensify farm production by use of more fertilizer.

We may ask whether the lower willingness to spend the given budget on fertilizer at harvest time than at planting time could be due to the lower food prices at harvest time. We have tested for this directly in Table 3 by including the maize price in the nearest location where monthly prices are collected for each of our study sites for the months we carried out the survey and experiments. Price change expectations may be based on observed price changes in the past. An indication of the importance of these follows from Table 4 which shows the average prices at harvest time and planting time the previous two years. It can be seen that maize prices were much higher (near double) at planting time as compared to at harvest time. As shown in our theoretical model, this should give a good reason for net buyers of food to buy the additional maize requirement at harvest time rather than later and this effect may dominate the eventual effect of present bias causing low fertilizer demand at planting time. However, the maize price variable was not significant in Table 3 while the planting time dummy remained significant after its inclusion. The other variables that were included to capture fertilizer access were neither significant. It seems that fertilizer demand has remained high for households that have accessed subsidies. This may be due to the rationing of subsidized fertilizer among those accessing it.

Experiment 2. The results from the 5 kg fertilizer experiment for the choice between 5 kg fertilizer and randomized amounts of cash varying between MK 200 and 1500 are summarized in Figure 1 and Table 5. Logit models were used for the analysis and the figures in the table are average partialal effects. We see from Figure 1 that the preference for fertilizer was reduced from above 90 percent for the two lowest amounts of money to about 40 percent for the two highest amounts of money where we recall that the highest price is 375% of the commercial price of fertilizer at the time of the experiment. This illustrates that there is a substantial demand for small amounts of fertilizer offered at the farm gate among many households where they are willing to forsake cash that they have available. The input subsidy program appears not to have undermined the valuation of fertilizer. The high prices also indicate that few households are willing to resell inputs unless the price offered is raised high above the commercial price for fertilizer. The results may also indicate that input demand could be stimulated by offering fertilizers in smaller bags than the standard 50 kg bags. Repacking and selling in small bags could potentially be a lucrative business.

The logit models (Table 5) assessing the factors correlated with the choices in the 5 kg fertilizer experiment confirmed the significance of the planting time dummy variable which remained positive and significant even after having controlled for the maize price and a set of variables capturing market access and access to subsidies. The maize price variable was also significant and with a negative sign, implying that a higher maize price was associated with a lower demand for fertilizer. While this sounds counter-intuitive for a net producer, it may be a rational response by a net buyer of maize whose maize demand is inelastic.

The third model in Table 5 includes an interaction variable for the cash amount offered and the planting time dummy. We see that this variable was insignificant on average in the table. However, this does not necessarily imply that the interaction effect is unimportant (Ai and Norton 2003). We used a command provided by Norton et al. (2004) to graph the interaction effect with Stata. The graph is presented in Figure 2. The graph shows that there was a significant positive interaction effect for a substantial proportion of the observations, which means that many households were significantly more likely to choose the fertilizer at planting time after having controlled for covariates.

Furthermore, Table 5 reveals that households with more male labor force, higher asset endowment and more livestock were more likely to prefer fertilizer to cash, showing that more wealthy households are more able and willing to invest in fertilizer. On the other hand, households with larger farm size were significantly less likely to prefer fertilizer rather than cash, *ceteris paribus*. This indicates that poverty in labor and assets reduces the shadow price of fertilizer while land scarcity increases the shadow price of fertilizer. Offering the experiment at planting time rather than at harvest time also increased the probability that households preferred fertilizer rather than cash. This is consistent with the finding in Experiment 1. Decisions in these two experiments do not require any extra cash out of the pocket of households. We state this as a "control for varying cash availability in the household". A liquidity constraint may be more severe at planting time than at harvest time, and may have given different results if imposed in the experiments. Our third experiment provides some additional insights about this issue.

Experiment 3 involved randomly allocating the households with an input package for maize production consisting of one bag of basal fertilizer, one bag of urea (top dressing), and one bag of hybrid maize seeds, or if they were not lucky to "win" the package, they were offered the opportunity to buy the same package. The allocation of the package for free was determined by the toss of a coin. The lucky winners were then offered the possibility of selling the package at an amount determined by throwing a die. The fitted values of the responses, with a 95% confidence interval, are presented as the upper line in Figure 3. The unlucky ones were offered to buy the package at an amount also determined by throwing a die. The fitted responses to this offer with a 95% confidence interval are presented in Figure 3 (the lower line). The y-axis indicates the probability that respondents prefer the package to the cash amount offered. The cash amounts varied according to the scale on the x-axis, from MK1000 (full subsidy) to MK 9000 (no subsidy).

Figure 3 demonstrates that very few were willing to sell the package even at the highest amount of money offered which was equivalent to the commercial price of the inputs. This also indicates that households value the input package highly. Figure 3, however, also demonstrates that many households face problems buying such an input package due to their cash constraints and only slightly above 20 percent were willing to buy the package at the full commercial price and only about 50 percent were willing to buy it at a 50 percent level of subsidy (half price). Although the difference between the WTA and WTP responses could partly be due to the "endowment effect", the responses in the real experiment with fertilizer should not create such an endowment effect as households were offered the choice between cash or fertilizer without being given any of these first. Their response probabilities were close to those in the WTA experiment for those who had been endowed with the input package for prices close to the commercial price of fertilizer. This should indicate that the gap between the lines in Figure 3 primarily is due to a cash constraint effect. The confidence intervals in the graph demonstrate the significance of the difference between the WTA and WTP shares.

Figure 4 combines the real experiment with small amounts (5 kg) of fertilizer with the hypothetical experiments where households were randomly winning a full 100 kg fertilizer package that they were offered to sell at randomly offered prices or if they did not win they were offered to buy the package at randomly varying prices. The x-axis shows the price in MK/kg fertilizer to allow comparison of the different experiments in the same scale (the value of seeds has not been included and is relatively small). The y-axis shows the share of households that preferred the fertilizer package at the different prices offered. It can be seen that we used a much wider price range for the real experiment with small amounts of fertilizer while the price range was from full subsidy (>90%) to no subsidy (at 2009 June-December prices). The graph provides the means and 95% confidence intervals for the experiments. The graph illustrates the strong effect of imposing people's liquidity constraint when offered to buy the full package. It is possible that this effect would have been smaller if we offered them to buy small amounts but we did not test that and leave that for future research.

Factors associated with the Willingness to sell (WTA) and Willingness to buy (WTP) the input package were investigated with logit models presented in Table 6. We see that the probability of selling was not significantly associated with the random price offered when this price ranged from 90% subsidy to no subsidy (commercial price). The maize price and the planting time dummy were also insignificant. Perhaps surprisingly, households that had been offered to buy coupons for fertilizer in the informal market were significantly (at 1% level) more willing to sell the package. They probably considered that they had another opportunity to obtain cheap fertilizers. On the other hand, households that had actually bought fertilizer in this informal market were significantly less willing (at 0.1% level) to sell their input package. Such households apparently still had a high shadow price for fertilizer. Households that had experienced good access to subsidized fertilizer in the past were also less likely to (significant at 5% level) be willing to sell the input package. Male-headed households were significantly (at 5% level) less likely to be willing sell the package while marketed surplus of maize was positively correlated (significant at 10% only) with willingness to sell the package. Two of the districts in Southern Malawi, Zomba and Chiradzulu, were associated with a higher willingness to sell the package.

The second model in Table 6 shows factors associated with Willingness to buy the package and we see that the price offered for the package was highly significant and negative, unlike for the previous model. This is in line with our cash constraint hypothesis that a cash constraint may be more severe as the price of the package increases and thus limit the ability of households to purchase inputs even though their unconstrained demand and profitability of input use are high. This may also imply that offering inputs at harvest time, as suggested by Duflo et al. (2011) and in small quantities, could stimulate input demand and reduce the need to provide subsidized inputs at planting time. Those who had been offered cheap fertilizers last season had a higher probability of being willing to buy the input package at given prices (significant at 10% level). It is possible that those exposed to such offers have been searching for them and therefore are less cash constrained. Overall, however, these results seem to indicate the existence of a poverty trap in a second best world where interventions such as input subsidies create positive welfare effects that partly may be "paid for" by the efficiency gains from increased input use. The budgetary costs are high, however, giving good reasons to further experiment to reduce these costs and enhance the efficiency of subsidies and alternative policy interventions.

Our theoretical model emphasized seasonality and tradeoffs between short-term and medium term needs where seasonal price changes for outputs and access to subsidized inputs affect input demand. The alternative (β, δ) preference model may capture irrational procrastination as well as rational responses to liquidity constraints where we favor the latter interpretation as more important in our context. Our findings point in direction of limited ability to buy a lumpy input package and more so the more expensive the package is. The input subsidy program may also have contributed to the lumpiness of fertilizer inputs (distributed in 50 kg bags) only through officially accepted depots that impose additional transaction costs on households unlike in the study of Duflo et al.(2011) in Kenya where inputs were available in divisible amounts in nearby markets.

While the study by Duflo et al.(2011) assessed a situation where a small share of households used fertilizer even though it was found to be profitable, we assessed a situation where the large majority of rural households used fertilizers partly due to access to input subsidies. Our study complements the study of Duflo et al.(2011) and the broader literature on input demand and food production in low-income risky environments in three important ways. First, we investigated the demand for fertilizer and food at harvest time and planting time while taking into account the local variation in maize prices and access to input subsidies. Second we investigated the unconstrained shadow prices for small amounts of fertilizer at harvest time and at planting time and how it was affected by covariates. Third, we investigated the gap between Willingness to sell and Willingness to buy a standard input package used in the subsidy program and showed that this gap was increasing sharply with increasing price, demonstrating the effect of what we believe is a severe liquidity constraint. Our findings do not contradict those of Duflo et al.(2011) but rather provide complementary evidence of high importance for the design of better agricultural policies to enhance food security in low-income environments facing severe climate risks, food insecurity and budget restrictions.

Conclusion

Overall this study revealed that rural Malawian households value fertilizers highly even though they have been exposed to very high fertilizer subsidies over several years. More than 50 percent of the households preferred small amounts of fertilizer to a cash amount that was 50 percent higher than the current commercial price for fertilizer during our experiments carried out in 2009 (Figure 4). Access constraints for commercial as well as subsidized fertilizer may explain these remarkably high shadow prices together with the nature of these experiments which were designed to avoid a direct effect of households' cash constraint, demands that therefore reflect cash-unconstrained utility-maximization.

The study tested out Duflo et al.'s (2011) proposal to stimulate input demand by supplying inputs at harvest time rather than at planting time. A hypothetical budget allocation experiment revealed that households were willing to allocate about 40 percent of a cash budget of MK10000 for fertilizer at harvest time while this budget share increased to about 60 percent at planting time. A real choice experiment between cash and fertilizer revealed a significantly higher share of households preferring fertilizer to cash at given prices at planting time than at harvest time. This difference could not be explained by the maize price difference at harvest time vs. at planting time or access to input subsidies but may reflect a certain reluctance to buy inputs earlier than necessary. However, the facts that households were willing to allocate a substantial budget share to input purchase at harvest time and were not likely to resell these inputs later, point in direction of a potential positive effect of this approach on input demand especially when the input subsidy program has to be scaled down as was the case from the 2011/12 season.

On the other hand, when households were offered a full input package consisting of two bags of fertilizer and a bag of hybrid seeds, the share of households preferring the input package rather than the cash amount declined to 22 percent when the WTP price increased to MK9000, equivalent to the commercial price of the package. This demonstrates the significance of the cash constraint that households face irrespective of season. When households who have been offered the same package for free were asked about their WTA selling price, more than 80 percent of the households preferred to keep the package even when they were offered a WTA price of MK9000, equivalent to the commercial price. This fits well with the finding of Holden and Lunduka (2012) who found that a very small share of the households that were given subsidized fertilizers resold these inputs in the informal market. This implies that such input expenditures are "sticky" and sale of inputs at harvest time may serve as a commitment device (DellaVigna, 2009).

Due to high international fertilizer and oil prices which recently have contributed to fuel and foreign exchange shortages, Malawi faces problems sustaining the input subsidy program even though it has contributed substantially to improve national and household food security. An advantage of distributing inputs at harvest time is also that the same trucks that collect the maize can at the same time bring out the inputs and thus save on the transportation costs. One would also reduce the credit default problems that are linked to supplying inputs on credit at planting time in a risky environment.

Finally, we do not think we need to resort to irrationality explanations to explain the limited demand for fertilizer in developing countries in areas such as in Malawi where people are well aware of the positive fertilizer response and food security depends on fertilizer access. Limited ability to buy inputs may represent a rational response to hard constraints. Poor people have less freedom to act in irrational ways than wealthy people.

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Table 1. Costs of the Farm Input Subsidy Program

	Year	Costs (million US$)
Cost of importing food in drought year	2004/05	110
Cost of fertilizer subsidy program	2005/06	50
Cost of fertilizer subsidy program	2006/07	91
Cost of fertilizer subsidy program	2008/09	360
Total donor assistance to Malawi	2007	500

Sources: Harrigan 2005; Dorward et al. 2008; Denning et al. 2009; Logistic Unit 2009.

Table 2. Allocation of a budget of MK10000 by type of expenditure and time of experiment

Time of experiment		Fertilizer	Food	Other needs	Save-Invest
Harvest time	Mean	4295	2453	1660	1592
	Standard error	175	128	113	133
	Sample size	280	280	280	280
Planting time	Mean	6563	1510	1296	630
	Standard error	368	246	233	161
	Sample size	79	79	79	79

Table 3. Determinants of preferences for cash allocation for fertilizer versus for food purchase

Right hand side variables	Fert 1	Fert 2	Fert 3	Food 1	Food 2
Maize price, MK/kg		29.885	16.489	-143.803	-137.480
Planting time dummy	3229.539*	3074.601*	2999.794*	219.473	378.696
Offered to buy coupons in 2008/09			-409.342		516.401
Bought coupons in 2008/09			735.733		-1011.517
Offered cheap fertilizer in 2008/09			236.870		-365.405
Aggregate access to subsidies	112.779	115.378	97.937	-601.479****	-589.845****
Marketed surplus of maize 2008/09		79.266	44.022		-133.772
Distance to larger market, km	-18.672	-23.243	-21.768	36.986	37.364
Sex of household head, 1=Male	-763.292*	-783.862*	-887.010*	578.830	664.800
Age of household head	-2.331	-2.140	-3.314	18.614	18.385
Education of household head	6.240	4.685	7.280	61.369	60.551
Male labor force	-74.400	-73.739	-11.985	134.174	128.044
Female labor force	-257.843	-253.961	-213.455	287.458	284.531
Consumer-worker ratio	-1049.267	-1045.008	-711.748	190.136	-67.537
Quality of house	181.436**	181.343**	171.062**	-121.846*	-103.730
Value of assets, 1000MK	21.244*	20.765*	21.638*	-18.537	-18.925
Tropical livestock units	161.929	158.524	189.022	-157.825	-276.222
Farm size, ha	-354.444*	-356.926*	-338.287	50.872	132.137
Zomba	193.911	240.421	297.165	-262.648	-384.252
Chiradzulu	175.169	170.633	210.493	163.434	86.345
Machinga	1010.698	1297.109	1326.166	-2408.489	-2873.991
Kasungu	800.341	1305.561	1222.019	-4402.140	-4630.251
Lilongwe	2996.630	3301.285	3334.852	-2988.443	-3239.094
Prob > chi2	0.000	0.000	0.000	0.000	0.001
Number of obs.	340	340	322	340	322
Number of left censored obs.	40	40	37	107	104

Note: Standard errors in parentheses. Significance levels: *:10%, **:5%, ***:1%, ****:0.1%. The dependent variables are the cash expenditure on fertilizer (3 first models) or on food (2 last models). Model results are from Tobit models with district fixed effects. The table presents average partial effects.

Table 4. Average monthly maize prices at harvest time and planting time by year

Month	2007	2008
June (Harvest time)	14.55	37.91
December (Planting time)	30.01	63.35

Source: MoAFS (2009)

Table 5. Real experiment for choice between 5 kg basal fertilizer and a random amount of cash

Right hand side variables	Logit 1	Logit 2	Logit 3
Cash amount offered, in 1000MK	-0.449****	-0.456****	-0.490****
Maize price, MK/kg	-0.048**	-0.053*	-0.049**
Planting time dummy	0.395***	0.416***	0.278*
Cash amountXPlanting time dummy			0.143
Offered to buy coupons in 2008/09		0.001	0.006
Bought coupons in 2008/09		-0.172*	-0.168*
Offered cheap fertilizer in 2008/09		0.067	0.070
Aggregate access to subsidies		0.008	0.006
Marketed surplus of maize 2008/09		-0.047	-0.049
Distance to larger market, km	0.005	0.005	0.004
Sex of household head, 1=Male	-0.061	-0.053	-0.051
Age of household head	0.001	0.001	0.001
Education of household head	0.004	0.007	0.006
Male labor force	0.043*	0.042	0.042*
Female labor force	-0.035	-0.041	-0.044
Consumer-worker ratio	-0.034	-0.009	-0.008
Quality of house	0.001	0.003	0.003
Value of assets, 1000MK	0.006***	0.006**	0.007***
Tropical livestock units	0.019	0.048**	0.044**
Farm size, ha	-0.047**	-0.045*	-0.043*
Zomba	0.161*	0.118	0.128
Chiradzulu	0.116	0.089	0.094
Machinga	-0.460**	-0.478**	-0.435**
Kasungu	-0.732**	-0.825**	-0.784**
Lilongwe	-0.372*	-0.444**	-0.406*
Prob > chi2	0.000	0.000	0.000
Numbe..	340	322	322

Note: Standard errors in parentheses. Significance levels: *:10%, **:5%, ***:1%, ****:0.1%. The table shows the average partial effects from the logit models. The dependent variable is a dummy variable =1 if households chose fertilizer and =0 if households chose the random cash amount.

Table 6. Factors associated with Willingness to sell and Willingness to buy input package

Right hand side variables	WTSell	WTBuy
Cash amount offered, 1000MK	-0.015	-0.069****
Planting time dummy	0.303*	-0.037
Cash amountXPlanting time dymmy	-0.020	0.228
Maize price, MK/kg	-0.021*	-0.213
Offered to buy coupons in 2008/09	0.641***	-0.105
Bought coupons in 2008/09	-0.831****	-0.022
Offered cheap fertilizer in 2008/09	-0.010	0.181*
Aggregate access to subsidies	-0.071***	-0.024
Marketed surplus of maize 2008/09	0.269**	0.034
Distance to larger market, km	-0.004	-0.006
Sex of household head, 1=Male	-0.194**	-0.100
Age of household head	-0.002	-0.003
Education of household head	-0.014*	0.012
Male labor force	0.082	0.016
Female labor force	0.074	0.048
Consumer-worker ratio	-0.016	0.236*
Quality of house	0.025***	0.022
Value of assets, 1000MK	0.004	0.001
Tropical livestock units	0.020	-0.002
Farm size, ha	0.033	0.060
Zomba	0.285****	0.152
Chiradzulu	0.233****	0.140
Machinga	0.098	-0.089
Kasungu	-0.035	-0.060
Lilongwe	Dropped	0.152
Prob > chi2	0.000	0.000
Number of obs.	104	174

Note: Standard errors in parentheses. Significance levels: *:10%, **:5%, ***:1%, ****:0.1%. Logit models with WTSell=1 and WTBuy=1 if answer is yes to given random amounts of cash, zero otherwise. Numbers in the table are average partial effects.

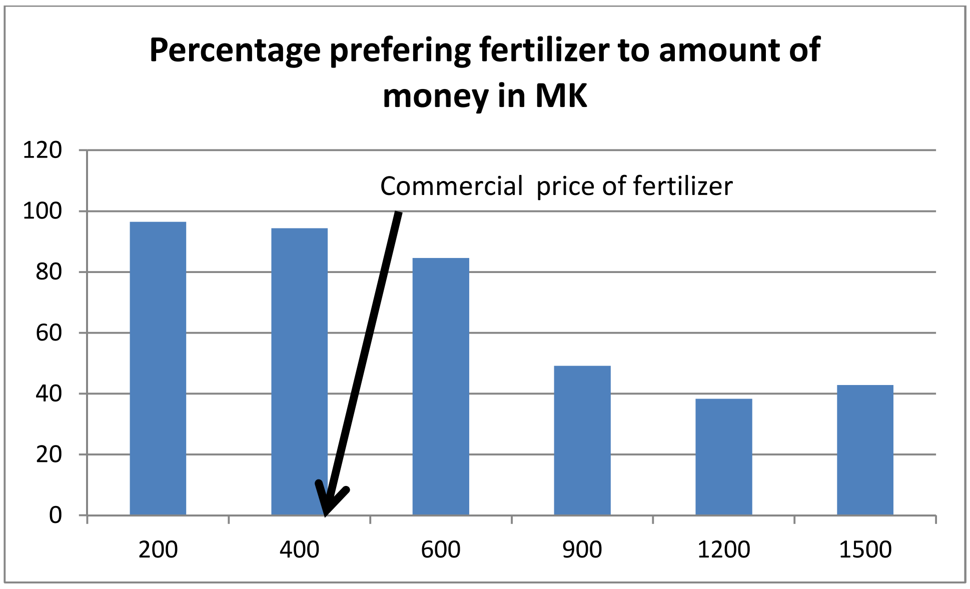

Figure 1. Choice experiment between receiving 5 kg basal fertilizer and a varying amount of cash.

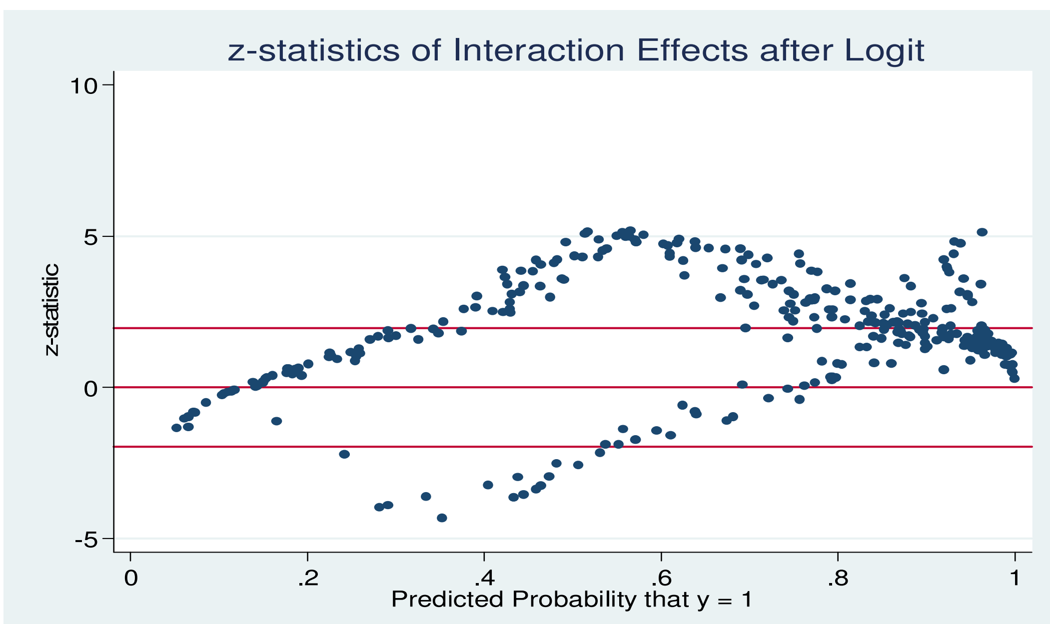

Figure 2. The interaction effect between cash amount and planting time dummy in model Logit 3 in Table 5.

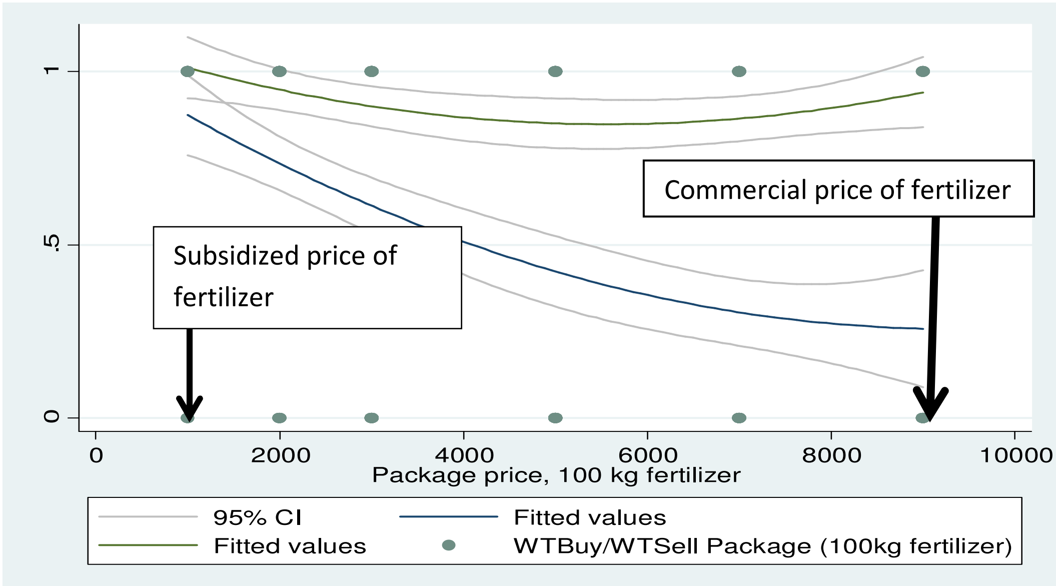

Figure 3. Ratio preferring input package to cash in WTA (upper line) and WTP (bottom line) experiments with varying cash amounts (MK) (quadratic prediction plots with 95% confidence intervals)

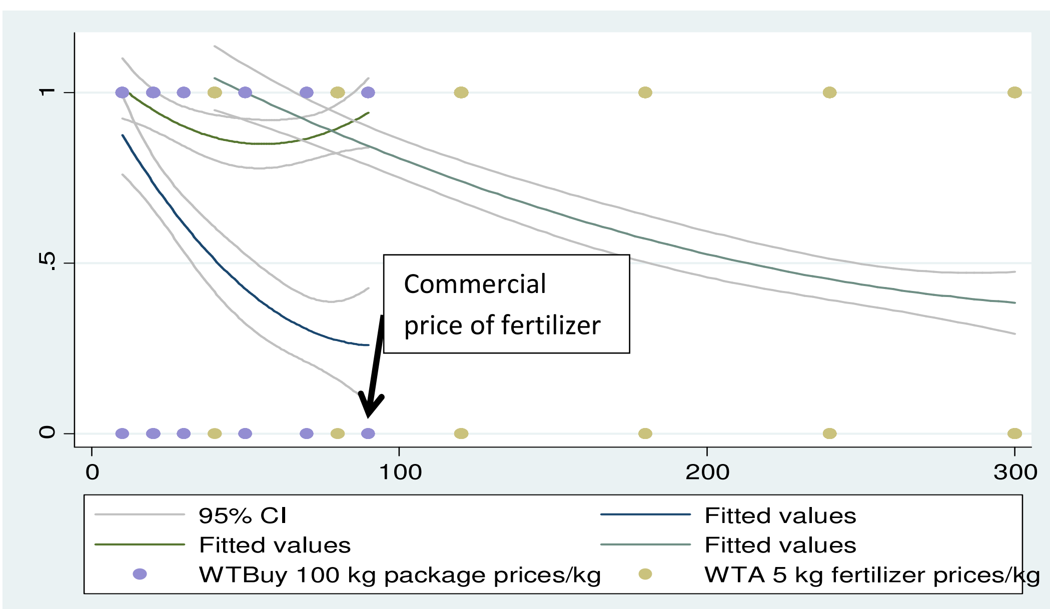

Figure 4. Fertilizer package price for real experiment versus hypothetical WTSell and WTBuy package: Share of households preferring fertilizer package to money at varying prices (quadratic prediction plots with 95% confidence intervals)

Appendix.

Table A1. Sample mean comparisons for the two samples for key household characteristics variables

	Harvest season sample			Planting season sample			
Variable	Mean	St.error	N	Mean	St.error	N	t-test
Fertilizer expenditure	4295	175	280	6563	368	79	-5.913***
Sex of household head	0.750	0.026	284	0.722	0.051	79	0.512
Age of household head	46.043	0.928	280	45.867	1.899	75	0.086
Education years of hhhead	4.843	0.241	280	6.027	0.456	75	-2.270**
Number of children	2.569	0.095	281	2.973	0.185	75	-1.948*
House quality index	8.928	0.169	278	9.123	0.274	73	-0.546
Value of assets, ML	3795	866	281	6667	1632	75	-1.530
Tropical livestock units	0.432	0.063	277	0.897	0.255	75	-2.589***
Farm size	0.793	0.033	280	1.630	0.191	74	-7.186***