What are the Dynamic Effects of Fertilizer Subsidies on Household Well-being? Evidence from Malawi

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Abstract

This study uses household level panel data from Malawi to measure the contemporaneous and dynamic impacts of fertilizer subsidies on different indicators of household well-being. Well-being is measured in this paper using indicators contained in available survey data, such as area cultivated, maize production, asset wealth, respondent-stated adequacy of food consumption and respondent-stated life satisfaction. The study uses fixed effects and instrumental variable methods to control for endogeneity caused by the non-random distribution of targeted fertilizer subsidies. Results indicate that the quantity of subsidized fertilizer acquired by a household has a positive contemporaneous effect on area planted, area planted to maize and maize production at the household level. The subsidy also has a significant dynamic effect on the quantity of maize that households produce. Subsidized fertilizer has no significant contemporaneous or dynamic effect on household asset accumulation. Receiving more subsidized fertilizer does not make households feel that their food consumption has been adequate over the past year, but receiving more subsidized fertilizer makes household heads say that they are more satisfied with their lives. Subsidized fertilizer appears to be going to people with more land. In addition, people in villages where members of parliament reside also receive greater quantities of subsidized fertilizer. These findings raise questions about how subsidy recipients are targeted. Improving targeting could increase the positive impacts of fertilizer subsidies on household well-being.

Fertilizer subsidies are once again becoming a popular policy to boost agricultural productivity in Sub-Saharan Africa (SSA). In recent years numerous countries including Kenya, Tanzania, Uganda, Zambia and Malawi have all introduced programs that provide inputs to farmers below commercial market prices. The ultimate goal of subsidizing fertilizer is to improve the well-being and food security of rural households, through boosting production of staple crops. However, the costs of financing large scale fertilizer subsidies are high. For example, Malawi spent US $210 million on fertilizer subsidies during the 2008/09 growing season, roughly equal to 70% of the ministry of agriculture's budget (Dorward, Chirwa and Slater 2010). In Zambia 20% of total government spending on agriculture went to fund fertilizer support in 2008 (Govereh et. al 2009). Despite these relatively high costs, to date little quantitative impact evaluation has been conducted to measure the benefits of fertilizer subsidies and weigh them against program costs.

The objective of this study is to determine how fertilizer subsidies affect the well-being of rural households in Malawi, both contemporaneously and, more importantly, over time. Well-being is measured in this paper using indicators contained in available survey data, such as area cultivated, maize production, asset wealth, respondent-stated adequacy of food consumption and respondent-stated life satisfaction. The effect of fertilizer subsidies on these indicators provides a broad understanding of how the policy affects the lives of rural households.

To address this important policy issue, this study aims to make a disciplinary and subject matter contribution by developing a framework for measuring the dynamic effects on household well-being indicators. Do the benefits afforded to households by each additional kilogram of subsidized fertilizer last only one season or do the benefits last longer? Understanding the dynamic effects helps advance the debate about whether or not subsidizing fertilizer can in fact help poor households break out of a poverty trap, spurring future economic growth to provide sustainable long term benefits. If benefits are one off, lasting only one season, the program may be financially sustainable if the benefits outweigh the costs but the dynamic growth process is not achieved. If the program produces no significant effects at any point in time then serious doubts should be raised about the policy's relevance to boosting productivity and improving livelihoods. On the other hand, if receipt of the subsidy in prior years has enduring long-term benefits, then this would give some credence to the notion that subsidies can help break the alleged poverty trap that catches many poor smallholder households. These questions can now be tested empirically thanks to the recent availability of farm-level panel data with information on fertilizer use spanning six years in Malawi.

This study uses panel data from Malawi to estimate the dynamic effects of fertilizer subsidies over time. Malawi makes for an interesting case study because since 2005/06 the country has implemented an innovative targeted input voucher program where the government distributes vouchers to selected farmers, who then redeem them in exchange for fertilizer at a reduced price. The program received popular acclaim in a front-page New York Times article (Dugger 2007) and is widely being perceived as a test case for possible broader implementation elsewhere in Africa. However, more evaluation needs to be conducted in order to help policy makers understand how fertilizer subsidies help improve the lives of recipients.

Two previous studies focus on the impact of fertilizer subsidies on crowding out private sector sales (Xu, Burke, Jayne and Govereh 2009; Ricker-Gilbert and Jayne 2009). Several other studies look at the effect of fertilizer subsidies on increasing maize yields (Xu, Guan, Jayne and Black 2009; Ricker-Gilbert, Jayne and Black 2009; Holden and Lunduka 2010). A recent paper for the OECD uses a Policy Evaluation Model to determine that the costs of universal input subsidies generally outweigh the benefits and a majority of the benefits from fertilizer subsidies accrue to fertilizer dealers (Brooks, Dyer and Taylor 2008). Another study using experimental evidence from Kenya finds that offering small, time-limited fertilizer subsidies during harvest (while farmers have cash) can substantially increase fertilizer use the next season (Duflo, Kremer and Robinson 2009). The authors argue that small, timely discounts increase welfare more than large-scale fertilizer subsidies or *laissez-faire*. Other policy papers have raised the question of whether or not subsidizing fertilizer is a sustainable strategy for growth (Harrigan 2008, GRAIN 2010). To our knowledge this paper is the first household-level study to look at impacts of fertilizer subsidies beyond just the plot level by also considering their effect on household well-being. Furthermore many studies are only able to measure the immediate or contemporaneous impacts of a program but our study benefits from a rich data set with recall data that allows us to see how the program affects recipients over time.

It is essential to understand that targeted fertilizer subsidies are not distributed randomly, so dealing with this issue is a major part of the paper's modeling effort. It is likely that the amount of subsidized fertilizer that a household receives is endogenous in a model of household wellbeing, because it is likely correlated with factors in the error term of that model. Another issue is that in these models subsidized fertilizer takes on the properties of a corner solution variable. The corner solution issue arises because many people in Malawi receive no subsidized fertilizer but beyond that, the quantity obtained takes on a relatively continuous distribution for those who receive the subsidy. By making a serious attempt to address endogeneity and corner solution issue this paper should be a useful application for researchers dealing with non-random program selection where the potentially endogenous variable of interest is non-linear. This study will be useful to policy makers in SSA by providing an accurate estimate of the effect of fertilizer subsidies on key indicators of household well-being, and how those benefits are sustained or dissipate over time.

The rest of the paper is organized as follows. The next section gives a brief background on the recent fertilizer subsidy program in Malawi. Next is the conceptual framework, then an explanation of the measures of well-being used in this study, followed by methodology. Subsequent sections present data, results and conclusions.

Fertilizer Distribution and Subsidies in Malawi

Small-scale fertilizer subsidy programs have existed for decades in Malawi. However, after experiencing a drought-affected poor harvest in 2004/05, the Government of Malawi decided to embark on a large-scale fertilizer subsidy program to promote maize and tobacco production. During the 2005/06 season coupons for 147,000 metric tons of fertilizer (2.9 million 50kg bags) were distributed to farmers. Coupons for hybrid maize seeds were distributed as well. The subsidy program cost US $51 million during the 2005/06 growing season.

The rains were good in 2005/06 and yields were high, making the subsidy program very popular. Consequently it was extended and scaled up for the 2006/07 growing season. During that year the government procured and distributed 185,000 metric tons of fertilizer to farmers. Coupon recipients paid the rough equivalent of US $6.75 for a 50 kg bag of fertilizer. The same 50 kg bag of fertilizer cost the government US $24.50 delivered at market (Dorward et al. 2008). Officially each household was eligible to receive two coupons good for two 50 kilogram bags of fertilizer at a discounted price. In reality, the actual amount of subsidized fertilizer that households acquired varied greatly. The program cost more than US $73 million with most of the bill being paid by the Malawian government and a minority by the UK's Department for International Development (DFID).

Fertilizer was also available for purchase from private suppliers at commercial prices during both the 2005/06 and 2006/07 growing season. Six private firms won the right to procure and distribute subsidized fertilizer through their retail networks. Farmers who received coupons could redeem them at participating retail stores along with US $6.75 to obtain their fertilizer. Retailers would then submit the coupon and receipt to the government for payment.

The subsidy program was scaled up even further in 2007/08 when 216,000 metric tons of fertilizer was procured by the Malawian government at an estimated cost of US $95 million. In 2009 the government made nearly 218,500 metric tons of subsidized fertilizer available and spent an estimated US $252 million on the program. The higher cost was due to an increase in fertilizer prices and an expansion of the subsidy to small holder tea and coffee crops (Dorward, Chirwa and Slater 2010). The private sector was excluded from distributing subsidized fertilizer in 2008/09, however a seed subsidy was scaled up in that year which involved private retailers. The proportion of the fertilizer cost that was paid by the government increased to greater than 90% in 2008/09. Farmers were officially required to pay the equivalent of US $3.33 for a 50 kg bag of fertilizer that cost between US $40 to $70 at commercial prices.

Throughout the years of the subsidy's implementation, the process of determining who received coupons for fertilizer subsidies was subject to a great deal of local idiosyncrasies. At the regional level, coupons were supposed to have been allocated based on the number of hectares under cultivation. At the village level, subsidy program committees and the village heads were supposed to determine who was eligible for the subsidy. The general program eligibility criteria was that beneficiaries should be "full time smallholder farmers who cannot afford to purchase one or two bags of fertilizer at prevailing commercial prices as determined by local leaders in their areas" (Dorward et al. 2008). However, numerous unofficial criteria may have been used in voucher allocation, such as households' relationship to village leaders, length of residence and social and/or financial standing of the household in the village. Along the same lines it is also possible that factors which are unobservable to us as researchers and affect household well-being such as health shocks could also influence how much subsidized fertilizer a household receives. Therefore, subsidized fertilizer could potentially be endogenous in our model.

Conceptual Framework

Figure 1 outlines a conceptual image of the dynamic effects of receiving some quantity of subsidized fertilizer on a recipient's well-being overtime, (area cultivated, maize production, assets, adequacy of food consumption and respondent-reported life satisfaction are the well-being indicators used in this study). Point *t* represents the growing season in which the household receives some amount of fertilizer at a subsidized price. The first question is whether or not there is a significant contemporaneous boost to well-being from fertilizer subsidies that occurs between time *t* and time *t+1*, signifying the start of the next growing season? One might expect *ex ante* that a household who receives the subsidy would experience a contemporaneous boost in well-being. For example, the subsidy may help households overcome a credit constraint that limits fertilizer use or it could encourage fertilizer adoption by making fertilizer use more profitable than it is at current market prices.

Perhaps a more interesting question than looking at contemporaneous increases in well-being is what happens to household well-being after point *t+1*, in the years after a household has received the subsidy (the dynamic effect)? Does the household continue on an elevated path of growth, symbolized by path *A*? Does the household revert back to a well-being rate of change along path B that is similar to the household's growth rate prior to receiving the subsidy at point *t*? Or do we observe path *C* where the household regresses back to the level of well-being it maintained before the subsidy? Supporters of fertilizer subsidies often describe a scenario similar to path *A*, where fertilizer subsidies help farmers break out of a poverty trap and achieve a new level of future growth. The benefits of fertilizer subsidies are easy to justify should we observe path *A*. The subsidy may also be justifiable if path *B* is observed on the basis of providing a contemporaneous but sustainable boost to well-being. If point *C* is observed and the household returns to the same level of well-being it held before the fertilizer subsidy then the effectiveness and long-term sustainability of fertilizer subsidies should be called into question, at least in terms of their ability to "kick-start" growth processes that help households escape from poverty after the withdrawal of the program after several years.

Figure 1: The Dynamic Effects of Fertilizer Subsidies on Well-being

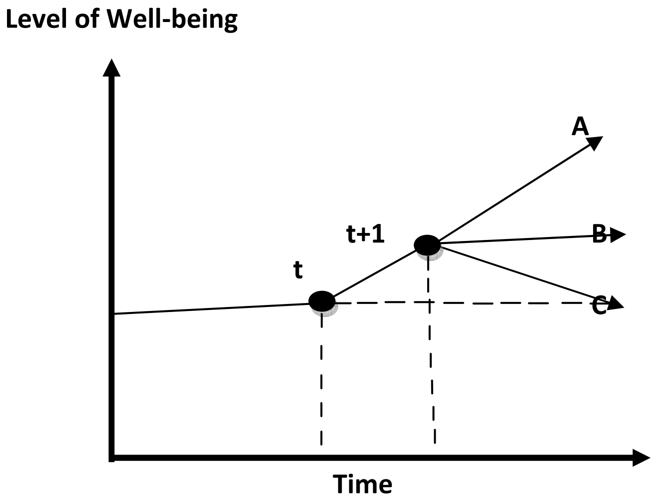

Figure 1 is an adaptation of the framework used by Jacobson, LaLonde and Sullivan (1993) to investigate the effect of job loss on future earnings. This framework is also adapted by Kirimi (2008) to study the effect of working adult deaths from HIV/AIDS on farm output in rural Kenya. Feder, Murgai and Quizon (2003) use a similar framework to understand the effect of Farmer Field School attendance on participants' knowledge over time. It is important to note that in these three studies the variable of interest is a binary variable as to whether or not the event occurred. Remember that in Malawi people received various quantities of subsidized fertilizer, so our study extends this framework to look at a policy intervention with a more continuous distribution.

Household decision making under targeted input subsidy

After developing a framework to measure the benefits of fertilizer subsidies on household well-being overtime, understanding how farm households behave when they receive a coupon to acquire fertilizer at a subsidize price must be addressed. Consider a farm household that maximizes current and discounted future utility through consumption of an agricultural good *X*. Following Roe and Graham-Tomasi (1986), household i at time t maximizes the following utility function over its time horizon t= 0, 1,…., T.

$$(1) \quad Max\ U\ f\{X_{it}\}_{t=0}^{t=T} = \sum_{t=1}^{t=T} \propto^{t} u(X_{it})$$

Where the discount factor $\propto = (1+e)^{-1}$ and 0< e <1. Assume that the household wants to maximize its utility either through purchasing *X* in the market, producing *X* on farm or some combination of the two. If the household receives a voucher in time *t* , giving them the right to acquire fertilizer at a reduced price, the household may sell the voucher (or sell the subsidized fertilizer acquired with the voucher) for cash or in kind transfer. The household may also decide to redeem the voucher for fertilizer and apply that fertilizer to the production of X on its farm, subject to the following production function.

$$(2) \quad X_{it}= f(F_{it}, L_i, \varepsilon_{it})$$

Where *F* represents the quantity of fertilizer applied, and L represents the fixed quantity of land. The stochastic nature of production is denoted by ε. Given the risky nature of producing X, the household must decide whether it obtains greater utility from using the subsidized fertilizer on farm subject to a risky production process or by selling it. When *X* is grown on farm it either contributes to household well-being directly through increased production leading consumption by its members, or if there is a surplus of X it is sold at market for per unit price P_x. Money earned from selling X in time t is invested with the goal of improving well-being in future periods. When subsidized fertilizer is not used on farm and is sold for price P_f, that money may be used to purchase *X* in the market or the money may be invested in other activities that may increase well-being over time.[1]

[1] For simplicity, assume that the amount of subsidized fertilizer a household receives in future periods is unaffected by what the household does with the subsidized fertilizer in period t.

It is important to note that the data used in this study provide information on the quantity of subsidized fertilizer received by households regardless of what they did with it. Therefore we can measure how subsidized fertilizer affects well-being for households who sold it and those who used it on their farm. It is also important to recognize that the household could decide to not use the subsidized fertilizer perhaps due to loss, theft, or not being able to easily access a fertilizer dealer to redeem it. The household could also decide to gift the voucher to someone with no direct compensation in return. Our survey asks households how much subsidized fertilizer they acquire in year t and in previous years. While most respondents say that they use the fertilizer on their own farm, we can never be sure exactly how respondents truly use it. However because these questions are asked at the household level rather than at the plot level, we can see how their well-being changes over time regardless of what the household does with the fertilizer.

Measures of household well-being

After looking at household behavior under a targeted input subsidy program we now consider five indicators used to measure the dynamic effects of fertilizer subsidies on well-being. 1) total area cultivated by household and total area of maize cultivated by household; 2) quantities of maize harvested by household; 3) value of assets, both productive and those used for consumption; 4) adequacy of food consumption; 5) household head's satisfaction with life. Note that sufficient consumption data is not available in the survey so we cannot estimate direct impacts on household consumption from the subsidy. The measures used in this study should however give a reasonable assessment of how the subsidy affects peoples' lives. These indicators will be used as dependent variables in the models estimating the effects of subsidized fertilizer on household well-being over time.

Area planted and area planted to maize

Investigating the total area planted by the household provides information on whether or not households are expanding their production due to the subsidy. If there is a dynamic effect on area cultivated in year t due to receiving subsidized fertilizer in some past year it provides evidence that households are able to bring more land into cultivation and more food may be produced. If area planted to maize increases this also indicates growth in staple crop production, unless area devoted to other staple crops is switch over into maize production. Area planted takes on a relatively continuous distribution and may be estimated via OLS.

Quantity of maize produced by the household

Maize is the staple crop for many rural households in Malawi and many parts of SSA. Since many rural households are autarkic or net consumers of maize, increases in its production may indicate an improvement in the household's food security situation. An increase in maize production resulting from receipt of subsidized fertilizer would indicate that households are using the fertilizer for on farm production. Additional maize production will either translate into increase consumption or increased sales used to purchase other goods that improve household well-being. Maize production takes on a relatively continuous distribution and may be estimated via OLS.

Investment in assets by household

Using assets as an indicator of well-being enables us to better understand if fertilizer subsidies provide farm households with the incentives and opportunities to purchase assets that improve their lives. The paper breaks assets into productive assets such as livestock or farm equipment and consumption assets such as furniture or cooking equipment. Assets take on a relatively continuous distribution and are estimated via OLS.

Adequacy of Food Consumption

Farm households were asked in the survey whether or not their food consumption over the past twelve months has been adequate. This indicator gives a subjective measure of household consumption and thus food security. After controlling for household size, an increase in the probability that food consumption has been adequate indicates that food security is improving, either through growing more food on farm or from purchasing food in the market. The lagged effect of fertilizer subsidies on this measure is of particular interest since the quantity received in year t-1 affects food consumption in year t. The adequacy of food consumption is asked as a binary question, therefore this model can be estimated via probit.

Life Satisfaction

In the survey household heads are asked how happy they are with their life at the current time on a scale of 1 to 5. Knowing how satisfied households are with their life provides a subjective assessment of the household's level of happiness; how that may have changed over time and how current and past quantities of subsidized fertilizer a household receives may have influenced it. This assessment is subjective and a certain score for one person may not mean the same thing for another person. Keep in mind that with panel data we are measuring the changes in an individual's score over time rather than across individuals. Therefore the indicator of life satisfaction is valid if we assume that an individual's scale remains constant over time. The variable for life satisfaction is not entirely continuous but is estimated in this paper via OLS to get a reasonable approximation with results that are easy to interpret.

Methodology

Consider the well-being of farm household (i) at time (t) as a function of the following:

(3) $$Y_{it} = \alpha + \sum_{j=0}^{J} \beta_j S_{i,t-j} + X_{it}\delta + \varepsilon_{it}$$

(4) $$\varepsilon_{it} = c_i + \mu_{it}$$

where Y_{it} represents one of the five measures of household well-being (area planted, maize production, assets, adequacy of food consumption and life satisfaction). Note that separate regressions are run for each of the factors influencing well-being. The quantity of subsidized fertilizer that a household receives at time (t-j) is represented by $S_{i,t-j}$, where j= 0, 1, ….., J. When j=0, the parameter, β, provides an estimate for the contemporaneous effect of subsidized fertilizer on well-being in year t. When j>0, β indicates fertilizer subsidy's dynamic effect on well-being. Other factors that affect well-being are denoted by the vector $\mathbf{X}_{it}$. These factors include household characteristics, community and market access characteristics, maize prices, fertilizer prices, and rainfall (see table 1 for a full list of explanatory variables). Unfortunately the data do not allow us to create lagged variables for other covariates that affect well-being besides the quantity of subsidized fertilizer received by the household.

The error term ε_{it} in equation (4) is a function of two components 1) time constant unobserved factors that affect well-being, such as farming ability and degree of risk aversion are denoted by c_i; 2) time-varying shocks that affect production and food security are represented by μ_{it}. These factors include intra-household dynamics and health shocks.

Controlling for unobserved heterogeneity c_i

When the underlying model for well-being is linear, correlation between covariates and c_i is controlled using fixed effects. The fixed effects estimator is used for all models except adequacy of food consumption which is non-linear. When the underlying model is non-linear the covariates must be independent of c_i in order for them to be consistent. This is often a strong assumption, but it can be relaxed by modeling c_i using a framework called either correlated random effects (CRE) or the Mundlak-Chamberlain device following Mundlak (1978) and Chamberlain (1984). In order to implement the CRE framework in equation (3), the time means for household (i) denoted by $\overline{X}_i$ for the vector of all time-varying covariates are added to the equation. One benefit of the CRE estimator is that by including time averages one may obtain a fixed-effect interpretation while avoiding the incidental parameters problem in non-linear models. Another advantage of CRE is that it allows measurement of the effects of time-constant covariates just as in a traditional random-effects environment. (For further reading on the CRE framework, see Wooldridge 2002).

Controlling for unobserved shocks μ_{it}

Even after controlling for correlation between S_{it} and c_i, the estimates of the impact of subsidized fertilizer on production and food security will still be inconsistent if S_{it} is correlated with unobservable time-varying shocks μ_{it}. Many panel studies simply assume independence between covariates and μ_{it}, however this may be a strong assumption, particularly when the covariate of interest is not determined randomly. In this study, the amount of subsidized fertilizer acquired is likely to be correlated with unobserved time varying factors that affect food security due to its non-random distribution process.

In our models of well-being the potentially endogenous explanatory variable, subsidized fertilizer, is non-linear so the control function (CF) method is used to control for correlation between S_{it} and μ_{it}. The CF method entails taking the residuals from a reduced from model for subsidized fertilizer and including them as a covariate in the structural models of household well-being. The significance of the coefficient on the residual both tests and controls for correlation between S_{it} and μ_{it}. (for more information on the CF approach see Rivers and Vuong 1988, Smith and Blundel 1986, Vella 1993, Papke and Wooldridge 2008). This study maintains the assumption that previous quantities of subsidized fertilizer S_{it-j} received by the household in past years is predetermined and not correlated with μ_{it} *in* the current period.

In order to implement the CF approach one needs an instrumental variable (IV) that is correlated with the potentially endogenous variable S_{it} but not correlated with μ_{it} in the structural models of well-being. A good IV for our model is a variable for whether or not a member of parliament resides in the community. This seems like a suitable instrument *ex ante* because it is a measure of socio-political capital that could influence how much subsidized fertilizer a household receives. Also, there is little reason to believe that after conditioning on other covariates $\mathbf{X}_{it}$, having a member of parliament in the village would be directly correlated with other time varying factors in the error term of the well-being models. This maintained hypothesis makes it reasonable to assume that the instrument itself is exogenous.

In this study, the CF approach is implemented by estimating a reduced form model for the factors affecting the potentially endogenous variable, quantity of subsidized fertilizer a household acquires in year t. The covariates in this model include the IV and the other variables in the structural model from equation 3. The reduced form is estimated via tobit to account for the corner solution nature of the subsidized fertilizer variable where many households receive no subsidy but beyond that the quantity received takes on a relatively continuous positive distribution.

Data

Data used to construct the well-being indicators and household level variables used in this study come from two nationally representative surveys of rural households in Malawi. The first wave of data comes from the 2007 Agricultural Inputs Support Survey (AISS1) conducted after the 2006/07 growing season. In total 3,287 households were surveyed in AISS1. The second wave of data comes from the 2009 Agricultural Inputs Support Survey II (AISS2) conducted after the 2008/09 growing season. In total 1,982 households were surveyed for AISS2. Note that there is another household survey from Malawi, the IHHS2, which was collected during the 2002/03 & 2003/04 growing season. Unfortunately The IHHS2 survey did not ask recall questions on fertilizer quantities, so this wave of data cannot be used for measuring the dynamic effect of fertilizer subsidies on well-being. This study uses the IHHS2 dataset only to get the quantity of fertilizer acquired by households in the year of that survey in order to set up lagged values for subsidized and commercial fertilizer. In total we end up with 1,366 households in our balanced two wave panel.

Lag structure

The AISS1 and AISS2 surveys both ask questions about the quantities of subsidized and commercial fertilizer that households received in current and previous years. Ultimately we are able to obtain current year and three-year-lagged quantities of subsidized and commercial fertilizer at the household level. The IHHS2 survey is used only to obtain the quantity of fertilizer households received during 2002/03 or 2003/04 growing seasons which makes up the three year lagged quantity for households in the AISS1 data.[2] With more years of recall data it would have been useful to give the lags a more flexible structure such as Almon (polynomial distributed) or partial adjustment. Given that we have only three years of lagged values of fertilizer to go along with two panel years of well-being indicators, we end up running an unrestricted distributed lag model with subsidized fertilizer quantities and commercial fertilizer quantities in their level form. The long run impact of fertilizer subsidies on production and food security can be measured using a joint F-test. We test a variable for the number of years a household has continuously received subsidized fertilizer, in order to test if continuity affects well-being.

Attrition Bias

[2] For 692 observations the quantity of subsidized and commercial fertilizer they acquired in year t-3 comes from the 2002/03 growing season since the IHHS2 data took two growing seasons to collect. Therefore for these observations their t-3 fertilizer quantities are actually t-4 quantities. We control for this issue by interacting the t-3 subsidized fertilizer quantity with a year dummy for 2002/03.

Potential attrition bias caused by households leaving the panel in different waves is a major issue that must be addressed. To deal with potential attrition bias, this study assumes that the factors affecting whether or not a household that was interviewed in 2006/07 was re-interviewed in 2008/09 may be correlated with unobserved heterogeneity, c_i, in equation 4) but are uncorrelated with μ_{it}. Doing so allows us to control attrition bias by running fixed effects on a balanced panel for the well-being models. Fixed effects removes the unobserved time constant factors affecting re-interview and furthermore with fixed effects, all observations that are only available for one time period drop out due to the demeaning process (Wooldridge, 2002, pg. 580). Under the same principle, we use the CRE framework which includes the household time averages to control for attrition bias in the non-linear model of whether or not household food consumption has been adequate. It would be of no benefit to add the time averages of households that only appear in one time period since the time averages are equivalent to its value for the one year it appears in the dataset.

Fertilizer Prices

Fertilizer prices used in the study are reported in Malawian Kwacha per kilogram of fertilizer. The price is an aggregation of Urea and Nitrogen/Phosphorus/Potassium (NPK) prices. These prices are based on what respondents in the survey say they paid for commercial fertilizer during the planting season from October to December. For those buying commercially we use the observed price that they paid, while for those who did not buy commercially we use the district median price to proxy for the price that the farmer faces for the input. Fertilizer prices are in real 2009 terms.

Maize prices

In a supply response model (which in our paper includes models of area planted and maize production), maize prices should be modeled as expectations, not realized post-harvest prices as contained in the survey data, because the latter are not known at the time that fertilizer use decisions are made. Hence we develop a naive expectation of the average real maize price for the six months prior to the planting season, which is May to October in Malawi. The prices are in Malawian Kwacha per kilogram and come from district-level monthly maize prices collected by the Ministry of Agriculture. We also recognize that tobacco prices affect area planted and maize production. Unfortunately suitable tobacco price data for Malawi are not available and could not be included in the model yet they are controlled for to some extent by the inclusion of year dummies. Maize prices are in real 2009 terms.

Rainfall

The rainfall variables come from district-level experiment station records. In a supply response model such as for area planted, the appropriate rainfall variable is also a farmer's expectation based on rainfall from previous years. We include the average cumulative annual rainfall over the previous five growing seasons to model farmer expectation. The standard deviation of rainfall over the past five years is also included to give an estimate of rainfall variability. This variable is expected to be negatively related to area planted and maize production. For the model of household maize production we also include cumulative rainfall over the growing season to account for rainfall's impact on production.

All other explanatory variables are constructed from the household surveys.

Results

Table 1 presents the descriptive results for the variables used in the analyses. The variable denoting kilograms of subsidized fertilizer received in year t indicates that that average subsidized fertilizer received by households increased from 62.4 kilograms to 64.8 kilograms between the 2006/07 seasons and 2008/09 seasons. Some other interesting findings from table 1 are that the average number of months that a village is accessible by truck increased from four months to eleven months between 2006/07 and 2008/09 while the average distance to market decreased from 8.6 km in 2006/07 to 5.3 km in 2008/09. This may indicate that infrastructure improvements have taken place in Malawi. The average number of fertilizer dealers in the village decreased from 0.9 in 2006/07 to 0.5 2008/09. This may be because the private sector was excluded from distributing the fertilizer subsidy in 2008/09 so many input dealers likely stopped operating.

Table 2 presents the reduced form model for factors affecting how much subsidized fertilizer a household receives in year t. The IV, if a member of parliament (MP) resides in the community, is statistically significant at the 6% level signifying that it is a strong instrument because it is partially correlated with how much subsidized fertilizer a household receives. The coefficient indicates that households in villages with a MP get 7.34 more kilograms of subsidized fertilizer than households in other villages. This finding highlights the possibility that political connections affect subsidized fertilizer receipt in Malawi.

The quantity of subsidized fertilizer that a household receives in year t-1 has a significant positive effect on the quantity of subsidized fertilizer received in year t. Interestingly the quantity of subsidized fertilizer received in year t-2 has a significant negative effect on quantity of subsidized fertilizer received in year t while the quantity of subsidized fertilizer purchased in year t-3 has a significant positive effect. Households that cultivate larger tracts of land receive more subsidized fertilizer.

Table 3 presents the factors affecting household supply response. Column 1 shows factors affecting total area planted and column 2 shows the area planted to maize. Results from these two models show that the quantity of subsidized fertilizer acquired in year 1 has a significant positive effect on area planted and area planted to maize. The coefficients indicate that if the household receives 100 kg of subsidized fertilizer area planted increases by 0.2 hectares and area planted to maize increases by 0.1 hectare. Though there is a contemporaneous effect, the dynamic effect of subsidized fertilizer on area planted is not statistically significant in either column 1 or column 2.

Female headed households plant less total area and less area to maize than male headed households. Households with more young children plant larger areas, possibly because they have more labor available and/or more people to feed. When looking at the average expected price for maize we note that the elasticity of supply for area planted is lower than the elasticity of supply for area planted to maize. The elasticities are 0.36 and 0.44 respectively when they are taken at the data means. This makes sense because when farmers expect maize prices to be high it is easier for them to switch area from other crops into maize then it is for them to acquire more land. Higher expected rainfall has a positive effect on both total area planted and area planted to maize while the standard deviation has a negative effect. Both of these results are what one would expect *ex ante*.

Column 3 from table 3 shows the factors affecting household level maize production. Results indicate that the quantity of subsidized fertilizer received in year t has a positive and significant effect on maize production in that year. The coefficient indicates that each additional kg of subsidized fertilizer contributes 2.30 kilograms of additional maize production *ceteris paribus*. The dynamic effect of fertilizer subsidies on household maize production also has a significant coefficient. The dynamic results show that the sum of each kilogram of subsidized fertilizer received by the household over the three previous years contributes 2.49 kilograms to the current year's maize production. It is also interesting to note that households with higher assets, larger plots of land, older heads and more working age males produce larger quantities of maize.

Table 4 presents the factors affecting household asset accumulation. Results show that fertilizer subsidies have no contemporaneous effect on assets in year t. The dynamic effect on total assets in column 1 of table 4 has a coefficient approaching significance with a p-value of 0.12. The coefficient in column 1 demonstrates that each additional kilogram of subsidized fertilizer received over the previous three years contributes 626 kwacha (roughly US $4.00) to total household assets in the current year.

Households with more land have higher assets, as each additional hectare of land leads to 14,183 kwacha (roughly US$ 95.00) in additional assets for the household. The number of adult males under 65 leads to an increase in total household assets. This finding stems from an increase in productive assets in column 3. Each additional working age male increases total household assets by 12,242 kwacha (roughly US $82.00). Lower expectation of maize price has a significant negative effect on assets. It could be that because many households are net buyers of maize, they may sell off assets if they expect maize prices to be higher in order to purchase staples in the coming months.

Table 5 presents the factors affecting household subjective assessment of well-being. Column 1 shows factors affecting whether or not food consumption has been adequate for the household over the past year. Since consumption during the past year is not affected by production in the current year, the quantity of subsidized and commercial fertilizer acquired in year t is not included in the model in column 1. Cumulative rainfall for the current year is also excluded. The model indicates that the quantity of subsidized fertilizer receipt does not have a significant contemporaneous or dynamic effect on whether or not household heads feel that their family's food consumption has been adequate over the past year. The value of household assets has a significant positive effect on the probability that food consumption has been adequate, but the magnitude is small. The number of children under twelve years old has a significant negative effect on the probability that food consumption has been adequate as each additional child reduces that probability that food consumption has been adequate by three percentage points. This makes sense because each child is another mouth to feed.

Column 2 of table 5 shows the factors affecting a household head's satisfaction with life on a 1 to 5 scale. This model is assumed to be linear and is estimated via Fixed Effects. This may not be the best estimator but gives a first approximation and results are easy to interpret. The model shows that subsidized fertilizer has a positive contemporaneous effect on life satisfaction but there is no significant dynamic effect. It is also interesting to note that households with more assets and land are happier.

Average expected maize price makes people less happy which seems plausible since most people are net consumers of maize.   Oddly the price of fertilizer makes people happier, but the magnitude of the effect is small. Also higher expected rainfall and lower expected variation in rainfall makes people happier, probably because they plan to have a better production year and they expect food prices to be cheaper.

Conclusions

This study uses panel data to determine the contemporaneous effects of receiving subsidized fertilizer in year t and the dynamic effects of receiving subsidized fertilizer in previous years on households' year t level of well-being in Malawi. Well-being in this paper is measured using indicators such as area planted, area planted to maize, maize production, asset accumulation, adequacy of food consumption and respondent-reported life satisfaction.   The main findings are as follows: 1) Fertilizer subsidies have a positive contemporaneous effect on supply response in terms of area planted, area planted to maize and kilograms of maize produced by the household. The magnitude of these coefficients are also significant as each additional kilogram of subsidized fertilizer adds 0.002 ha of total area planted, 0.001 ha of area planted to maize and 2.30 kilograms to household maize production. 2) There is significant evidence of a positive dynamic effect of fertilizer subsidies on the quantity of maize produced by households, as each additional kilogram of subsidized fertilizer acquired over the previous three years add 2.49 kilograms of maize to current year production. 3) Fertilizer subsidies also seem to have no significant contemporaneous or dynamic effect on assets. Asset accumulation appears to be driven by landholding, working age males and maize prices. 4) Fertilizer subsidies have no significant effect on whether or not households feel their food consumption has been adequate over the previous year. 5) Fertilizer subsidies have a positive effect on the household heads satisfaction with life but there is no dynamic effect.

These findings provide evidence that fertilizer subsidies have a fairly strong contemporaneous impact on area planted, production and life satisfaction. There is significant evidence of dynamic improvements in maize production due to the subsidy. The results also show that in Malawi there are also issues in terms of who is targeted for the subsidy. Households in areas where a member of parliament resides get 7.39 kilograms more subsidized fertilizer on average than households in other areas. Households with more land under cultivation also get more subsidized fertilizer. The shortcomings with targeting need to be overcome in order to maximize the contemporaneous and dynamic benefits of subsidized fertilizer on household well-being in Malawi.

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Table 1: Distribution of Variables Used in the Analysis, by Survey Year

VARIABLES	2007/08 10th	2007/08 25th	2007/08 50th	2007/08 75th	2007/08 90th	2007/08 mean	2008/09 10th	2008/09 25th	2008/09 50th	2008/09 75th	2008/09 90th	2008/09 mean
Dependent Vars.: Total value of HH assets,1,000 kwacha (real 2009 value)	1.6	5.4	16.1	37.2	86.1	51.2	1.9	7.5	20.2	45.9	116.2	58.7
Tot. value of HH productive assets 1,000 kwacha (real 2009 value)	0.7	1.5	5.3	18.6	50.2	31.9	0.9	2.1	8.3	27.4	82.6	41.5
Tot. value of HH consumption assets 1,000 kwacha (real 2009 value)	0	1.4	7.2	14.9	25.5	13.2	0	2.2	8.9	18.2	30.8	17.2
Area cultivated by HH in ha	0.4	0.4	0.8	1.2	2.0	1.0	0.4	0.5	0.8	1.2	1.8	1
Area with maize cultivated by HH in ha	0.2	0.4	0.8	1.2	1.6	0.9	0.2	0.4	0.6	1	1.4	0.8
Kg of maize harvested by HH	16.1	80.7	186.6	466.6	933.2	390.7	46.7	96.8	234.1	513.2	933.2	416.0
Life Satisfaction (1 to 5 scale)	1	1	2	3	4	2.3	1	1	2	4	4	2.3
Food consumption adequate over past 12 mos (=1)	0	0	1	1	1	0.5	0	0	0	1	1	0.5
Fertilizer Qty: Kgs subsidized fertilizer in year t	0	0	50	100	100	62.4	0	0	50	100	100	64.8
Kgs subsidized fertilizer in year t-1	0	0	0	50	100	24.8	0	0	50	100	100	44.7
Kgs subsidized fertilizer in year t-2	0	0	0	0	0	3.0	0	0	50	100	100	62.4
Kgs subsidized fertilizer in year t-3	0	0	0	10	10	9.1	0	0	0	50	100	24.8
HH Characteristics: Female headed household (=1)	0	0	0	1	1	0.3	0	0	0	1	1	0.3
Age of household head	27	33	44	60	71	47.4	28	35	46	60	71	48.1
# of males over 65 in hh	0	0	0	0	1	0.1	0	0	0	0	1	0.1
# of females over 65 in hh	0	0	0	0	1	0.1	0	0	0	0	1	0.2
# of adult males under 65 in hh	0	1	1	2	3	1.5	0	1	1	2	3	1.6
# of adult females under 65 in hh	1	1	1	2	3	1.6	1	1	1	2	3	1.6
# of children under 12 yrs in hh	0	1	2	3	4	2	0	1	2	3	4	2
Mortality in HH, past 2 yrs (=1)	0	0	0	0	1	0.1	0	0	0	0	0.1	0.1
Region: Northern Region (=1)	0	0	0	0	1	0.2	0	0	0	0	1	0.2
Central Region (=1)	0	0	0	1	1	0.4	0	0	0	1	1	0.4
Southern Region (=1)	0	0	0	1	1	0.4	0	0	0	1	1	0.4
Village Factors: Months village is passable by truck	0	0	4	5	12	4.1	8	10.8	12	12	12	10.8
Distance from village to market (km)	0	0	4	12	21	8.6	0	0	5	7	12	5.3
Number of fertilizer dealers in village	0	0	1	1	2	0.9	0	0	0	0.5	2	0.5
Farm credit in village (=1)	1	1	2	2	2	1.6	0	0	0	0.2	1	0.2
Observed commercial fertilizer price, in real 2009 kwacha/kg	73.7	76.6	80.6	83.2	102.2	82.1	160	170	180	190	202	181.6
Avg. maize price for 6 mo's prior to planting season: (kw/kg) at district level: (May - Oct) in real 2009 terms	17.0	23.0	25.2	26.5	27.94	23.6	38.7	44.0	49.6	49.9	50.5	47.4
IV: Member of parliament resides in community (=1)	0	0	0	1	1	0.3	0	0	0	0	1	0.1
Weather: Cumulative rainfall during growing season in mm	763	870	966.3	1,174.60	1,225.00	1,007.30	780	869	978	1,149.40	1,149.40	1,038.30
Average cumulative rainfall over past 5 yrs in mm	735	803	857.8	1,021.40	1,159.20	883.1	776	791	835	981.4	1,149.80	897.2
Standard deviation of 5yr avg. cumulative rainfall	127	149	213.5	267.7	354.3	229.3	128	159	251	290.4	328.1	227.6

Table 2: Reduced Form, Factors Affecting Quantity of Subsidized Fertilizer Acquired by Households in Kilograms

VARIABLES	Coeff.	P-Value
IV: Member of parliament resides in community (=1)	7.39*	(0.06)
Kgs subsidized fertilizer in year t-1	0.32***	(0.00)
Kgs subsidized fertilizer in year t-2	-0.71***	(0.00)
Kgs subsidized fertilizer in year t-3	0.19***	(0.00)
Farm credit in village (=1)	0.27	(0.92)
Months village is passable by truck	-0.52	(0.19)
Distance from village to market (km)	0.01	(0.92)
Number of fertilizer dealers in village	-1.91	(0.22)
Real HH assets, in 1,000 kwacha	0.00	(0.60)
Area cultivated by HH in ha	5.15***	(0.00)
Female headed household (=1)	-0.36	(0.95)
Age of household head	-0.14	(0.44)
# of males over 65 in hh	-2.30	(0.68)
# of females over 65 in hh	-13.87***	(0.00)
# of adult males under 65 in hh	-0.54	(0.75)
# of adult females under 65 in hh	-1.56	(0.38)
# of children under 12 yrs in hh	1.68	(0.18)
Mortality in HH, past 2 yrs (=1)	-5.08	(0.23)
Avg. real maize price for 6 mo's prior to planting season: (kw/kg) at district level: (May - Oct)	-0.12	(0.66)
Observed commercial fertilizer price at district level at planting season (kw/kg)	0.03	(0.70)
Average cumulative rainfall over past 5 yrs in mm	0.01	(0.90)
Std dev of 5yr avg cum. rainfall	-0.05	(0.35)
Interaction: subsidized fertilizer t-3 * (=1) if t-3 is 2002/03	-0.21***	(0.00)
Year dummy 2009 (=1)	49.13***	(0.00)
Northern region (=1)	19.38***	(0.00)
Central region (=1)	4.50	(0.11)
Number of Observations	2,732	
R-squared	0.12	

Note: *, **, *** indicates that the corresponding coefficients are significant at the 10%, 5% and 1% level respectively; Coefficients are Average Partial Effects; Model includes time averages of all time-varying explanatory variables except the year dummies.

Table 3: Factors Affecting Household's Supply Response: Area Planted and Maize Production

VARIABLES	(1) Hectares Cultivated by Household Coef.	P-value	(2) Hectares of Maize Cultivated by Household Coef.	P-value	(3) Maize Produced by Household in kgs. Coef.	P-value
Kgs subsidized fertilizer in year t	**0.002*** **	**(0.00)**	**0.001** **	**(0.03**	**2.30** **	**(0.01)**
Kgs subsidized fertilizer in year t-1	0.000	(0.64)	0.000	(0.85)	0.52	(0.38)
Kgs subsidized fertilizer in year t-2	0.001	(0.43)	0.000	(0.85)	1.44*	(0.09)
Kgs subsidized fertilizer in year t-3	0.001	(0.41)	0.001	(0.28)	0.52	(0.38)
Dynamic effect of subsidized fertilizer (t-1 + t-2 + t-3)	**-0.001**	**(0.48)**	**-0.001**	**(0.49)**	**2.49** **	**(0.02)**
Farm credit in village (=1)	0.06	(0.12)	0.001	(0.98)	54.29	(0.12)
Months village is passable by truck	0.001	(0.88)	0.01**	(0.01)	6.74	(0.18)
Distance from village to market (km)	0.00	(0.16)	0.00	(0.59)	0.02	(0.99)
Number of fertilizer dealers in village	-0.04*	(0.08)	-0.03	(0.10)	18.48	(0.19)
Real HH assets (1,000 Kwacha)	0.00	(0.36)	0.00	(0.23)	0.08***	(0.01)
Area cultivated by HH in ha	-	-	-	-	104.70***	(0.01)
Female headed household (=1)	-0.24***	(0.00)	-0.15***	(0.01)	37.28	(0.44)
Age of household head	0.00	(0.65)	0.00	(0.89)	3.06*	(0.06)
# of males over 65 in hh	0.03	(0.80)	0.00	(0.98)	-11.65	(0.83)
# of females over 65 in hh	0.16*	(0.07)	0.10	(0.12)	-73.80	(0.29)
# of adult males under 65 in hh	0.04	(0.29)	0.01	(0.66)	36.02*	(0.09)
# of adult females under 65 in hh	0.05	(0.16)	0.05*	(0.06)	5.50	(0.81)
# of children under 12 yrs in hh	0.07***	(0.00)	0.06***	(0.00)	17.05	(0.22)
Mortality in HH, past 2 yrs (=1)	0.09	(0.15)	0.04	(0.54)	33.89	(0.69)
Avg. real maize price for 6 mo's prior to planting season: (kw/kg) at district level: (May - Oct)	0.01***	(0.00)	0.01***	(0.00)	-4.32	(0.21)
Observed commercial fertilizer price at district level at planting season (kw/kg)	0.00*	(0.07)	0.00	(0.68)	-0.83	(0.49)
Cumulative rainfall during growing season (October to May) in mm	-	-	-	-	0.00	(0.96)
Average cumulative rainfall over past 5 yrs in cm	0.02*	(0.05)	0.01*	(0.07)	-6.4	(0.34)
Std dev of 5yr avg cum. Rainfall in cm	-0.02**	(0.02)	-0.01**	(0.04)	0.2	(0.97)
Interaction: subsidized fertilizer t-3 * (=1) if t-3 is 2002/03	0.00	(0.98)	0.00	(0.48)	-2.80*	(0.08)
Year dummy 2009 (=1)	-0.53***	(0.01)	-0.62***	(0.00)	128.28	(0.40)
Number of Observations	2,732		2,732		2,616 (households who did not plant maize not included)	
R-squared	0.08		0.08		0.10	

Note: *, **, *** indicates that the corresponding coefficients are significant at the 10%, 5% and 1% level respectively; Models estimated via fixed effects; reduced form residual not found to be significant so not included. The variable for the number of years the household has continuously received subsidized fertilizer was not statistically significant in these models so it was dropped from the analysis.

Table 4: Factors Affecting Household's Nominal Assets in Year t: Total Assets, Production & Consumption

	(1) Total Household Assets in Kwacha		(2) Total Household Consumption Assets in Kwacha		(3) Total Household Productive Assets in Kwacha	
	Coef.	P-value	Coef.	P-value	Coef.	P-value
Kgs subsidized fertilizer in year t	**31.21**	**(0.89)**	**85.77**	**(0.32)**	**-54.56**	**(0.74)**
Kgs subsidized fertilizer in year t-1	179.48	(0.53)	-11.60	(0.87)	191.09	(0.47)
Kgs subsidized fertilizer in year t-2	89.58	(0.66)	68.22	(0.34)	21.36	(0.90)
Kgs subsidized fertilizer in year t-3	357.32	(0.21)	17.35	(0.76)	339.97	(0.21)
Dynamic effect of subsidized fertilizer (t-1 + t-2 + t-3)	**626.39**	**(0.12)**	**74.96**	**(0.36)**	**552.42**	**(0.16)**
Farm credit in village (=1)	4,271.71	(0.76)	-1,868.02	(0.53)	6,139.72	(0.65)
Months village is passable by truck	-1,967.81	(0.35)	556.95	(0.31)	-2,524.76	(0.21)
Distance from village to market (km)	-36.97	(0.91)	-89.48*	(0.07)	52.51	(0.87)
Number of fertilizer dealers in village	9,265.85	(0.41)	-819.37	(0.65)	10,085.23	(0.36)
Area cultivated by HH in ha	14,182.72**	(0.03)	5,497.13	(0.11)	8,685.59	(0.11)
Female headed household (=1)	-4,287.57	(0.66)	5,666.37	(0.35)	-9,953.94	(0.21)
Age of household head	-1,585.86	(0.28)	-15.19	(0.91)	-1,570.66	(0.29)
# of males over 65 in hh	23,515.59	(0.17)	4,172.16	(0.21)	19,343.44	(0.24)
# of females over 65 in hh	16,634.61	(0.42)	-2,267.24	(0.58)	18,901.85	(0.33)
# of adult males under 65 in hh	12,241.48**	(0.02)	1,537.00	(0.47)	10,704.49**	(0.01)
# of adult females under 65 in hh	-884.62	(0.86)	3,215.62	(0.15)	-4,100.24	(0.35)
# of children under 12 yrs in hh	-8,592.75	(0.19)	-2,160.63	(0.13)	-6,432.12	(0.32)
Mortality in HH, past 2 yrs (=1)	8,627.97	(0.48)	1,809.60	(0.83)	6,818.37	(0.47)
Avg. nominal maize price for 6 mo's prior to planting season: (kw/kg) at district level: (May - Oct)	-1,398.58**	(0.04)	-315.12	(0.26)	-1,083.46*	(0.08)
Observed commercial fertilizer price at district level at planting season (kw/kg)	-489.99	(0.19)	-94.12	(0.17)	-395.88	(0.28)
Average cumulative rainfall over past 5 yrs in mm	64.72	(0.90)	-187.76*	(0.07)	252.47	(0.61)
Std. dev. of 5yr avg cum. rainfall	-86.80	(0.82)	150.36*	(0.07)	-237.17	(0.52)
Interaction: subsidized fertilizer t-3 * (=1) if t-3 is 2002/03	-319.62	(0.32)	77.48	(0.37)	-397.10	(0.21)
Year dummy 2009 (=1)	95,085.01**	(0.05)	12,832.33	(0.23)	82,252.68*	(0.07)
Number of Observations	2,732		2,732		2,732	
R-squared	0.01		0.03		0.01	

Note: *, **, *** indicates that the corresponding coefficients are significant at the 10%, 5% and 1% level respectively; Models estimated via fixed effects; reduced form residual not found to be significant so not included. The variable for the number of years the household has continuously received subsidized fertilizer was not statistically significant in these models so it was dropped from the analysis.

Table 5: Factors Affecting Household's Subjective Assessment of Well-being: Adequacy of Food Consumption and Life Satisfaction

	(1) Adequacy of Food Consumption		(2) Household Head's Satisfaction with Life	
	Coef.	P-value	Coef.	P-value
Kgs subsidized fertilizer in year t	-	-	**0.002**	**(0.06)**
Kgs subsidized fertilizer in year t-1	0.00	(0.65)	0.00	(0.95)
Kgs subsidized fertilizer in year t-2	0.00	(0.11)	0.00	(0.40)
Kgs subsidized fertilizer in year t-3	0.00	(0.10_	0.00	(0.91)
Dynamic effect subsidized fertilizer (t-1 + t-2 + t-3)	**-0.003**	**(0.17)**	**0.00**	**(0.65)**
Farm credit in village (=1)	-0.05	(0.10)	-0.19**	(0.02)
Months village is passable by truck	-0.01*	(0.09)	-0.01	(0.24)
Distance from village to market (km)	0.00	(0.93)	0.00	(0.59)
Number of fertilizer dealers in village	0.02	(0.27)	0.10**	(0.01)
Real HH assets (kwacha)	0.00***	(0.00)	0.00***	(0.01)
Area cultivated by HH in ha	0.01	(0.53)	0.13***	(0.01)
Female headed household (=1)	-0.08	(0.24)	0.14	(0.39)
Age of household head	0.00	(0.51)	-0.01*	(0.04)
# of males over 65 in hh	0.04	(0.54)	0.12	(0.43)
# of females over 65 in hh	-0.10*	(0.06)	0.13	(0.28)
# of adult males under 65 in hh	0.01	(0.69)	-0.01	(0.88)
# of adult females under 65 in hh	-0.01	(0.59)	0.05	(0.30)
# of children under 12 yrs in hh	-0.03**	(0.02)	0.00	(0.93)
Mortality in HH, past 2 yrs (=1)	-0.06	(0.23)	-0.03	(0.82)
Avg. nominal maize price for 6 mo's prior to planting season: (kw/kg) at district level: (May - Oct)	0.00	(0.41)	-0.01*	(0.06)
Observed commercial fertilizer price at district level at planting season (kw/kg)	0.00	(0.61)	0.00**	(0.05)
Cumulative rainfall during growing season (October to May) in mm	-	-	0.00	(0.55)
Average cumulative rainfall over past 5 yrs in mm	0.00	(0.98)	0.01***	(0.00)
Std dev of 5yr avg cum. Rainfall	0.00	(0.42)	-0.01***	(0.00)
Interaction: subsidized fertilizer t-3 * (=1) if t-3 is 2002/03	0.00	(0.63)	0.00	(0.17)
Year dummy 2009 (=1)	0.00	(0.97)	-0.29	(0.36)
Northern region (=1)	-0.07	(0.21)	-	-
Central region (=1)	-0.04	(0.27)	-	-
Number of Observations	2,732		2,732	
R-squared	0.07		0.05	

Note: *, **, *** indicates that the corresponding coefficients are significant at the 10%, 5% and 1% level respectively; Model for food adequacy estimated via correlated random effects probit and includes household level time averages of every time varying variable other than the year dummy. Model for life satisfaction estimated via fixed effects, region dummies dropped; reduced form residual not found to be significant in either model so it is not included. The variable for the number of years the household has continuously received subsidized fertilizer was not statistically significant in these models so it was dropped from the analysis.