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Chirwa, Themba G.

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Themba Gilbert Chirwa*[a]

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** Millennium Challenge Account – Malawi (A Project under Ministry of Finance), P. O. Box 31513, Lilongwe, Malawi, Central Africa*

Abstract

Several evaluations have been conducted to assess the impact of agricultural input subsidies in Malawi but have been mostly either descriptive or qualitatively inferred of the intervention impacts on the overall goal of the subsidy program. In most studies cited in this paper their approaches do not control for misspecification errors that might arise due to selection bias. One common erroneous approach is the lack of controlling for treatment effects. In this study we employ quasi-experimental econometric techniques using propensity scores to control for selection bias by creating control groups for those individuals that benefit from agricultural input subsidies. The study utilizes raw household data from two surveys conducted through the Malawi National Statistical Office in 2004/05 and 2006/07 production seasons. A household model for each dataset is estimated together with Average Treatment Effects on the Treated to assess the impact of targeted fertilizer input subsidies in 2004/05 and a refined program adopted in 2006/07 production periods. The evidence suggest that the starter pack or targeted input program implemented before 2004/05 focusing on one tenth of a hectare had a significant negative impact on household food expenditures compared to the refined program in 2006/07 that targeted about half a hectare for marginalized smallholder farmers. The latter, though portraying mostly insignificant results, showed positive impacts on household food expenditures. The approach adopted also proposes ways in which policy makers can effectively and independently evaluate the impact of public programs on social and economic welfare.

JEL Classification: C31, D13, H23, H43, I38

Keywords: Fertilizer Subsidies; Propensity Scores; Logit; Nearest Neighbor; Stratification; Kernel; Radius; Complex Survey Design; Average Treatment Effects on the Treated

[a] The views expressed in this paper are those of the author not affiliated to any institution. Email address: themba.chirwa@mca-m.gov.mw, Phone (265) 888-511-848, Fax (265) 1-774-302

1.0 INTRODUCTION

Almost 85% of Malawi's population belongs to farm (peasant) households and agricultural production and productivity are often importantly dependent on their performance as farmers. Malawi, being labor intensive, the importance of these farmers is often underestimated and understanding the determinants of their welfare, functionality of markets in their communities and which interventions are more effective in improving their livelihoods are of vital importance both to Government and policy makers. Understanding this approach helps policy makers in developing strategies of poverty alleviation that seek to address all problems faced by peasant farmers.

However, once such strategies are developed they are faced with lack of sustainability partly because there is failure to understand how *agrarian* institutions work and how to promote such agrarian societies up the life cycle ladder. Some of these problems arise due to lack of an understanding that peasant households are single institutions where decisions are made holistically on production, consumption and reproduction over time (Sadoulet and de Janvry, 1995). These decisions require the functioning of markets within and outside their social stratum.

In this case, the problem to be solved is two-fold: one need to understand why households are always semi-commercialized in the sense that, even when markets are working, they still keep part of their production for home consumption or utilize part of their household labor for their own use. Secondly, on the markets, one needs to understand why markets fail in forming backward and forward linkages to the household entity. As we will see in later sections, the failure to comprehend these two important questions necessitates the formulation of poor policies that do not maximize the utility of the householder's social welfare function.

This failure is partly attributed to erratic prices for different agricultural commodities and lack of information whereby supply and demand schedules are always going in opposite directions. In an ideal world where all markets work, linkages between production and consumption decisions are found at the level of income (capitalist market). When not all markets are functioning, the forward and backward linkages do not exist and interrelations are directly related to production and consumption decisions. It is the latter that affect most Malawian farmers and the impact of most Government-led interventions targeting the poor household are met with a complex set of problems that make the programs/projects unsustainable. For instance, a program may target farmers in rural areas by providing irrigation equipment but if no market exists for the produce, the program becomes unsustainable.

The agricultural system in Malawi is seasonal and several months in a given year are left idle or farmers have to seek alternative ways of generating income for their survival. Government interventions in this case become very important to boost the income of the household in lean periods. Government either would initiate a public works program or provide safety nets that target marginalized smallholder households. However, the creation of favorable markets has been overlooked and the emphasis on social programs have derailed government's role of creating a macroeconomic environment suitable for private-sector led growth towards targeting the income function of the poor. This becomes unsustainable and wrought to underrate government's facilitative role.

The study objectives, therefore, are twofold. The first one seeks to evaluate government interventions using quasi-experimental econometric or treatment evaluation techniques that focus on evaluating periodic panel datasets with the aim of assessing intervention effects on the goal of a given program. Secondly, to provide evidence that focusing more on programs

or interventions aiming at correcting market failures outweigh the importance of short-term interventions to selected households.

The sections of the paper are as follows: section 2 explores the background of government policies in Malawi including interventions adopted. Section 3 looks at literature review. Section 4 outlines the methodology to be adopted in this paper. Section 5 looks at results and findings. Lastly, section 6 concludes and provides recommendations for future policy interventions.

2.0 BACKGROUND TO THE STUDY

Since 1964 when Malawi attained her independence from the British Protectorate, government policy formulation was guided by central planning strategies aimed at promoting sustained economic growth and transforming the nation from a poor country to a relatively middle-income, industrialized, nation. The paradigm of development economics during the 1960s was Rostow's (1960) growth theory that focused primarily on the agricultural sector. The agricultural sector was seen as the '*take off*' point towards an industrialized nation and the top priority for the Malawi Government was to raise agricultural productivity (DEVPOL; 1971-80)[1]. In Malawi between 1974 and 1979 this approach resulted in an average real gross domestic product growth of 6.0% per annum.

The key driver during this period was the agricultural sector that benefited from subsidized inputs such as fertilizer through state-owned enterprises. The emphasis on agriculture was based on the *comparative advantage paradigm* in that Malawi was seen to have abundant natural resources (land) and a bulk of labor supply. The obvious logic was then to follow *labor-intensive* production techniques so that the country could reap its benefits from

[1] DEVPOL refers to 'The Statement of Development Policies in Malawi, a document prepared by then the Office of the President and Cabinet, Economic Planning Division.

utilizing fully both its abundant labor and natural resources. Additional investments to support the growth theory and address market failures were to improve on infrastructure development especially on transport and commercial markets paving the way for private sector development.

The industrial structure in the 1970s comprised of Parastatals or Government/state-owned companies with the aim of adding-value to the raw produce made by smallholder farmers. Examples of such companies include the Agricultural Development and Marketing Corporation (ADMARC) who owned some processing plants such as cotton ginneries; the Press Corporation Limited, who owned several companies in fisheries, bakery, and sugar processing (ethanol); Grain and Milling Company that processed maize and other leguminous plants, among others.

As a prerequisite for future development of transforming the country from a peasant economy to an industrialized country, the Malawi government in the 1970s laid foundations on the fiscal front and significant achievements where realized. These included a rapid reduction in the budgetary deficit and reliance on foreign budgetary aid. The overarching performance was partly a result of sound macroeconomic management by the government due to controlled government budget deficits averaging 10.0% of GDP, low inflation, good and reliable weather conditions, and ready export markets of key agricultural exports such as tobacco, tea and sugar on the international scene (DEV POL, 1987-96).

The *trickle down effect* from such an approach was that government believed the rate of agricultural growth would largely determine and feed into the rate of growth in the manufacturing sector. In other words, there were *backward* and *forward* linkages to be realized by creating vertically integrated industries and the productivity of smallholder farmers was significant to such developments. However, the Malawi Government envisaged

that such agricultural projects would only affect directly a minority of the population (smallholder farmers) and that even less people would be able to find an appropriate wage employment (DEVPOL, 1971-80) – *a decision in my own view that first created the problems that Malawi is currently facing*. This moved the emphasis from private-sector led growth towards a more socially oriented policy with special emphasis on poverty alleviation as opposed to poverty reduction through necessary means.

The structure of the industrial base was categorized into food processing, textiles, tobacco and tea processing and there were improvements in capacity utilization and profitability in almost all firms (DEVPOL, 1987-96). To support these improvements, the Malawi Government had made important developments that were necessary and vital for private sector development in the 1970s and included the construction of new and improved roads, a new railway line, a hydro-electric scheme and a university for human resource development (DEVPOL, 1971-80). The constraint at this stage, however, was that the industrial base was still in its infant stage and comprised of a small number of firms that were either controlled by parastatals or multinational companies that needed some form of government protection.

Nevertheless, no significant investments such as roads, electricity, water and information, communication and technology (ICT) were made to attract private firms to invest in rural areas where the hub of most agro-processing resided. As of 2004, the poverty headcount based on kilocalorie household expenditures was at 45.39% (48.49% in rural areas). Access to electricity still remained negligible of which only 6% of the national population had access to electricity for lighting (less than 2% in rural areas) and less than 2% (0.36% in rural areas) used electricity for cooking. Access to better roads was also marginal representing 17% in rural areas.

Table 1: Household Basic Statistics based on IHS2 Data – 2004/05

	Statistic	Percent		
		National	Rural	Urban
Poverty based on kilocalorie household expenditures	Headcount Ratio	*45.39*	*48.49*	*22.57*
	Extreme Poverty Headcount Ratio	*11.18*	*12.16*	*3.95*
Access to Electricity	for lighting	*5.67*	*1.88*	*31.60*
	for cooking	*1.59*	*0.36*	*10.00*
Access to Roads	Tar/Asphalt Graded	*14.94*	*16.97*	*1.04*
	Graveled	*21.25*	*14.81*	*65.28*
	Dirt Road (Maintained)	*44.60*	*48.57*	*17.50*
	Dirt Track	*19.21*	*19.65*	*16.18*

The DEVPOL (1987-96) recognized that the most significant economic development in the 1970s was the acceleration of instability and insecurity of the Malawian economy mainly from external shocks and concerns were now towards stabilization policies. In the early 1980s most African countries began to adopt the World Bank (WB)/International Monetary Fund (IMF or the Fund) Structural Adjustment Policies (SAPs) and Poverty Alleviation Programmes (PAP) designed to provide loans to affected less developed countries to mitigate the consequences of the aftermath of the shocks (Tarp, 1993; Franses, 1995).

With pressures from international financial institutions, Malawi liberalized the input markets to some degree as part of the structural adjustment programs (SAPs) propagated by the Washington Consensus. In the mid-1990s Malawi eliminated universal fertilizer subsidies for smallholder farmers only to see a reintroduction of the program with limited subsidies in 1998 through the '*Starter Pack program*'. This gave smallholder farmers, free of charge, 10-15 kg of fertilizer and enough hybrid seed to cultivate approximately 0.1 hectares of farm size. In 2001, the Starter Pack program was downgraded to a Targeted Input Program which distributed the same quantities of fertilizer and seed to groups of targeted farmers.

Current Policies in Malawi

The economic history of the Malawian economy since independence can be summarized in three stages: the first period (1964-1980) is regarded as a period of '*economic growth with trickle down effects*'. The second period (1980-1996) was a period of '*economic growth with poverty alleviation*'. The third period (1996-2004) economic paradigm was that of '*poverty reduction and empowerment*' which was implemented through the Poverty Reduction Strategy (PRS) concept propagated by the Breton Woods Institutions.

At the completion point for the Malawi Poverty Reduction Strategy (MPRS) in 2003/4, the Malawi Government replaced the MPRS with the Malawi Economic Growth Strategy (MEGS). The MEGS was designed after government realized that the MPRS pillar of rapid sustainable pro-poor growth did not lead to sustainable economic growth. The MEGS was implemented in 2004 and the economy was still susceptible to external shocks such as weather, changes in terms of trade, oil shocks, political developments and fluctuations in foreign aid. Instead, MEGS accentuated on private sector development focusing primarily on spreading the risk in key sectors such as agriculture (tobacco, tea, coffee, cotton, etc.), mining, tourism and manufacturing.

To consolidate the MEGS government in 2005 designed the Malawi Growth and Development Strategy (MGDS) in order to incorporate social policy issues. The MGDS is a five-year strategic plan (2006-2011) that comprises of two parts; the '*growth*' strategy, which emphasizes creating conducive environment for private sector development, and the '*development*' strategy, focusing on social factors. The main agenda of the MGDS is to revive the economy through sustainable economic growth and infrastructure development targeted to create wealth and reduce poverty that Malawi has faced for several decades.

3.0 LITERATURE REVIEW

It has been noted that different researchers often ask the wrong questions and use wrong methodologies when assessing agricultural empirical questions that target the poor or less privileged in any given society. In any assessment of a public program or intervention seeking to improve a given social welfare function of the disadvantaged groups, it is important to ask the question whether the targeted beneficiaries were better or worse off after the intervention was implemented. It becomes irrelevant, in my view, to consider the cost implications of such interventions especially when the intervention proved to be a success. With regard to the second Pareto Optimality principle[2], Government's role is to redistribute wealth and if such distribution is done in a transparent and accountable manner without making other players worse off that would be an added advantage. On the issue of methodology, Lalonde (1986) argues that standard non-experimental techniques such as regression, fixed effects, and latent-variable selection models are either inaccurate or sensitive to model specification.

Other researchers have attempted to compare smallholder farmers with commercial farmers in which those who received subsidized fertilizers have been compared with yield responses of farmers who pay commercial prices (Ricker-Gilbert et. al, 2009). This depicts a lack of understanding of how smallholder households behave. According to Sadoulet and de Janvry (1995), on one hand, smallholder farmers are usually semi-commercialized and usually production is at a subsistence level. They only sell if they have excess production and this depends on their production and consumption needs.

[2] The second theorem of welfare economics states that if all consumers have convex preferences and all firms have convex production possibility sets, any Pareto efficient allocation can be achieved as the equilibrium of a complete set of competitive markets after a suitable redistribution of initial endowments (Gravelle and Rees, 2004)

Secondly, for one to make such a comparative analysis it has to be done at a similar level playing field. For instance, access to effective and efficient agricultural extension services, educational programs, market and transport systems and credit markets are vital and necessary components if we are to compare commercial and smallholder farmers. Commercial farmers are usually strategically positioned and can easily access these basic services. They usually have access to skilled personnel that are well conversant with latest technologies of improving agricultural production. As such, utility functions for smallholder and commercial farmers are incomparable.

Therefore, arguments that assume that smallholder farmers who receive subsidized inputs at discounted prices through the Government may obtain similar output responses as commercial farmers may be an assumption that does not reflect reality. This hypothesis on its own is an oversimplification and would lead to gross measurement errors and model misspecification. This approach would and has always led to the non-acceptance on the use of input subsidies and thus has confused policy makers and development partners of the need to subsidize inputs to the underprivileged or marginalized groups.

It also follows that a smallholder farmer will only have an incentive to use a productive asset as efficiently as possible regardless of the purchasing price if and only if the farmer has access to the same conditions faced by commercial farmers. In this case, access to knowledge, information and years spent on education become important. Some studies, for example, have found that fixed costs (distant to market) and variable costs (price per unit) may affect market participation (Key et al, 2000; Bellemare et al, 2006). Others have also shown that access to credit and insurance may be constraints being faced by farmers in order for them to purchase inputs at reasonable prices (Kherallah et al, 2000; Croppenstedt et al, 2003; Jayne et al, 2003).

Another misconception that is frequently being abused is the combination of a social welfare function with profit-maximizing behavior. Gregory (2006) argues that input subsidy vouchers are an income transfer to the farmer from Government, donor or any other implementing agency but also a transfer that can be realized through private sector participation (see also Kelly et al, 2003). This assumption, however, has its own problems and in this paper we identify two.

Firstly, the role of Government is to raise taxes from private entities and distribute wealth to marginalized households or communities. Since private sector entities are profit driven and liable to additional taxation, the process affects the '*laissez-faire*' assumption of the free operation of market forces and becomes one that continuously add transaction costs that become unsustainable rendering the intervention too expensive to public coffers. Government comes in to correct a market failure – a failure that was created by the private sector in the first place that profiteers a social good. Secondly, since other factors such as access to basic services may affect the distribution of agricultural inputs to smallholder farmers, the involvement of private sector participants creates *rent-seeking behavior* amongst private players as the business involved is risk-free guaranteed by Government thereby adding more on the transaction costs.

As Shultz (1945) indicates, smallholder farmers in developing countries may be poor but efficient. It, therefore, depends on the quality and quantity of agricultural inputs being supplied to the targeted beneficiaries and whether they would have access to the same privileges that a normal commercial farmer would receive. As Kelly and Murekezi (2000) and Duflo et al (2008) note, application of fertilizer in maize, for example, improves the yield if the application is made in right quantities and using the correct methods. In other words, the rate of return to fertilizer application is positive but varies by region.

The other mistake that researchers make is to employ panel data sets which may have been developed using different set of conditions. Therefore, any assessment of the impact of fertilizer subsidy before and after an intervention is made, for example, cannot be justified by looking at different periods or time series but rather creating a counterfactual within the same period. This reduces potential selection bias by utilizing the same dataset to create a control group (Dehejia and Wahba, 1999; Browyn and Maffioli, 2008).

To substantiate this argument, the targeted input program (TIP) that was implemented in 2001 gave farmers, free of charge, 10-15 kg of fertilizer and enough hybrid seed worthy to plant 0.1 ha of land. Creating panel data that overflows to the period when the new Government in 2005/06 introduced an Agricultural Input Subsidy Program (AISP), using the voucher system by giving marginalized farmers 100 kg worth of fertilizer and a sizeable amount of seed, would distort the results culminated with measurement error as the two programs are totally different.

As evidenced by Ricker-Gilbert et al (2009), one problem could be that the same respondents have different farm size within and between agricultural seasons. Thus, in order to avoid such plot-level unobserved heterogeneity, the study considers seasonal analysis in order to contain for any measurement errors. Recent econometric tools are available to make such an assessment and it is this approach that will be adopted in this paper in order to assess the effectiveness of public interventions targeting the poor.

4.0 METHODOLOGY

The problems assessed in sections 1-3 above in evaluating the impact of interventions on input subsidies in Malawi warrant different methodologies to be looked into. It is more relevant to assess the impact of an intervention based on ‘with or without’ the intervention scenario of the sample or population that benefited from the project. As Browyn and Maffioli

(2008) notes, this provides a rigorous strategy of identifying statistically robust control groups on non-participants. Though the ideal evaluation of an intervention necessitates the creation of a treatment of control group, this approach cannot be applied on human beings prior to the beginning of the intervention.

Rosenbaum and Rubin (1983) proposed '*propensity score matching*' (PSM) as a method that can be used to measure the impact of interventions on outcomes of interest. Propensity score matching is a method used to reduce selection bias in the estimation of treatment or intervention effects with observational data sets. The methodology developed is used to assess a counterfactual in a given set of observational data just like in any scientific experiment where the same sample can be used to assess the impact on the outcome if the treatment was not administered. Unlike interventions made on human beings, it is not likely that an intervention can be administered in one case and also assess the outcome on the same individual if the intervention was not administered, hence the need for propensity score matching.

The effect of treatment evaluation on policy formulation is direct because if an intervention is successful it can be linked to desirable social programs or improvements in existing programs through reviews. The aim of adopting such a process is to enable policy makers attain the objectives or goals of the intervention. According to Cameron and Trivedi (2005), the standard problem of treatment evaluation involves the '*inference of a causal*' connection between the treatment and the intended outcome. Therefore, for a given intervention, we observe the following:

$$\left(y_i, \mathbf{x}_i, D_i\right),\ i = 1,...,N \qquad (1)$$

In equation (1), y_i is the dependent variable or outcome of interest, $\mathbf{x}_i$ is a vector of independent variables and D_i is a binary variable indicating whether the treatment was given to an individual or not. The binary variable takes the following form:

$$D_i = \begin{cases} = 1 & \text{if intervention occured} \\ = 0 & \text{Otherwise} \end{cases} \qquad (2)$$

It is the impact of a hypothetical change of D_i on y_i, holding the vector constant $\mathbf{x}_i$, that is of interest. In this case, the outcome y_i is compared to the treated and non-treated states. Since no individual is simultaneously observed in both states we cannot use the ones who did not receive the treatment in the sample as a counterfactual. As such the situation becomes one of a 'missing data' state. The method of causal inference can be tackled by creating a counterfactual. Therefore, the question we tackle when applying PSM is to assess how the outcome of an average *untreated* individual would change if such a person did not receive the intervention.

Treatment Effects Framework

The idea of measuring the effect of a treatment or intervention requires constructing a measure that compares the average outcomes of the treated and non-treated groups. Rosenbaum and Rubin (1983) define a propensity score as a conditional probability of receiving a treatment given pre-treatment characteristics. Rosenbaum and Rubin show that if the exposure to treatment or an intervention is random within cells defined by the vector $\mathbf{x}_i$, it is also random within cells defined by the values of the propensity score. Therefore, given a population or sample of units i the propensity score or the conditional probability of receiving a treatment given $\mathbf{x}_i$ is:

$$p(\mathbf{x}) = \Pr\{D = 1|\mathbf{x}\} = E[D|\mathbf{x}] \tag{3}$$

Once propensity scores are known, we then can calculate the *Average effect of Treatment on the Treated* (ATT) as follows:

$$\begin{aligned} ATT &= E\{y_{1i} - y_{0i}|D_i = 1\} \\ &= E\{E\{y_{1i} - y_{0i}|D_i = 1, p(\mathbf{x})\}\} \\ &= E\{E\{y_{1i}|D_i = 1, p(\mathbf{x})\} - E\{y_{0i}|D_i = 0, p(\mathbf{x})\}|D_i = 1\} \end{aligned} \tag{4}$$

In equation (4), y_{1i} assumes if individual receives a treatment or intervention and y_{0i} is a counterfactual if the same individual receives no treatment. This hypothesis requires two key assumptions namely: the *conditional independence* assumption and the assumption of *unconfoundedness*.

The first assumption states that conditional on $\mathbf{x}_i$, the outcomes are independent of treatment. In other words, participation in the program intervention does not depend on the outcome. Mathematically, the representation states that the intervention outcomes are orthogonal of treatment conditional on the covariates given as follows:

$$y_0, y_1 \perp D|\mathbf{x} \tag{5}$$

The unconfoundedness assumption, which in some cases is referred to as the Balancing condition, is necessary if we are to identify some population measures of impact (Rosenbaum and Rubin, 1983; Cameron and Trivedi, 2005). Given the overlap or matching assumption in equation (3), the assumption in equation (5) ensures that for each value of the vector $\mathbf{x}_i$, there exist both treated and non-treated cases. The propensity score measure can be computed given the data $(D_i, \mathbf{x}_i)$through either a probit or logit regression. The selection of variables

within the vector $\mathbf{x}_i$, may be based on policy intervention selection criteria. For instance, an intervention targeting a certain population may be defined based on observable human characteristics (age, gender, socioeconomic status, etc.). Thus, for the unconfoundedness assumption, it states that given the propensity score:

$$D \perp \mathbf{x} | p(\mathbf{x}) \tag{6}$$

Equation (6) states that for individuals with the same propensity score, the assignment of an intervention is orthogonal or random. Thus, with the balancing condition, the conditional independence assumption given $\mathbf{x}$ implies conditional independence given $p(\mathbf{x})$:

$$y_0, y_1 \perp D | \mathbf{x} \Rightarrow y_0, y_1 \perp D | p(\mathbf{x}) \tag{7}$$

Based on the above set of assumptions, the PSM technique employs *predicted probability* of group membership – that is, treatment versus non-treatment group – based on observed predictors usually obtained from a probit or logistic regression to create a counterfactual group.

Matching using Propensity Scores

Using calculated propensity scores as defined in equation (3) is not enough to estimate average treatment effects of an intervention (Dehejia and Wahba, 1999; Cameron and Trivedi, 2005; Becker and Ichino, 2009). The reason is that the propensity score is usually a continuous variable and the probability of observing two units with exactly the same propensity score is in principle not possible. A number of methodologies have been proposed in the literature with the aim of overcoming this problem (see Cameron and Trivedi, 2005). In this evaluation exercise, however, we will consider only four most common methods widely

used: nearest neighbor matching, radius matching, kernel matching and stratification or interval matching[3].

Methods and Application

Thus far, we have outlined one of the effective ways of assessing any program interventions made either by Government, donors, or implementing agencies on a desired outcome or goal. Policy makers ought to know whether their interventions have been successful or not before formulating another intervention. Employing treatment evaluation techniques provides such leverage.

In this study, we employ treatment evaluation methods to assess the impact of input subsidy programs in Malawi. We use random data collected by the National Statistical Office (NSO) to assess the impact of two interventions: the Targeted Input Program (TIP) that ended in 2004/05 fiscal year and the Agricultural Input Subsidy Program (AISP) that commenced immediately after in 2005/06 fiscal year. The data was collected in 2006/07 fiscal year by the NSO through a special survey called the Agricultural Input Subsidy Survey (AISS). The TIP will be assessed using the Integrated Household Survey 2004/05 (IHS2).

Model Specification

The Malawi Government in fiscal year 2005/06 introduced the AISP, following a poor harvest in fiscal year 2004/05. The AISP increased the quantity of fertilizer given to smallholder farmers to 100 kg of basal and top dressing fertilizer worth of cultivating an acre of farm land and 10 kg of hybrid seed to plant on the same farm size. The TIP program offered 10-15 kg of fertilizer and about 1 kg of hybrid seed worth of cultivating 0.1 hectares

[3] Details on how these matching estimators are calculated can be found in Cameron and Trivedi, 2005, p.871-879

of farm land. The AISP in 2005/06 extended input subsidies to tobacco smallholder farmers but was later dropped in the 2006/07 planting period.

The main objective of the input subsidy programs before and after 2004/05 was to increase agricultural productivity and food security. In particular, the program aimed at improving land and labor productivity and production of both food and cash crops by smallholder farmers that faced heavy cash constraints restraining them from purchasing the necessary inputs (Dorward et al, 2008). The overall goal of the program was to promote economic growth and reduce vulnerability to food insecurity, hunger and poverty. The AISP was implemented through the distribution of fertilizer vouchers of which the beneficiary had to contribute MK950 per voucher of fertilizer and exchange a voucher of seed free of charge. In later years, the contribution made by beneficiaries reduced to MK500 in 2009/10 fiscal year. In comparison to the TIP program, targeted smallholder farmers were given all inputs free of charge but in small quantities.

To assess the impact of such interventions in the given seasons or fiscal years, we will employ an empirical model on food security. The model adopts Sadoulet and De Janvry (1995) household model with less efficient markets where the household problem is to solve simultaneously allocation of resources between production, consumption and work decisions given household characteristics. In its structural form, the household problem is to maximize utility $u(\cdot)$ with respect to consumption and work decisions subject to a given production function $g(\cdot)$ and household characteristics:

$$\begin{aligned} \max_{q_a,x,l,c_a,c_m,c_l} &= u\left(c_a, c_m, c_l; \mathbf{z}^h\right) \\ s.t. \quad & g\left(q_a, x, l, \mathbf{z}^h\right) \end{aligned} \tag{8a}$$

In equation (8a), utility is maximized given consumption goods (agricultural goods c_a and manufactured goods c_m), home time c_l and household characteristics $\mathbf{z}^h$ subject to a household production function q_a and a set of fixed and variable inputs (x,l). The empirical model assumes a linear function and in a reduced form format:

$$y_i = y_i(\mathbf{G},\mathbf{P},\mathbf{H},\mathbf{E},\mathbf{C},\mathbf{W},\mathbf{S},\mathbf{L}) \quad (8b)$$

In equation (8b), y_i is the outcome of interest – kilocalorie consumption per household; **G** is a vector of government interventions (starter pack program or TIP of 2004/05, agriculture extension services, Agricultural Input Subsidy Program of 2006/07); **P** is a vector of prices (tobacco auction price, maize grain price, maize flour price, fertilizer, casual labor – supply and demand prices, charcoal, transport, and price index of other consumables); **H** is a vector of household characteristics (age, gender, education, health status, sources of lighting and cooking, farm size, livestock assets, access to portable water, wellbeing); **E** is a vector of economic variables (market access, distance to market, area of residence, access to road surface); **C** is a vector of community characteristics (belonging to an association/cooperative, access to agricultural credit, irrigation scheme, access to small and large markets): **W** is a vector of weather conditions (availability of rain); **S** is a vector of seasonal effects (lean period, dry period, harvest period, year of interview); and **L** is a vector of location effects (agricultural division).

Data Management

The study utilizes raw household data from the 2004/05 second Integrated Household Survey (IHS2) and the 2006/07 Agricultural Input Subsidy Survey (AISS). The AISS is a follow-up panel data survey of households interviewed during the IHS2 survey. The variables within each vector of interest of the household model in equation (8a) and (8b) are calculated and

averaged over districts. The prices calculated are district averages from both household and community databases. A number of robustness checks are conducted which include controlling for outliers, management of duplicate records and conducting principal component analysis to create a livestock index.

The two datasets created are used to estimate a parsimonious specification of the household model in order to assess the basic determinants of household expenditure on food. Our variable of interest in the two models to be estimated is on the impact of the input subsidy programs on household food expenditure. We will investigate whether access to input subsidies at varying quantities were effective in increasing household food consumption.

The next section outlines diagnostic checks for omitted variables, functional form, heteroskedasticity and collinearity. After correcting for these checks, we estimate the household model using complex survey design techniques. Average Treatment Effects on the Treated (ATT) are also calculated to determine the effectiveness of the two input subsidies through the use of propensity scores. The calculation of propensity scores to assess the '*with and without*' intervention on the input subsidy beneficiaries are based on the input subsidy beneficiary selection criteria: *gender*, *household age* and whether the householder is considered *poor* or not. The preferred software for our analysis will be done using STATA.

The study presents ATT results based on four common matching mechanisms: nearest neighbor, kernel, stratification and radius matching techniques. We will utilize algorithms developed by Becker and Ichino (2009) that calculates ATT based on these matching methods. The results enable us to present a range of intervention effects of input subsidies on household food expenditures. Usually the variable of interest (or hypothesis test) is expected to contribute positively to food consumption as it is aimed at adding more to the food consumption basket.

Robustness Checks

The following table presents robustness checks on the data for the two models to be estimated.

Table 2: Robustness Checks on Survey Data

Robustness Checks	Null Hypothesis	Statistic	Model 1:	Model 2:	Conclusion
Ramsey RESET test using powers of the fitted values of dependent variable	Model has no omitted variables	F-statistic p-value	184.54 0.0000	40.1 0.0000	Reject null hypothesis. However dataset has limited observations
Functional Form and Heteroskedasticity using Cameron and Trivedi decomposition of IM-test	Heteroskedasticity Skewness Kurtosis	p-value p-value p-value	0.0000 0.0000 1.0000	0.0000 0.0000 1.0000	Reject but not for kurtosis. For skewness transform dependent variable to log form
Breusch-Pagan/Cook-Welsberg test for heteroskedasticity	constant variance	chi2 p-value	10550.27 0.0000	2040.06 0.0000	Reject & report Huber/White heteroskedastic-consistent standard errors: weighted least squares
Test for Multicollinearity using Variance Inflation Factors	No Multicollinearity	mean VIF	20.16	5.44	Drop some variables in both models and form principal components
Design Effect			SVYSET	SVYSET	Use Complex Survey Design

We first check whether the models have no omitted variables. We use the Ramsey RESET test using powers of the fitted values of the food expenditure dependent variable. The results show that the two models are affected by omitted variables. Since the two datasets are limited on the number of variables that can be created we still estimate the models given the present variables.

On functional form and heteroskedasticity, we use Cameron and Trivedi decomposition of the IM test that tests for heteroskedasticity, skewness and kurtosis. The results for both models suggest that there are problems of heteroskedasticity and skewness. We will therefore, use weighted least squares and a log-linearised model to correct for skewness.

The Breusch-Pagan/Cook-Welsberg test is used to test for overall heteroskedasticity in the two models and results show that both models are affected by heteroskedasticity. This further substantiates the need to report Huber/White heteroskedasticity consistent standard errors.

Finally, we test for multicollinearity on the variables of interest using variance inflation factors (VIF). In both models there is evidence of multicollinearity and such variables are dropped. One common variable in both equations is the square of household age.

Data Description – Complex Survey Design

The first data collected under the IHS2 used complex survey design methodologies. The first stage involved creating primary sampling units (PSU) using 564 Enumeration Areas (EA). Each EA was randomly selected from each strata (district) on the basis of probability proportional to size. Twenty (20) households were randomly selected from each PSU based on household population. The IHS2 database is a panel dataset that covered two growing seasons in Malawi. Some information collected in 2004 was based on crop production and input use from the 2002/03 production season and the data collected in 2005 was based on crop production and input use during the 2003/04 production season.

A follow-up survey was conducted in May/June 2007 re-interviewing 3,298 households in 175 EAs. Out of this sample, 2,874 households were previously interviewed in the IHS2 survey. This dataset will be referred in this study as the AISS. The survey design process was the same as the one adopted under IHS2. After controlling for duplicate records, the AISS sample size was reduced to 2,937 households of which 1,205 households reported to have benefited from the input subsidy. Based on this response, 57% reported receiving both 100kg basal and top dressing fertilizer through the Government Agricultural Input Subsidy Program (AISP). The analysis of the impact of the AISP will therefore be based on respondents who received 100kg of fertilizer based on the goal of the AISP.

The 2006/07 AISS database has a lot of missing values which constrains the analysis to only those variables that can be used to estimate the household model. In order to complement some of the missing variables, the study uses 2004/05 IHS2 estimates on some key variables such as food consumption expenditure. The 2004/05 food expenditure data is projected using real GDP growth rates commencing 2003/04 production season to 2006/07 production season. In addition, some of the basic services will be assumed to have remained constant in 2006/07 as they were before in 2004/05. Such variables include community based variables such as access to safe water, electricity, distance to and availability of markets in the community, among others.

5.0 MODEL ESTIMATION AND RESULTS

The results for the estimated models are given in tables 6 and 7 (see annex II) together with the estimated ATT for the input subsidy intervention based on Becker and Ichino (2009) algorithms. Table 8 and 9 (see annex III) present detailed ATT estimation using matching mechanisms and shows the number of treated and control groups for each methodology adopted. The estimated numbers of blocks and propensity score estimation results are given in tables 10 and 11 (annex IV) based on the common support approach. After controlling for complex survey design, the results after estimating a log-linear function with food expenditure as the dependent variable show that the Starter Pack (TIP) program had a significant negative impact of approximately 0.07 (7%) or reduced food expenditures by MK1,097.00 (1,097 Malawi Kwacha).

Overall the results obtained after controlling for treatment effects (nearest neighbor, stratification, radius and kernel matching) taken together, also give evidence of a significant negative ATT in the range of MK403-MK2922 associated with the TIP subsidy when evaluated with non-experimental or without intervention comparison groups. Note that the

ATT results are close to the coefficient estimate for the TIP impact given in our household model of MK1, 097[4]. The results also concur with evaluations made by government and some researchers on the TIP subsidy as not being effective in reducing poverty and food insecurity (Dorward et al 2008; Ricker-Gilbert et al 2009).

The second model assumes the same structure of the household model given in equations (8a) and (8b). Due to incoherent and inconsistent variables tracked in the 2006/07 follow-up survey, some of the vectors in the second model have reduced the number of variables than in the first model on TIP subsidy. Some common variables such as access to markets within communities, access to roads, main source of lighting and cooking are assumed to be constant in 2006/07 as they were during the 2004/05 IHS2 survey. The dependent variable on food expenditures is projected based on real GDP growth rates experienced since 2003/04 to 2006/07 fiscal years. The impact of the AISP will thus be assessed on whether it was effective in positively contributing to increased food expenditures in 2006/07 production year.

The survey design process of the 2006/07 AISS followed a complex survey design and we will use the same modeling as in the first model. Table 7 reports the results and the test statistics. Though the results show insignificant results on the effectiveness of the AISP in improving food security, the sign of the coefficients are positive indicating that the new approach adopted by Government in 2005/06 and continued during the 2006/07 positively contributed to reducing food insecurity by increasing household food consumption.

The second household model results show that those who benefited from the full subsidy of the AISP, though insignificant, had a positive contribution of MK148 towards food

[4] Note that the coefficient estimates in log-terms given in table 1 and 2 are transformed using the exponential function.

expenditure than those who did not benefit from the AISP. Overall, the results obtained after controlling for ATT also give evidence that for those who received a full subsidy from Government had a positive impact in the range of MK74 to MK8,955 associated with the 2006/07 AISP when evaluated without the intervention comparison group. However, the results presented may be subjected to misspecification errors due to lack of data and appear to be sensitive if some of the variables are included (e.g., TIP in 2004 or total income in 2006/07). One of the key contributing factors could be the period of the evaluation which was too short (May-July 2007) and a lot of missing values in the dataset.

The study also evaluated the impact of market access on household food expenditures. Four key variables were included in each household model that looked at market access and the effect of distance to the market. The study results show that those who had access to large markets or small markets in their communities in both production years negatively impacted on household food expenditures.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The paper has demonstrated on how we can use treatment effects to evaluate the impact of public interventions based on independent datasets. The study has also employed new algorithms developed by Becker and Ichino (2009) to assess input subsidy effects on household food expenditures. The main conclusions from this study can be summarized as follows: the impact of the input subsidy programs in Malawi becomes stronger as policy makers improve on the quantities of inputs subsidized. There is clear significant evidence of the negative impact of the Starter Pack (TIP) program and some significant evidence on the impact of the AISP on household food security when we use treatment effects at the ten percent significance level. The latter could be a result of the short window given to evaluate the AISP and the numerous missing values of the tracked variables. However, it is expected

that future surveys as organized by the IHS2 may provide positive significant evidence on the effectiveness of input subsidies on household food expenditures.

We have also found that access to basic services in rural areas such as markets negatively impact on the availability of household food security. We conclude that interventions geared towards complementing input subsidies should be supported with interventions aimed at improving basic services such as the development of markets in rural areas. In concluding, we offer a few recommendations based on the results obtained in this study when assessing the impact of input subsidies in Malawi or any other program intervention aimed at improving national economic growth and poverty reduction. Some of the recommendations are based on weaknesses envisaged when evaluating the two NSO survey datasets in this study.

Finally, in order to effectively, efficiently, independently and successfully evaluate public interventions the following recommendations should be adopted by program implementers and collectors of national statistical data:

i) A detailed assessment of the project rationale of a given public intervention policy should be effectively analyzed that includes a description of possible market failures that the intervention could face and would be addressing in the course of implementing the project including the targeted groups expected to address the problem.
ii) A description of short, medium and long term expected outcomes that the intervention aims to address should be provided so that specific surveys can be developed and conducted for each stage of project benefits. To evaluate the impact of a given program, it is the long-term goal that is of interest and key indicators should be developed based on the expected outcomes.

iii) Relevant tracking mechanisms should be adopted to collect primary data on key variables that would be affected by the intervention in question. In most cases a *household model* would be the best starting point of determining the type of information to be tracked and how that dependent variable will be affected by the intervention in question.

iv) In order to assess the impact of public interventions effectively and independently it is important that implementers of such programs should link up with the National Statistical Office personnel in country in order to formulate the type of questions to be tracked as they may provide a '*low cost*' independent platform of collecting the same information by simply including specific '*program intervention*' sections on existing questionnaires that they randomly collect.

v) Follow-up surveys conducted by the National Statistical Office should promote the continuance collection of original questionnaire variables collected in the Integrated Household Survey in order to be able to evaluate the impact of a specific intervention based on the household model. This observation is based on the different sets of variables that were collected in the 2006/07 follow-up survey on assessing the impact of agricultural input subsidies in Malawi that were different from the original IHS2 survey.

vi) Project implementers should also defer from conducting project evaluations on their own and should allocate project costs on evaluation towards assisting data collection by the National Statistical Office. The National Statistical Office has different forms of surveys that are tracked annually including the Welfare Monitoring Surveys (WMS). Project implementers can utilize these datasets as a platform of collecting their annual data independently. The NSO would then be responsible for coordinating the annual flow of funds from these projects towards their independent data collection.

7.0 BIBLIOGRAPHY

Becker, S. O., and A. Ichino (2009), 'Estimation of Average Treatment Effects Based on Propensity Scores', *available at* www2.dse.unibo.it/ichino/psj7.pdf

Bellemare, M., C. Barrett (2006), 'An Ordered Tobit Model of Market Participation: Evidence from Kenya and Ethiopia', *American Journal of Agricultural Economics*, 88(2): 324-337

Browyn, H., and A. Maffioli (2008), 'Evaluating the Impact of Technology Development Funds in Emerging Economies: evidence from Latin America,' a Technical Report *available at* http://hd1.handle.net/10086/15999

Cameron, A. C. and P. K. Trivedi (2005), Microeconometrics: Methods and Applications, New York: *Cambridge University Press*

Croppenstedt, A., M. Demke, M. Meschi (2003), 'Technology Adoption in the Presence of Constraints: The Case of Fertilizer Demand in Ethiopia', *Review of Development Economics*, 7(1): 58-70

Dehejia, R. H., and S. Wahba (1999), 'Causal Effects in Non-Experimental Studies: re-evaluating the evaluation of training programs', *Journal of the American Statistical Association*, 94, 1053-1062

Dorward, A., E. Chirwa, V. Kelly, T. S. Jayne, R. Slater, and D. Boughton (2008), '*Evaluation of the 2006/07 Agricultural Input Subsidy Programme, Malawi*', Final Report, Ministry of Agriculture and Food Security, Lilongwe: March

Duflo, E., M. Kremer, J. Robinson (2008), 'How High are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya', *American Economics Association Meetings*, New Orleans, Los Angeles: January

Franses, S. (1995), Adjustment and Poverty: Options and Choices. *New York: Routledge*

Gravelle, H. and R. Rees (2004), 'Microeconomics', Third Edition, Edinburgh Gate: *Pearson Education Limited*

Gregory, I. (2006), 'The Role of Input Vouchers in Pro-Poor Growth', *Background Paper Prepared for the African Fertilizer Summit*, Abuja, Nigeria: June 9-13

Jayne, T. S., J. Govereh, M. Wanzala, M. Demke (2003), 'Fertilizer Market Development: a comparative analysis of Ethiopia, Kenya and Zambia', *Food Policy*: 28(4): 293-326

Kelly, V. and A. Mukerezi (2000), '*Fertilizer Response and Profitability in Rwanda*', Ministry of Agriculture, Animal Resources and Forestry, Kigali, Rwanda: February

Key, N., E. Sadoulet, A. de Janvry (2000), 'Transaction Costs and Agricultural Household Supply Response', *American Journal of Agricultural Economics*, 82(5): 245-259

Kherallah, M., C. Delgado, E. Gabre-Madhin, N. Minot, M. Johnson (2000), 'Agricultural Market Reform in Sub-Saharan Africa: a synthesis of research findings', Washington D. C.: *International Food Policy Research Institute*

Malawi Government (1971), '*Statement of Development Policies 1971-1980',* Office of the President and Cabinet: Economic Planning Division.

Malawi Government (1987), '*Statement of Development Policies 1987-1996*', Office of the President and Cabinet: Department of Economic Planning and Development

Malawi Government (2002), '*Malawi Poverty and Reduction Strategy Paper',* Lilongwe: Ministry of Economic Planning and Development.

Malawi Government (2006), '*Malawi Growth and Development Strategy: From Poverty to Prosperity 2006-2011*', Lilongwe: Ministry of Economic Planning and Development

Ricker-Gilbert J., T. S. Jayne and J. R. Black (2009), 'Does Subsidizing Fertilizer Increase Yields? Evidence from Malawi', *Selected paper prepared for presentation at the Agricultural and Applied Economics Association 2009 AAEA and ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29, 2009*

Rosenbaum, P., and D. B. Rubin (1983), 'The Central Role of Propensity Score in Observational Studies for Causal Effects,' *Biometrika*, 70, 227-240

Rostow, W. W. (1963). The Economics of Take-Off into Sustained Growth: Proceedings of a Conference held by the International Economic Association. W. W. Rostow (ed.), London: *Macmillan*.

Sadoulet, E., and A. de Janvry (1995), 'Quantitative Development Policy Analysis', Baltimore and London: *The John Hopkins University Press*

Schultz, T. W. (1945), Food for the World. Chicago: *University of Chicago Press*

Tarp, F. (1993), Stabilization and Structural Adjustment: Macroeconomic frameworks for analyzing the crisis in Sub-Saharan Africa. *New York: Routledge*

8.0 ANNEXES

Annex I: Data Description and Sources

Table 3: Data Description from IHS2 Cleaned data.dta

IHS2 Household Level Key Variables
Observations: 11280
Date of Analysis: 2/14/2010 18:59

Variable Name	Variable Label	Binary
TIP	Householder Received a Starter Pack (TIP) as safety net from Government	yes
agext	Field Assistant resides in Community	yes
agextcp	Householder receives advice from field assistant on general crop production	yes
agextsv	Householder receives advice from field assistant on new seed varieties	yes
agextfu	Householder receives advice from field assistant on fertilizer use	yes
agextirri	Householder receives advice from field assistant on irrigation	yes
agextac	Householder receives advice from field assistant on general animal care	yes
agextmkt	Householder receives advice from field assistant on marketing/crop sales	yes
agextcre	Householder receives advice from field assistant on access to credit	yes
p_tobauction	Average price of tobacco in district at auction floors MK/kg	
p_maize	Average price of maize in district MK/kg	
p_fert	Average price of fertilizer in district MK/kg	
p_ganyu	Average hire price of casual/ganyu labor in district MK/day	
p_index	Average price index of miscellaneous consumables	
p_char	Average price of charcoal in district	
p_ker	Average price of kerosene in district	
p_tpt	Average price of transport in district	
p_mflour	Average price of maize flour in district MK/kg	
p_dwage	Average price of casual/ganyu labor in district MK/day	
hhage	Age of Household Head	
fadult	HH: Females 15-64 years of age	
madult	HH: Males 15-64 years of age	
mlgtp	Householder uses paraffin for lighting fuel	yes
mlgte	Householder uses electricity for lighting	yes
mcooke	Householder uses electricity for cooking	yes
mcookf	Householder uses firewood for cooking	yes
mcookc	Householder uses charcoal for cooking	yes
nonlabor	Non-labor income (MK per year)	
fhh	Householder is female (0/1)	yes
yrsed	years of education	
inter	Interaction term between female householder and years of education	
elderly	H: Individuals 65+ years of age	
illness	Householder or wife had a serious illness that prevented participation in activities	yes
farmszpc	Total land holding per person	
l_index	Livestock index based on principal components analysis	

IHS2 Household Level Key Variables

Observations: **11280**

Date of Analysis: **2/14/2010 18:59**

Variable Name	Variable Label	Binary
water	Householder has access to personal water supply	yes
wbeing	Householder considers wellbeing in year improved 0/1	yes
distmkt	distance (km) to nearest daily market	
reside	Urban/Rural dummy	yes
roadbin1	road==Tar/Asphalt Graded	yes
agcredit	Existence of Farmers credit clubs in community	yes
coop	Existence of Farmers cooperatives in community	yes
irriscm	Irrigation scheme in community	yes
mktsmall	Access to a Daily Market in community	yes
mktlarge	Access to a Larger Market in community	yes
rain_l	For growing maize, the amount of rain was too little	yes
rain_m	For growing maize, the amount of rain was too much	yes
season1	Interview took place in the months of Dec, Jan, Feb (planting period)	yes
season2	Interview took place in the months of March, April, May (lean period)	yes
season4	Interview took place in the months of Sept, Oct, Nov (dry period)	yes
year2004	Interview took place in 2004	yes
psu	Primary Sampling Unit or Enumeration Area (564 total)	
hhwght	IHS2 Household weight	
hhsize	HH Size based on household members	
strata	Stratum: district & urban/rural (30 total)	

Table 4: Data Description from AISSfinal.dta

IHS2 Household Level Key Variables
Observations 2937
Date of Analysis: 2/17/2010 20:12:00 PM

Variable Name	Variable Label	Binary
aissf	Householder received both basal and top dressing subsidy fertilizer	yes
agextsv	Householder received advice from FA on seed varieties	yes
agextfu	Householder received advice from FA on fertilizer use	yes
p_lmaize	Average price of local maize in district MK/kg	
p_hmaize	Average price of hybrid maize in district MK/kg	
p_tobacco	Average price of burley tobacco in district MK/kg	
p_wage	Average wage of casual/ganyu labor in district MK/day	
hhage	Age of Householder	
fhh	Householder is female 0/1	yes
consyr	Householder considers food consumption inadequate	yes
l_index	Livestock index based on principal component analysis	
water	Householder has access to personal water supply	yes
madult	HH: Males 15-64 years of age	
fadult	HH: Females 15-64 years of age	
elderly	HH: Individuals 65+ years of age	
mlgtp	Householder uses paraffin for lighting fuel	yes
mlgte	Householder uses electricity for lighting	yes
mcooke	Householder uses electricity for cooking	yes
mcookf	Householder uses firewood for cooking	yes
mcookc	Householder uses charcoal for cooking	yes
distmkt	distance (km) to nearest daily market	
mktsmall	Access to a Daily Market in community	yes
mktlarge	Access to a Larger Market in community	yes
roadbin1	road==Tar/Asphalt Graded	yes
roadbin3	road==Dirt Road (maintained)	yes
roadbin4	road==Dirt track	yes
ADMARC	Access to permanent ADMARC market in community	yes
farmszpc	Total land holding per person	
wbeing	Householder considers welfare has deteriorated	yes
poor	Householder considers status in 2006/07 poor	yes
coop	Existence of Farmers cooperatives in community	yes
irriscm	Irrigation scheme in community	yes
ICT	Householder has access to cellphone	yes

Table 5: Descriptive Statistics for Key Variables Used

Model 1

Variable	Observations	Mean	Std. Dev.	Min.	Max
TIP	11280			0.00	1.00
kcalpc	11280	14172.63	13107.24	1076.74	260675.00
lkcalpc	11280	9.31	0.67	6.98	12.47
p_tobauction	9360	67.15	4.58	56.98	80.57
p_maize	11280	14.75	2.99	9.49	22.63
p_fert	11280	48.95	3.48	36.00	56.13
p_ganyu	11040	55.10	2.69	50.00	65.00
p_index	11280	74.02	3.29	64.34	80.40
p_char	11280	142.20	19.28	100.00	200.00
p_ker	11280	19.64	2.73	16.00	28.56
p_tpt	11280	238.25	18.46	204.00	274.29
p_mflour	11280	18.13	0.76	15.70	19.84
p_dwage	11280	59.65	3.82	53.69	69.71
hhage	11280	42.46	16.35	14.00	103.00
nonlabor	11276	488.65	6787.11	0.00	350000.00
yrsed	11240	4.85	4.22	0.00	19.00
farmszpc	11039	0.26	0.32	0.00	5.10
l_index	11272	0.00	1.20	-0.20	30.11
distmkt	11260	7.08	10.33	0.00	76.00
hhsize	11280	4.55	2.34	1.00	27.00
propensity score	10999	0.54	0.12	0.33	0.88

Model 2:

Variable	Observations	Mean	Std. Dev.	Min.	Max
aissf	1205			0.00	1.00
kcalpc07	2937	15377.18	12536.48	1584.34	200790.00
lkcalpc07	2937	9.43	0.63	7.37	12.21
p_lmaize	2937	11.25	2.57	5.71	18.00
p_hmaize	2937	10.28	1.32	8.27	13.67
p_tobacco	2937	142.76	14.86	116.25	179.43
p_wage	2937	175.69	18.72	143.09	214.18
hhage	2923	47.01	16.89	0.00	99.00
l_index	2868	-0.04	1.56	-1.37	46.07
distmkt	2937	7.83	9.77	0.00	55.00
farmszpc	2866	0.30	0.33	0.00	5.10
propensity score	1171	0.57	0.08	0.34	0.67

Annex II: OLS Estimates of Household Model (Dependent Variable: Kilocalorie Food Expenditure per Capita)

Table 6: Regression Results on Model 1 with Average Treatment Effects on the Treated

	SVYSET[5]		ATTND		ATTR		ATTK		ATTS	
Model 1	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**
TIP	***-0.07***	***-1097***	***-0.069***	***-992***	***-0.074***	***-1636***	***-0.060***	***-403***	***-0.202***	***-2922***
	(0.00)***		(0.00)***		(0.00)***		0.00)***		(0.00)***	
agext	-0.10		0.31		0.31		0.31			
	(0.00)**		(0.00)***		(0.00)***		(0.00)***			
agextcp	-0.09		0.31		0.31		0.31			
	(0.21)		(0.16)		(0.16)		(0.16)			
agextsv	0.05		0.12		0.12		0.12			
	(0.36)		(0.57)		(0.57)		(0.57)			
agextfu	0.03		0.18		0.18		0.18			
	(0.68)		(0.40)		(0.40)		(0.40)			
agextirri	-0.02		0.47		0.47		0.47			
	(0.66)		(0.01)**		(0.01)**		(0.01)**			
agextac	0.04		-0.12		-0.12		-0.12			
	(0.37)		(0.50)		(0.50)		(0.50)			
agextmkt	-0.03		-0.11		-0.11		-0.11			
	(0.47)		(0.52)		(0.52)		(0.52)			
agextcre	0.02		-0.06		-0.06		-0.06			
	(0.59)		(0.73)		(0.73)		(0.73)			
p_tobauction	0.00		0.01		0.01		0.01			
	(0.43)		(0.33)		(0.33)		(0.33)			
p_maize	-0.00		0.08		0.08		0.08			
	(0.61)		(0.00)***		(0.00)***		(0.00)***			
p_fert	0.01		-0.01		-0.01		-0.01			
	(0.01)*		(0.32)		(0.32)		(0.32)			
p_ganyu	-0.00		-0.10		-0.10		-0.10			
	(0.94)		(0.00)***		(0.00)***		(0.00)***			
p_index	-0.00		-0.04		-0.04		-0.04			
	(0.80)		(0.06)		(0.06)		(0.06)			
p_char	0.00		-0.00		-0.00		-0.00			
	(0.00)***		(0.30)		(0.30)		(0.30)			
p_ker	-0.00		0.07		0.07		0.07			
	(0.85)		(0.03)*		(0.03)*		(0.03)*			
p_tpt	0.00		-0.02		-0.02		-0.02			
	(0.10)		(0.00)***		(0.00)***		(0.00)***			

[5] Second column presents results on base OLS model using complex survey design. Columns 3-6 presents Average Treatment Effects on the Treated (ATT) using propensity scores – 3rd column: ATT (Nearest Neighbor matching); 4th Column: ATT (Radius matching); 5th Column: ATT (Kernel matching); 6th Column: ATT (Stratification matching)

	SVYSET[5]		ATTND		ATTR		ATTK		ATTS	
Model 1	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**
p_mflour	-0.00		0.16		0.16		0.16			
	(0.95)		(0.02)*		(0.02)*		(0.02)*			
p_dwage	0.00		0.03		0.03		0.03			
	(0.98)		(0.02)*		(0.02)*		(0.02)*			
hhage	0.00		0.02		0.02		0.02			
	(0.75)		(0.00)***		(0.00)***		(0.00)***			
fadult	-0.20		0.24		0.24		0.24			
	(0.00)***		(0.00)***		(0.00)***		(0.00)***			
madult	-0.08		0.13		0.13		0.13			
	(0.00)***		(0.00)***		(0.00)***		(0.00)***			
mlgtp	0.07		0.23		0.23		0.23			
	(0.01)**		(0.01)**		(0.01)**		(0.01)**			
mlgte	0.34		-1.28		-1.28		-1.28			
	(0.00)***		(0.00)***		(0.00)***		(0.00)***			
mcooke	0.53		0.01		0.01		0.01			
	(0.00)***		(0.98)		(0.98)		(0.98)			
mcookf	-0.02		0.09		0.09		0.09			
	(0.78)		(0.68)		(0.68)		(0.68)			
mcookc	0.35		-0.72		-0.72		-0.72			
	(0.00)***		(0.01)*		(0.01)*		(0.01)*			
nonlabor	0.00		-0.00		-0.00		-0.00			
	(0.19)		(0.04)*		(0.04)*		(0.04)*			
fhh	0.02		0.17		0.17		0.17			
	(0.43)		(0.04)*		(0.04)*		(0.04)*			
yrsed	0.03		-0.04		-0.04		-0.04			
	(0.00)***		(0.00)***		(0.00)***		(0.00)***			
inter	0.01		-0.01		-0.01		-0.01			
	(0.00)**		(0.48)		(0.48)		(0.48)			
elderly	-0.09		0.23		0.23		0.23			
	(0.00)***		(0.00)**		(0.00)**		(0.00)**			
illness	0.05		0.12		0.12		0.12			
	(0.00)***		(0.02)*		(0.02)*		(0.02)*			
farmszpc	0.47		0.39		0.39		0.39			
	(0.00)***		(0.00)***		(0.00)***		(0.00)***			
l_index	0.01		-0.06		-0.06		-0.06			
	(0.01)**		(0.00)**		(0.00)**		(0.00)**			
water	0.14		-0.36		-0.36		-0.36			
	(0.00)***		(0.00)**		(0.00)**		(0.00)**			
wbeing	0.16		0.04		0.04		0.04			
	(0.00)***		(0.47)		(0.47)		(0.47)			
distmkt	***-0.00***		0.01		0.01		0.01			
	(0.09)		(0.02)*		(0.02)*		(0.02)*			
reside	-0.08		1.15		1.15		1.15			
	(0.15)		(0.00)***		(0.00)***		(0.00)***			

	SVYSET[5]		ATTND		ATTR		ATTK		ATTS	
Model 1	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**
roadbin1	0.02		-0.06		-0.06		-0.06			
	(0.59)		(0.52)		(0.52)		(0.52)			
agcredit	0.13		-0.22		-0.22		-0.22			
	(0.00)***		(0.01)*		(0.01)*		(0.01)*			
coop	-0.03		0.17		0.17		0.17			
	(0.43)		(0.13)		(0.13)		(0.13)			
irriscm	-0.13		-0.18		-0.18		-0.18			
	(0.01)**		(0.15)		(0.15)		(0.15)			
mktsmall	***-0.03***		-0.08		-0.08		-0.08			
	(0.21)		(0.28)		(0.28)		(0.28)			
mktlarge	***-0.18***		0.47		0.47		0.47			
	(0.00)***		(0.00)***		(0.00)***		(0.00)***			
rain_l	-0.04		0.25		0.25		0.25			
	(0.21)		(0.00)***		(0.00)***		(0.00)***			
rain_m	0.03		0.09		0.09		0.09			
	(0.41)		(0.20)		(0.20)		(0.20)			
season1	-0.17		-0.08		-0.08		-0.08			
	(0.00)***		(0.36)		(0.36)		(0.36)			
season2	-0.02		0.06		0.06		0.06			
	(0.60)		(0.34)		(0.34)		(0.34)			
season4	-0.17		-0.14		-0.14		-0.14			
	(0.00)***		(0.04)*		(0.04)*		(0.04)*			
year2004	0.16		0.09		0.09		0.09			
	(0.00)***		(0.21)		(0.21)		(0.21)			
N	8835	N	8835		8835		8835		10999	
R-sq	0.337	pseudo R-sq	0.141		0.141		0.141			

Marginal Effects; p-values in parenthesis
(d) for discrete change of dummy variable from 0 to 1
="* p<0.05 ** p<0.01 *** p<0.001"

Table 7: Regression Results on Model 2 with Average Treatment Effects on the Treated[6]

	SVYSET		ATTND		ATTR		ATTK		ATTS	
Model 2	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**
aissf	***0.05***	***148***	***0.091***	***8955***	***0.043***	***74***	***0.052***	***181***	***0.059***	***365***
	(0.21)		(1.637)^		(0.261)		(1.509)^		(1.832)^	
agextsv	-0.08		0.62		0.62		0.62			
	(0.52)		(0.22)		(0.22)		(0.22)			
agextfu	0.19		-0.64		-0.64		-0.64			
	(0.15)		(0.20)		(0.20)		(0.20)			
p_lmaize	0.00		0.07		0.07		0.07			
	(0.76)		(0.03)*		(0.03)*		(0.03)*			
p_hmaize	0.03		-0.10		-0.10		-0.10			
	(0.31)		(0.10)		(0.10)		(0.10)			
p_tobacco	0.00		-0.02		-0.02		-0.02			
	(0.26)		(0.02)*		(0.02)*		(0.02)*			
p_wage	0.00		0.01		0.01		0.01			
	(0.85)		(0.00)**		(0.00)**		(0.00)**			
hhage	0.00		0.00		0.00		0.00			
	(0.39)		(0.61)		(0.61)		(0.61)			
fhh	0.02		-0.38		-0.38		-0.38			
	(0.59)		(0.02)*		(0.02)*		(0.02)*			
consyr	0.00		-0.24		-0.24		-0.24			
	(0.96)		(0.09)		(0.09)		(0.09)			
l_index	0.03		0.17		0.17		0.17			
	(0.09)		(0.02)*		(0.02)*		(0.02)*			
water	0.06		0.11		0.11		0.11			
	(0.60)		(0.72)		(0.72)		(0.72)			
madult	-0.08		0.20		0.20		0.20			
	(0.00)***		(0.01)*		(0.01)*		(0.01)*			
fadult	-0.17		0.23		0.23		0.23			
	(0.00)***		(0.02)*		(0.02)*		(0.02)*			
elderly	-0.10		0.11		0.11		0.11			
	(0.02)*		(0.50)		(0.50)		(0.50)			
mlgtp	0.20		0.32		0.32		0.32			
	(0.00)**		(0.19)		(0.19)		(0.19)			
mlgte	0.80		0.85		0.85		0.85			
	(0.00)***		(0.39)		(0.39)		(0.39)			
mcooke	-0.01		-1.23		-1.23		-1.23			
	(0.98)		(0.37)		(0.37)		(0.37)			
mcookf	-0.19		-0.24		-0.24		-0.24			
	(0.29)		(0.72)		(0.72)		(0.72)			
mcookc	0.04									
	(0.85)									
distmkt	-0.00		-0.00		-0.00		-0.00			

[6] Note that those in parenthesis for ATT are t-statistics.

	SVYSET		ATTND		ATTR		ATTK		ATTS	
Model 2	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**	**lkcalpc**	**kcalpc**
	(0.15)		(0.70)		(0.70)		(0.70)			
mktsmall	0.01		0.01		0.01		0.01			
	(0.85)		(0.94)		(0.94)		(0.94)			
mktlarge	***-0.16***		0.24		0.24		0.24			
	(0.04)*		(0.21)		(0.21)		(0.21)			
roadbin1	0.07		-0.37		-0.37		-0.37			
	(0.59)		(0.26)		(0.26)		(0.26)			
roadbin3	-0.20		-0.54		-0.54		-0.54			
	(0.01)**		(0.03)*		(0.03)*		(0.03)*			
roadbin4	-0.14		0.20		0.20		0.20			
	(0.15)		(0.48)		(0.48)		(0.48)			
ADMARC	0.03		-0.20		-0.20		-0.20			
	(0.73)		(0.34)		(0.34)		(0.34)			
farmszpc	0.54		0.14		0.14		0.14			
	(0.00)***		(0.55)		(0.55)		(0.55)			
wbeing	-0.11		-0.17		-0.17		-0.17			
	(0.01)**		(0.32)		(0.32)		(0.32)			
poor	-0.08		-0.56		-0.56		-0.56			
	(0.08)		(0.00)***		(0.00)***		(0.00)***			
coop	-0.01		0.53		0.53		0.53			
	(0.91)		(0.00)**		(0.00)**		(0.00)**			
irriscm	-0.19		-0.37		-0.37		-0.37			
	(0.03)*		(0.05)		(0.05)		(0.05)			
ICT	-0.14		-0.79		-0.79		-0.79			
	(0.32)		(0.44)		(0.44)		(0.44)			
N	1147	N	1143		1143		1143		1176	
R-sq	0.233	pR-sq	0.066		0.066		0.066			

Marginal Effects; p-values in parenthesis
(d) for discrete change of dummy variable from 0 to 1
="* p<0.05 ** p<0.01 *** p<0.001" ^p<0.10

Annex III: Number of Treated and Control Groups using ATT

Table 8: Bootstrapped Standard Errors for Model 1 based on IHS2 Dataset

ATTND

ATT estimation with Nearest Neighbor Matching method (random draw version)

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
4893	1959	-0.069	0.018	-3.863

Note: the numbers of treated and controls refer to actual nearest neigbor matches

ATTR

ATT estimation with the Radius Matching method

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
2959	2362	-0.074	0.024	-3.146

Note: the numbers of treated and controls refer to actual matches within radius

ATTK

ATT estimation with the Kernel Matching method

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
4893	3882	-0.060	0.013	-4.507

ATTS

ATT estimation with the Stratification Matching method

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
5919	5080	-0.202	0.012	-16.925

Table 9: Bootstrapped Standard Errors for Model 2 using AISS Dataset

ATTND

ATT estimation with Nearest Neighbor Matching method (random draw version)

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
651	273	0.091	0.056	1.637

Note: the numbers of treated and controls refer to actual nearest neigbor matches

ATTR

ATT estimation with the Stratification Matching method

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
95	96	0.043	0.166	0.261

Note: the numbers of treated and controls refer to actual matches within radius

ATTK

ATT estimation with the Kernel Matching method

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
651	491	0.052	0.034	1.509

ATTS

ATT estimation with the Stratification Matching method

Bootstrapped Standard Errors

No. Treated	No. Control	ATT	Std. Error	t-Statistic
672	494	0.059	0.032	1.832

Annex IV: Number of Treated and Control Groups Estimated

Table 10: Inferior Bound, Number of Treated and Controls for Each Block

Model 1

Inferior of block of p-score	Householder received a Starter Pack (TIP) as safety net from Government		
	No	Yes	Total
0.3	8	1	9
0.35	569	344	913
0.4	1356	958	2314
0.45	997	919	1916
0.5	671	796	1467
0.55	451	551	1002
0.6	420	740	1160
0.65	267	641	908
0.7	188	481	669
0.75	97	335	432
0.8	51	136	187
0.85	5	17	22
Total	**5,080**	**5,919**	**10,999**

Note: the common support option has been selected

Model 2

Inferior of block of p-score	Householder received both basal and top dressing subsidy fertilizer		
	No	Yes	Total
0.3	5	1	6
0.35	40	29	69
0.4	5	4	9
0.45	88	72	160
0.5	85	93	178
0.55	5	6	11
0.6	243	418	661
0.65	23	49	72
Total	**494**	**672**	**1,166**

Note: the common support option has been selected

Table 11: Calculation of Propensity Scores Results

Model 1 Binary	TIP	Model 2	aissf
hhage	0.03	hhage	0.00
	(0.00)***		(0.34)
fhh	0.20	fhh	-0.45
	(0.00)***		(0.00)**
		poor	-0.67
			(0.00)***
N	**10999**	**N**	**1171**
pR-sq	**0.042**	**R-sq**	

Note: Balancing property is satisfied

Marginal Effects; p-values in parenthesis

(d) for discrete change of dummy variable from 0 to 1

="* p<0.05 ** p<0.01 *** p<0.001"