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By

Levison Chiwaula,

Lucius Cassim

and

Laston Manja
Department of Economics,
University of Malawi,
Zomba, Malawi

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Abstract

Farm input subsidy (FISP) and irrigation programmes are two of the top agricultural policy interventions that compete for resources in Malawi. Although pockets of information exist on the impacts of these policies, there is no study that compares the respective intervention impacts on child nutrition status to guide policymakers in the face of competing needs. Therefore, this study aims to fill this gap. Using data from the Fourth Integrated Household Survey (IHS4), an instrumental variables (IV) approach and quasi-experimental techniques of propensity score matching (PSM) were used to measure the impacts. The findings show that children from households that are beneficiaries of FISP have better nutrition statuses than children from non-FISP or irrigation-practising households. However, the study fails to find a significant joint impact on child nutrition status, much less an individual impact, of irrigation policies, partly due to data limitations, which calls for a further, well-designed study to validate findings.

Key Words: *Malawi, FISP, PSM, Nutrition, Quasi-experimental*

1. Introduction

Improving nutrition and food security is one of the most important policy objectives in Malawi, as reflected in both the third Malawi Growth and Development Strategy 2017–2022 (MGDS III) (GoM, 2017) and the Malawi National Agriculture Policy (NAP) (MoAIWD, 2016). The need to improve nutrition and food security comes against the backdrop of high levels of malnutrition and food insecurity in the country. In 2015, the prevalence of stunting was estimated at 37% (NSO and ICF, 2017). Although this presents a decline from 53% in 2004, it is still higher than Africa's 32% regional average (NSO and ICF, 2017). High malnutrition has also been a problem for some time. In 2012 and 2013, USAID (2014) reported that nearly half of all children in Malawi suffered from chronic undernutrition (stunting) and micronutrient deficiencies, including iron and vitamin A, with rural children at a slightly higher risk of stunting (48%) than urban children (41%).

Two possible agricultural development programmes that can address these challenges are the Farm Input Subsidy Programme (FISP) and the Green Belt Initiative (GBI). The FISP was initiated in the 2005/06 agricultural season, following a poor maize harvest season and a high maize import bill, to improve resource-poor smallholder farmers' access to improved agricultural inputs (CDM and FUM, 2017). Many studies in Malawi have established the existence of positive impacts of farm input subsidies on nutrition and food security outcomes (Dorward et al., 2008; Dorward and Chirwa, 2011; Chirwa et al., 2013; Verduzco-Gallo et al., 2014; Sibande et al., 2015; Mukozho, 2015). The programme raises maize yields, contributing to economic growth and reducing food insecurity in Malawi (Chirwa and Doward, 2013). Assessing the transmission through which subsidies pass their impacts to child malnutrition, Karamba (2013) found that participation in FISP is associated with greater non-food expenditures rather than food expenditures or dietary diversity.

The alternative programme on irrigation is the Green Belt Initiative (GBI), an irrigation intensification programme targeted at attaining sustainable economic growth and development. The GBI aims to reduce poverty and improve sustainable food security by using freshwater resources covering 21% of Malawi's land, including lakes, perennial rivers and lagoons (MoAFS, 2011). Launched in 2009, the GBI set out to increase irrigated land from 78,000 hectares in 2009 to 1 million hectares by 2020 and was perceived to be more sustainable in keeping Malawi food secure than the FISP. This initiative has not been evaluated as it has not been fully implemented.

Still, we can draw lessons from studies that have evaluated the impact of irrigation programmes on nutrition and food security. Regionally, Rosegrant et al. (2009) found that an expansion of irrigated areas in Africa would greatly improve food supply and eventually reduce the number of malnourished children by two million. The few studies that have assessed the impact of irrigation in Malawi used intermediate outcomes of irrigation such as gross margins, net farm income, assets, and agricultural output. Almost all studies established that participation in an irrigation programme positively impacts these intermediate outcome indicators (Mangisoni, 2008; Nkhata, et al., 2014; Jumbe and Nkhata, 2015; Ng'ong'ola and Associates, 2015). This may lead to positive impacts on nutrition but needs to be evaluated empirically. Despite the observed positive impact of irrigation on nutrition, several studies found irrigation inversely related to nutrition. For example, in Bangladesh, irrigation increased production and eventually consumption of a specific product, thereby reducing the dietary diversity among poor households (Hossain et al., 2005). The negative impacts of irrigation can be observed if the installation of irrigation systems leads to monocropping (Domenech and Ringler, 2013).

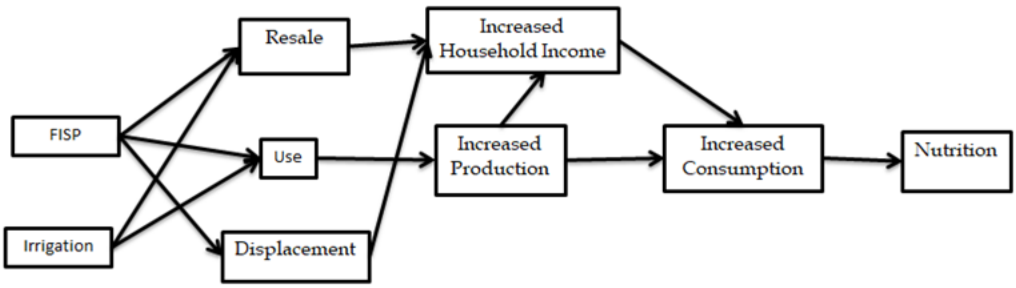
Although both FISP and GBI have the potential to improve nutrition and food security, their implementation has demonstrated continued competition for resources, with policymakers favouring FISP in resource allocation and implementation compared to the GBI. Possible reasons for this include that FISP has become popular among the electorate, while returns from the GBI have not been assessed, mainly due to poor or non-implementation. The returns to investments of GBI may also not be realised in the short term. As such, national budgets have consistently allocated more resources to FISP (up to 16% of GDP in some years), while the GBI has continued to suffer a lack of support. Despite this, initiatives related to irrigation and GBI in the MGDS III receive more prominence than activities associated with FISP. This may indicate the government's plan to slowly phase out FISP in favour of GBI. This has also been observed in the first real reforms in the 2016/17 agricultural season when, among other things, the number of beneficiaries in the FISP was reduced from 1.5 million to 900,000. There was also increased farmer contribution by a unit of inputs purchased. With this perceived competition of resources between these programmes, it becomes necessary to compare the potential impacts and provide policymakers with clear guidance. Therefore, this study was conducted to compare the impacts of FISP and irrigation programmes on child nutrition status in Malawi. This was done using the fourth integrated household survey (IHS4), collected as part of The World Bank-supported Living Standards Measurement Surveys (LSMS).

The rest of the paper is organised as follows: Section 2 presents a conceptual framework. In contrast, Section 3 presents the data description, explains the possible outcome variables and presents an analytical approach to the study. Section 4 presents the results and discusses the findings from the analysis, and Section 5 concludes.

2. Conceptual framework

Within the constructs of a rural economy, the nexus between most agricultural policies, especially farm input subsidy and irrigation policies, and household livelihood outcomes can be summarised in Figure 1.

Figure 1: Agricultural policies–household livelihood nexus in the rural economy



Source: Adapted from Chirwa and Dorward (2013).

Subsidies can be used in production, resold, or can displace unsubsidised inputs (Chirwa and Dorward, 2013), while resources from the irrigation programmes can be used in production or resold. These use directly impact production and income transfers, which ultimately affect consumption and, consequently, child nutrition (Chirwa and Dorward, 2013). In terms of the input subsidy policy, income transfers from the displacement of unsubsidised inputs and reselling of inputs contract labour supply from poorer households and expand labour demand by less poor households, thereby raising real wages in the labour market (Chirwa and Dorward, 2013). This gain in real wages and hence income is consequently seen to impact demand for and consumption of higher-value foods for both recipients and non-recipients. For farmers that use input subsidies to increase farm production, loosening effects are expected in the grain market whereby maize prices will fall, and real wages will rise due to decreased pre-harvest purchases and decreased hiring out of labour.

With irrigation policies, similar mechanisms are expected from the various operations at the implementation stage in irrigation schemes, mainly provided with irrigation technologies such as treadle pumps and irrigation channels. Resell is only possible if resources have private properties such as treadle pumps and not resources with public properties such as irrigation channels. In the case of privatised irrigation resources, resell of the equipment or inputs by farmers results in an increase in real incomes and consumption of nutritious food. Irrigation is expected to improve farm output, income and consumption, and, consequently, child nutrition status. However, for this pathway, the impact is not likely to come through displacement, as irrigation is usually done on a smaller scale within schemes rather than at a national level. Within this framework, we also only expect a one-way effect from production to income whereby households that produce higher output will earn more income, which can be converted to nutrition through nutritious foods. Conversely, households that resell what they receive from the policies mainly do so for consumption purposes and not to reinvest in production.

In both input subsidy and irrigation programmes, the policymaker expects the farmers to use the inputs to improve production. The other mechanisms recognised in Figure 1 should thus be looked at as a digression from the policy design. As such, this study assesses the impact on outcomes and the expected intermediate impacts on agricultural production and income.

3. Methodology

This section presents the methodological issues in light of previous empirical studies and the conceptual framework.

Data

The data used in this study are from the Fourth Integrated Household Survey (IHS4), a nationally representative sample survey designed to provide information on the various aspects of household welfare in Malawi. Fielded from April 2016 to April 2017, the IHS4 collected information from a sample of 12,480 households using four types of instruments: Household, agriculture, fisheries, and community questionnaires.

Outcome variables

Studies that evaluated the impact of irrigation have used a number of outcome indicators, such as level of malnutrition (Dorward et al., 2008; Karamba, 2013; Chirwa et al., 2013); kilocalories per capita per day, the number of months of household food security as well as the chances of a household being food secure over a year (Verduzco-Gallo et al., 2014; Sibande et al., 2015); and income (Dorward and Chirwa, 2011; Ricker-Gilbert et al., 2013). This study employs child anthropometric measurements that are available from the IHS4 data to generate commonly used indices of height/length-for-age, weight-for-age and weight-for- length/height z-scores. Length is used for children aged 0 to 2 years, and height is used for children older than 2 years. According to Strauss and Thomas (1998), child height is a long-run indicator of nutritional status, whereas weight is a short-run indicator capturing more current nutritional status. Given the cross-sectional nature of the data, an indicator reflecting the short-term changes in nutritional status was deemed a more appropriate outcome variable. Following Karamba (2013), weight-for-age, an indicator for underweight, may not be a suitable indicator for short-term changes in nutritional status as it is a composite measure of both stunting and wasting, capturing both past and present undernutrition. Karamba (2013) argues that this is because it is difficult to separate tall children who are too thin for their age (wasted) from children who are too short for their age (stunted) but of adequate weight. This means that the inability to distinguish current undernutrition from the past effects of undernutrition is problematic for interpretation. The study used weight-for length/height z-score as the main outcome variable. In addition, as derived in the conceptual framework, we analyse policy impacts not only on final outcomes but also on intermediate outcomes, i.e., agricultural productivity and sales revenue from agricultural produce. This allows us to map out the pathways through which the interventions affect the final outcome variables if indeed they do.

Study design

This impact evaluation study identified three treatment groups: 1) those that participated in the FISP programme; 2) those that participated in irrigation programmes; and 3) those that participated in both irrigation programmes and FISP. The three treatment groups were compared with the control group, which was households that participated in neither FISP nor irrigation programmes. Generally, participation in the FISP and irrigation programmes was not expected to be random. First, the land acquisition process in Malawi cannot be assumed to be random as irrigable land is usually allocated to individuals with specific characteristics such as connection to the local leadership or those with high incomes. With regard to FISP, the determination of programme beneficiaries is purposive as it targets poor small-scale farmers. As such, it would be very wrong to assume that households are equally likely to receive the FISP policy intervention. We used quasi-experimental methods because of non-random treatment assignments and the absence of experimental data (Gertler et al., 2016).

Analytical approach

In conducting this evaluation, cause-and-effect questions were measured precisely. Assessing the impact of a programme on a set of outcomes is equivalent to assessing the programme's causal effect on those outcomes (Gertler et al., 2016). Mathematically, defining Δ as the difference between the outcome (Y) in the treated (I = 1) and untreated (I = 0) states conditional on control variables (X) gives:

$$\Delta = (Y \mid I = 1, X) - (Y \mid I = 0, X) \tag{1}$$

The population values of the average treatment effect (ATE) and ATE on the treated average treatment effect (ATET) are defined as:

$$ATE = E[\Delta] \tag{2}$$

$$ATET = E[\Delta \mid I = 1] \tag{3}$$

According to Gertler et al. (2016), the challenge with impact evaluation is estimating counterfactuals ($Y|I=0$), that is, what would have happened without the intervention. As such, Δ is not directly observable because no individual can be observed in both states at the same time. The ideal for estimating the counterfactuals would be the implementation of a randomised control trial (Gertler et al., 2016). The use of survey data would thus mean a high chance of facing problems with sample selection bias (both selection on observables and unobservables). It is a well-known fact in the literature (see Heckman and Vytlacil, 2005; Cameron and Trivedi, 2005) that with observational data the problem of selection on observables is best solved using matching methods. Therefore, propensity score matching (PSM) was used to identify the counterfactuals based on the observables. For comparative reasons, we employed Mahalanobis distance matching, nearest neighbour matching, radius matching, stratified matching and kernel matching. The matching procedures attempted to identify four samples that have similar characteristics. The means in outcomes of the different treatment groups were therefore compared to measure the impact.

The PSM was complemented with an instrumental variable (IV) regression model. Using the IV regression model, the impact on final outcome variables was measured by estimating the following econometric regression model:

$$Y_{ij} = \alpha + \beta FISP_J + \gamma IRR_j + \delta\left(FISP_j \times IRR_j\right) + \Theta Z + \eta_j \quad (4)$$

where Y_{ij} is a vector of weight-for-height, height/length-for-age and weight-for-age z-score of child *i* in household *j*; FISP is the dummy variable for participation in FISP, taking 1 if a household was a beneficiary of FISP in a reference cropping season and 0 otherwise; IRR is a dummy variable that recognizes whether a household practiced irrigation agriculture, taking 1 if a household did and 0 if not; and Z is a vector for child, household and location characteristics. The Greek letters (α, β, γ, δ, Θ) are the parameters that have been estimated and η denotes a disturbance term.

Recognizing that policy interventions may not affect nutrition status indicators directly, the impact of the interventions was checked on these intermediate outcomes by running the following models:

$$yield_{pj} = \alpha_0 + \sum_{k=1}^{K} \alpha_k x_{pjk} + \sum_{k=1}^{K}\sum_{m=1}^{M} \pi_k x_{pjm} x_{pjk} + \sum_{j=1}^{J} \delta_j Z_j + \beta' W + \delta\left(FISP_j \times IRR_j\right) + \eta_{pj} \quad (5)$$

$$sales_j = \alpha_0 + \delta\left(FISP_j \times IRR_j\right) + \sum_{j=1}^{J} \delta_j M_j + \eta_{pj} \quad (6)$$

where: $Yield_{phc}$ represents total maize yield in kilograms for maize field *p* belonging to household *h*; α_0 is an intercept; $\alpha_k (k = 1,2,....K)$ are output elasticities with respect to inputs x_{pjk}; Z_j is a vector of household characteristics; W is a vector of agroecological zone dummies; M_j is a vector of variables indicating the ease of finding a market for the produce, e.g., distance to the nearest road and distance to the nearest ADMARC; and η_{pj} denotes the error component.

It is not correct to estimate Equations 4–6 directly as they are, as most papers that studied the impact of FISP in Malawi have done (see Dorward et al., 2008; Dorward and Chirwa, 2011; Sibande et al., 2015; Mukozho, 2015). This is because of endogeneity that may arise due to the fact that FISP and IRR are not random processes. As such, the IV approach was used in this study, following Karamba (2013) and Chibwana et al. (2012). Mindful of the fact that the success of the IV approach depends on the validity of chosen instruments, a literature search was conducted to identify the best instruments available for the data set. For FISP, the instruments adopted were: (1) the number of years that the household head has been living in the community; (2) whether the household head is a permanent resident of the community; (3) for irrigation participation, whether a household owns irrigable land (say a swamp or wetland); and (4) whether there is an irrigation scheme in the community or not.

In line with Chibwana et al. (2012), the choice of a first instrumental variable is premised on the fact that it is highly probable that a household whose head has lived in a community for a long time has strong social connections within the community. In this case, it is highly likely that the village head would consider such a household in the distribution of farm input subsidy coupons. However, having lived in a community for a long time has no connection at all with the nutrition status of children in a household. The same argument is analogous with regard to the second instrument; whether a household head is a permanent resident of a community or not. Concerning the third instrument, households that have irrigable land (wetlands or swamps) are more likely to practice irrigation compared to households that do not. The IV was implemented by using a two-stage least squares (2SLS) regression:

Step 1: Run the following models to get predicted treatment assignments:

$$FISP_j = \phi + \vartheta(years\_head)_j + \Omega X + \varepsilon_j \quad (7)$$

$$IRR_j = \varpi + \zeta\,(Irrigable)_j + \Lambda W + \mu_j \quad (8)$$

Step 2: Use the predicted treatment assignments (i.e., $FISP^P$ and IRR^P) to evaluate their impacts on child nutrition status and the intermediate outcomes:

$$Y_{ij} = \alpha + \beta FISP_j^P + \gamma IRR_j^P + \delta\left(FISP_j^P \times IRR_j^P\right) + \Theta Z + \eta_j \quad (9)$$

$$yield_{pj} = \alpha_0 + \sum_{k=1}^{K}\alpha_k x_{pjk} + \sum_{k=1}^{K}\sum_{m=1}^{M}\pi_k x_{pjm} x_{pjk} + \sum_{j=1}^{J}\delta_j Z_j + \beta' W + \delta\left(FISP_j^P \times IRR_j^P\right) + \eta_{pj} \quad (10)$$

$$sales_j = \alpha_0 + \delta\left(FISP_j^P \times IRR_j^P\right) + \sum_{j=1}^{J}\delta_j M_j + \eta_j \quad (11)$$

where Y_{ij} is the weight-for-height or height/length-for-age or weight-for-age z-score of child *I* in household j; ε, μ and η are disturbance terms for FISP participation, IRR participation and child nutrition regression equations, respectively; *years_head* represents the number of years that a household head has been in a community; *Irrigable* is a dummy variable taking a value of 1 if a household has a wetland/swamp and 0 otherwise; the Greek letters ($\phi, \vartheta, \omega, \Omega, \varpi, \zeta, \Lambda, \alpha, \beta, \gamma, \delta, \Theta$) are parameters to be estimated; and X and W are exogenous variables while Z is a vector for child, household and location characteristics.

The first step equations were estimated using a linear probability model (LPM) and not nonlinear discrete models (e.g., probit and logit models). Mindful of the shortfalls of an LPM, the model was used following an argument by Angrist (2001), echoed by Karamba (2013), that when a nonlinear model is used in the first step, second step estimates are inconsistent unless the first stage model is correct. As the second step equation is free from endogeneity; we identified it using an ordinally least squares (OLS) technique.

4. Results and discussion

In order to address the study objectives, this section presents the descriptive statistics that help to explore the data, followed by an analysis that links child nutrition status and severity of child nutrition status to programme participation.

Descriptive statistics

Table 1 shows the summary statistics of the variables employed in the analysis.

Table 1: Descriptive statistics of households and children

	Observations	Mean	Std. Dev.
Household head variables	**(12, 447)**		
FISP participation (Yes =1; otherwise=0)		0.176	0.381
IRR participation (Yes =1; otherwise=0)		0.004	0.065
Irrigable land (Yes =1; otherwise=0)		0.107	0.310
Household size		4.329	2.001
Age of household head (Years)		43.331	16.224
Permanent residence (Yes =1; otherwise=0)		0.681	0.466
Length of stay in community (Years)		4.689	10.474
Fertilizer extension (Yes =1; otherwise=0)		0.271	0.445
Untreated water (Yes=1, otherwise=0)		0.003	0.054
Piped and treated water (Yes=1; otherwise=0)		0.050	0.217
Open wells (Yes=1; otherwise=0)		0.228	0.420
Protected wells (Yes=1; otherwise=0)		0.075	0.263
Boreholes (Yes=1; otherwise=0)		0.031	0.172
Region			
Northern Region		0.200	0.400
Central Region		0.339	0.473
Southern Region		0.461	0.498
Education			
No education (Yes =1; otherwise=0)		0.158	0.365

continued next page

Table 1 Continued

	Observations	Mean	Std. Dev.
Primary education (Yes =1; otherwise=0)		0.521	0.500
Secondary education (Yes =1; otherwise=0)		0.106	0.308
Tertiary education		0.215	
Sex of household head (Male=1; Female=0)		0.712	0.453
Shocks (Yes =1; otherwise=0)		0.359	0.480
Marital status (Married=1; Otherwise=0)		0.707	0.455
Wealth index		-0.000	1.637
Residence (Rural=1; Urban=0)		0.817	0.386
ADMARC distance (kilometres)		18.445	140.613
Irrigation scheme (Yes =1; otherwise=0)		0.204	0.403
Household agricultural variables	**(9, 646)**		
Maize output (in kilograms per household)		437.13	970.02
Agricultural revenue		71,106.45	208,551.9
Child variables	**(5, 349)**		
Sex of child (Male=1; Female=0)		0.488	0.500
Age of child (Months)		32.610	15.347
Child illness (Yes=1; otherwise=0)		0.231	0.421
Weight-for-height z-score (WHZ)		0.053	1.260
Weight-for-age z-score (WAZ)		-0.634	1.095
Height-for-age z-score (HAZ)		-1.178	1.351

12,447 households had most variables of interest, while 9, 646 households had agricultural output variables. From these households, the average age of the head was about 43 years, and 71% of heads were male. The average household size in the sample was 4.3 individuals, similar to what was observed in the main IHS3 report (NSO, 2017). About 18% of households were beneficiaries of FISP, while only 0.4% participated in irrigation farming. This was the case although it was found that about 11% of households had irrigable land and 20% of households had an irrigation scheme within their community. This demonstrates the low patronage faced in irrigation programmes in Malawi. On average, households harvested 437kg of maize in a year while total agricultural revenue was equal to MK71,106 per year.

The average age of a child was 33 months and about 49% of the children were male. The mean weight-for-height z-score in the sample was 0.053, with a standard deviation of 1.260, while the mean weight-for-age z-score was -0.634 and the mean height-for-age z-score was -1.178. All three mean z-scores are greater than -2 implying that, on average, the children in the sample were well nourished. The lowest mean z-score is found for height for age, which shows that more children experience stunting than other forms of undernutrition.

Child nutrition status, FISP and irrigation participation

Table 2 provides a simple comparison of outcome variables between beneficiary and non-beneficiary households of the two programmes.

Table 2: Child nutrition status, FISP and irrigation participation

Child nutrition status	Programme			
	FISP		Irrigation	
	NO	YES	NO	YES
Weight-for-height (z-score)				
Mean	0.052	0.059	0.051	0.358
Std. Dev.	1.266	1.225	1.260	1.014
Min	-3.98	-3.92	-3.98	-2.56
Max	4.85	4.81	4.85	2.49
Height-for -age (z-score)				
Mean	-1.163	-1.263	-1.178	-1.211
Std. Dev.	1.350	1.349	1.350	1.545
Min	-5.15	-5.46	-5.46	-4.47
Max	2.99	2.98	2.99	2.93
Weight-for-age (z-score)				
Mean	-0.624	-0.687	-0.634	-0.456
Std. Dev.	1.200	1.069	1.096	0.899
Min	-4.58	-3.32	-4.58	-2.79
Max	2.98	2.97	2.98	1.27

The results in Table 2 show that the weight-for-height mean z-scores for children coming from FISP-beneficiary households was 0.059 compared to a 0.052 z-score from FISP non-beneficiary households. The height-for-age and weight-for-age scores were -1.263 vs -1.163, and -0.687 vs -0.624, for beneficiaries and non-beneficiaries, respectively. For participation in irrigation agriculture, we found that children from participating households are better off in terms of weight-for-height and weight-for-age, but the opposite is true for height-for-age z-scores. This simple descriptive analysis is thus inconclusive as it shows conflicting results for both FISP and irrigation programmes when we use different outcome indicators.

Econometric results

Propensity score matching results

The results from the PSM show that the differences between treatment and control groups are all significant for the FISP and irrigation programmes, but insignificant for joint treatment. Participating in irrigation programmes had a greater impact on both maize output and crop income than participating in FISP. The results mean that farm households that participated in FISP obtained higher maize output and crops revenue than households that did not participate in either FISP or irrigation programmes. Similarly, households that participated in irrigation programmes had greater maize output and crop revenue than households that did not participate in irrigation or FISP. The results further suggest that households that participated in irrigation programmes had relatively more maize output and crop revenue than households that participated in FISP programmes. The results are presented in Tables 3, 4 and 5.

Table 3: FISP average treatment effects of intermediate outcomes using PSM

Indicator	Nearest neighbour		Kernel		Radius		Stratified	
	ATET	t	ATET	t	ATET	t	ATET	t
Maize output	181.924	10.672**	163.123	8.984**	172.324	9.832**	129.963**	13.077
Agricultural income	24980.5	0.409	221234	0.423	216413	0.8567	24980.55	0.712

Table 4: Irrigation average treatment effects of intermediate outcomes using PSM

Indicator	Nearest neighbour		Kernel		Radius		Stratified	
	ATET	t	ATET	t	ATET	t	ATET	t
Maize output	227.194	3.216**	223.123	3.125**	217.324	3.734**	194.455 **	3.026
Sales	2034	0.256	2326.8	0.984	2324	1.375	3801.983	0.482

Table 5: Combined average treatment effects of intermediate outcomes using PSM

Indicator	Nearest neighbour		Kernel		Radius		Stratified	
	ATET	t	ATET	t	ATET	t	ATET	t
Maize output	455.021	1.499	432.124	0.369	400.54	1.654	455.021	1.499
Sales	24980.5	5.409**	221234	4.23**	216413	8.567**	-1.06e+04	-0.658

Further, the impacts on final outcome variables were assessed . The results are presented in Tables 6, 7 and 8.

Table 6: FISP average treatment effects of final outcomes using PSM

Indicator	Nearest neighbour		Kernel		Radius		Mahalanobis	
	ATET	T-Stat	ATET	T-Stat	ATET	T-Stat	ATET	T-Stat
HAZ	-0.051	-1.23	-0.06	-----	-0.10	-2.5**	-0.116	-1.76
WAZ	- 0.001	-2.3**	0.000	----	-0.06	-42**	-0.065	-1.14
WHZ	0.054	1.65	0.060	-----	0.231	0.007	-0.0	-0.01

Table 7: Irrigation average treatment effects of final outcomes using PSM

Indicator	Nearest neighbour		Kernel		Radius		Mahalanobis	
	ATET	T-Stat	ATET	T-Stat	ATET	T-Stat	ATET	T-Stat
HAZ	-0.076	-1.23	-0.06	-1.76	-0.00	-1.22	0.018	0.22
WAZ	.0326	1.85	0.021	---	0.177	1.43	0 .29	1.32
WHZ	.0326	1.85	0.021	---	0.306	1.68	2.87	0.032

Table 8: Combined average treatment effects of final outcomes using PSM

Indicator	Nearest neighbour		Kernel		Radius		Mahalanobis	
	ATET	T-Stat	ATET	T-Stat	ATET	T-Stat	ATET	T-Stat
HAZ	-0.079	-1.87	-0.07	-1.32	-0.10	-2.48	0.018	0.27
WAZ	0.432	0.23	0.123	0.85	0.823	0.99	0.055	0.15
WHZ	-0.082	-0.23	0.000	0.00	0.231	0.07	0.044	0.12

Neither irrigation programmes, nor a combination of FISP and irrigation programmes had an impact on child nutrition status indicators. However, the results are insignificant for the majority of estimators.

Regression approach

Before running the nutrition status regression equation directly using OLS, endogeneity was tested using the Durbin-Wu-Hausman test. The "estat endogenous" command, which provides both Durbin chi2 and Wu-Hausman F-statistics, was used in STATA to validate the findings. Table 9 presents the results of the test.

Table 9: Formal endogeneity test on final outcome indicators

Equation	Durbin (score) chi2	P-value	Wu-Hausman F	P-value
HAZ	2.23507	0.5251	0.74185	0.5270
WHZ	7.67289*	0.0533	2.54933*	0.0540
WAZ	7.03382*	0.0708	2.33672*	0.0717

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results indicate that the null of exogeneity is rejected for the WAZ and WHZ models. This means that running WAZ and WHZ equations using OLS, as most researchers have done previously, is not correct as it results in biased and inconsistent results. However, it is correct to estimate the HAZ equation using OLS as there is no endogeneity.

The same analysis was done for the intermediate outcome variables, and it was found that the null of exogeneity is rejected in the maize productivity model, but is not rejected in the agricultural sales model. This means that the treatment variables are exogenous in the sales equation, but they are endogenous in the productivity model. All this pointed towards employing a 2SLS technique for the WAZ, WHZ and productivity equations, and an OLS regression model for the HAZ and sales equations. The regression results for the intermediate and final outcome variables are presented in Tables 10 and 11, respectively.

Table 10 shows that the coefficient on the FISP dummy variable is not only positive, but statistically significant in the maize production function. The findings suggest that farmers that participated in the FISP programme harvested 267kg more maize than farmers that did not participate. This is significant considering that average production is only 437kg per household. However, the study found that both the individual coefficient of irrigation and the joint impact of irrigation and FISP were statistically insignificant in both models. FISP is insignificant in the income model. This implies that while recipients of FISP obtain higher maize yields compared to non-recipients, farm households that practice only irrigation but are not FISP beneficiaries are no different from households that do not practice irrigation in terms of maize yield. The study also fails to find significant combined effects of FISP and irrigation.

Table 10: Impacts of irrigation and FISP on maize productivity and sales

Variable	Maize productivity	Agricultural income
Household size	22.126***	
Log of land	273.415***	
Square of log of land	-4.097***	
Seeds	0.140***	
Square of seeds	-0.000***	
Distance to the nearest road		-0.001***
Distance to the nearest ADMARC		-0.000
Agroecological zones		
zone2: Blantyre, Zomba, Thyolo, Mulanje, Chiradzuru, Phalombe districts	105.718***	
zone3: Mwanza, Balaka, Machinga, Mangochi districts	96.378**	
zone4: Dedza, Dowa, Ntchisi districts	382.711***	
zone5: Lilongwe, Mchinji, Kasungu districts	302.015***	
zone6: Ntcheu, Salima, Nkhotakota districts	236.465***	
zone7: Mzimba, Rumphi, Chitipa districts	206.717***	
zone8: Nkhatabay, Karonga districts	111.024**	
Zone9: Blantyre, Zomba, Thyolo, Mulanje, Chiradzuru, Phalombe districts	291.701***	
FISP	266.916***	0.376
Irrigation	1935.845	4.476
Combined effects	-5180.336	-13.868
_cons	-140.618***	10.462***
N	9, 646	9, 646

Standard deviation (SD) in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.

The study found that FISP has a positive significant effect on weight-for-height and weight-for-age but it is insignificant on height-for-age. This is shown in Figure 11.

The insignificance of FISP on height-for-age is not surprising as height-for-age is a long-term indicator of nutrition status, as explained earlier. Generally, the study finds that FISP positively affects child nutrition status in Malawi, yet irrigation is negative. In other words, children that come from households that are beneficiaries of FISP have better nutritional statuses compared to children that come from households that are not beneficiaries of FISP, while those that come from irrigation-practicing households are no different from those coming from irrigation non-practicing households. It is observed that the coefficients of the interaction term are not statistically significant in all regression models. In other words, children that come from households that practice both irrigation and FISP are no different from children that come from households that practice neither in terms of nutrition status. This is a rather surprising result bearing in mind the fact that, individually, FISP has a positive and significant impact. However, this result may be a consequence of data issues as there are very few households that reported being beneficiaries of FISP while also practicing irrigation. In fact, the low variability that resulted from this problem may have affected the size of the standard errors and the t-statistics of the interaction effect coefficients, resulting in insignificant results. This is why the study fails to find a significant impact of the interaction term. Collection of new data may be very useful in order to fully understand the phenomenon.

Table 11: Regression results on final outcome variables

Variable	WHZ	SD	HAZ	SD	WAZ	SD
FISP	1.378**	(2.48)	-0.002	(-0.00)	1.094**	(2.31)
Irrigation	3.862	(0.47)	-6.830	(-1.09)	-1.110	(-0.16)
Joint effects	-8.232	(-0.42)	35.839	(1.10)	4.053	(0.24)
Age of household head	-0.002	(-0.07)	0.031***	(2.61)	0.007	(0.40)
Age squared	0.000	(0.07)	-0.000**	(-2.01)	-0.000	(-0.13)
Household size	-0.043**	(-2.55)	-0.021	(-1.53)	-0.042***	(-2.93)
Sex of household head	-0.052	(-0.60)	-0.061	(-0.88)	-0.047	(-0.65)
Marital status of household head	0.040	(0.38)	-0.009	(-0.11)	-0.010	(-0.11)
Wealth index	0.059***	(3.45)	0.064***	(4.09)	0.078***	(5.38)
Location	-0.165*	(-1.87)	0.042	(0.57)	-0.121	(-1.61)
Sex of child	-0.034	(-0.73)	-0.116***	(-3.18)	-0.088**	(-2.25)
Water_source_2	0.120	(1.36)	-0.074	(-0.93)	0.041	(0.54)
Water_source_3	0.117*	(1.76)	-0.076	(-1.26)	0.040	(0.70)
Water_source_4	-0.026	(-0.36)	-0.249***	(-3.78)	-0.172***	(-2.80)
wWter_source_5	0.052	(0.40)	-0.134	(-1.36)	0.011	(0.10)
Age of a child	0.009***	(5.61)	-0.028***	(-24.78)	-0.012***	(-9.48)
Child illness	-0.196***	(-3.56)	-0.024	(-0.55)	-0.144***	(-3.08)
Central Region	-0.275***	(-4.72)	-0.435***	(-8.33)	-0.430***	(-8.67)
Southern Region	-0.376***	(-6.70)	-0.377***	(-7.33)	-0.474***	(-9.92)
Primary education	0.028	(0.40)	-0.027	(-0.62)	0.032	(0.53)
Secondary education	-0.112	(-1.51)	-0.009	(-0.14)	-0.087	(-1.38)
_cons	0.268	(0.65)	-0.356	(-1.49)	0.230	(0.65)
N	5349		5349		5349	

Standard deviation(SD) in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01.

The findings also suggest that FISP affects maize productivity, but does not affect the agricultural income from the sale of agricultural produce. Plus, FISP affects child nutrition status positively. It can then be said that FISP affects child nutrition status through increased food availability and not through the improved command over food in the market. Households that produce more maize because of FISP consume this and other food items to improve nutrition. The improvement in income is not different, meaning they do not have higher purchasing power relative to non-beneficiaries.

5. Conclusion

The main objective of this study was to compare the impact of FISP and irrigation programmes on child nutrition status in Malawi. The study compared the magnitude and significance of the impact of farm input subsidy and irrigation programmes by using data from the Fourth Integrated Household Survey (IHS4) for Malawi. The quasi-experimental techniques of propensity score matching (PSM) were employed to achieve the objective. The study also used an instrumental variables (IV) approach because of the non-randomness of access to FISP and exposure to irrigation opportunities.

The findings show that participation in FISP improves weight-based child nutrition status (weight-for-age and weight-for-height) but not height-based nutrition indicators (height-for-age) through improvements in maize production. This means that child nutrition improves through self-consumption and not market purchases, probably due to low production as seen from average levels of production. Further, the short-run impact of farm input subsidies is seen in the short-run measures of child nutrition. We could not assess the long-term impact due to the nature of the data. The study failed to establish the impact of irrigation on intermediate outcomes as well as final outcomes, probably due to data limitations. This is also reflected in the assessment of the joint impact of irrigation and FISP. We recommend a properly designed research study to compare the impacts and to measure the joint impact.

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Middle East Bank Towers,
3rd Floor, Jakaya Kikwete Road
Nairobi 00200, Kenya
Tel: +254 (0) 20 273 4150
communications@aercafrica.org