

**THREE ESSAYS ON THE IMPACT OF PUBLIC INVESTMENTS AND
MICROFINANCE ON DEVELOPMENT IN TANZANIA**

By

Kilugala Malimi

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Supervisors

Lina Song, Professor of Development Economics

Jing Zhang, Assistant Professor of Development Economics

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DEDICATION

To my sister Mwalu Mponeja (1969 – 2022) whose investment in my secondary education fuelled my academic journey. Unfortunately, she died three months before the submission of this thesis. I am so indebted for her courage, initiative, and love.

ABSTRACT

This study examined the effects of public investments and microfinance on development in Tanzania. The study focused on three aspects of development, namely, farm labour productivity, poverty reduction, and child mortality reduction. The study used three waves of panel data from the National Panel Survey in Tanzania collected between 2008 and 2013. The study presented three papers presented in the three final chapters of this report: Chapter 2, 3, and 4.

Chapter 2 estimated the effects of public investments in agricultural input subsidies (AIS) and Agricultural extension services (AES) on farm labour productivity. Estimates in Chapter 2 show that both AIS and AES are effective in raising farm labour productivity among farmers involved in maize production. Moreover, the two programmes are also effective in raising land productivity. Further estimates in Chapter 2 show that both AIS and AES have comparable effects on labour productivity and land productivity. Chapter 3 estimates and compared the effects of AIS and microfinance on poverty reduction among maize and rice farmers in Tanzania. Using control function and instrumental variable approaches to control for the endogeneity of the two programmes, estimates in Chapter 3 show that AIS and microfinance are effective in reducing poverty among farmers involved in maize and rice production. Moreover, estimates in Chapter 3 show that both programmes have comparable effects on household consumption, indicating that they have equal poverty reduction effects.

Lastly, Chapter 4 estimated the effects of subsidized insecticide-treated nets (ITNs) and free medicare on malaria-caused child mortality in Tanzania. This chapter used residual inclusion to estimate the survival model and found that while subsidized ITNs are effective in reducing the hazard associated with malaria-caused child mortality, the use of free medicare in malaria treatment was not effective in reducing child mortality. However, when deaths from all diseases are considered, both subsidized ITNs and free medicare are significantly effective. This suggests that while free medicare is not effective in reducing malaria-caused mortality, it is, however, effective in reducing overall child mortality. Moreover, when the effects of the two programmes are compared, both programmes have comparable effects against malaria-caused child mortality. However, when deaths from all diseases are considered, the effect of subsidized ITNs is significantly bigger than that of free medicare. This suggests that in reducing overall mortality, the use of subsidized ITNs reduces more child mortality than the use of free medicare alone.

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CHAPTER 1

INTRODUCTION

This thesis examines the effects of public investment and microfinance on development in Tanzania. The thesis contributes to the debate on development in sub-Saharan Africa (SSA), which has attracted a great deal of attention from development policymakers, lenders, and analysts. The ever-growing interest in the development of SSA is related to the fact that SSA is the most underdeveloped part of the world. In this thesis, I specifically focus on three aspects of development: labour productivity, poverty reduction, and child mortality. These three aspects have dominated international agendas on agricultural development, poverty reduction, and mortality reduction in multinational development and financial institution (United Nations, 2015; World Bank, 2019).

Unfortunately, SSA countries have poor performances in each of these development indicators. First, although growth in farm labour productivity is a key factor in reducing poverty among farmers, the overall farm productivity across SSA is low and lags behind farm labour productivity in other parts of the world (Collier and Dercon, 2014). Second, most of the population in SSA countries is classified as income poor. In Tanzania, which is the focus of this thesis, 26.4% of the population lived below the national poverty line by the end of 2018 and poverty is higher in rural areas (31.3%) than in urban areas (15.8%) (National Bureau of Statistics [Tanzania], 2019). Applying the international poverty line of \$1.9 per day, 49% of the country's population is classified as poor (World Bank, 2020). Third, SSA has the world's highest mortality rate for children under the age of five (under-fives). By the end of 2020, SSA accounted for 53% of the global mortality of the under-fives (United Nations, 2020). To address these challenges, countries in SSA must identify and sustain effective policies and poverty-reducing programmes.

Public investments and access to finance can play a key role in development. For instance, public investments in various health interventions can play a key role in disease prevention and cure and, therefore, reduce mortality (Alsan & Goldin, 2019; Wang, 2003; Rutstein, 2000). Key examples in this area include the distribution of subsidized mosquito bed nets which protect people against malaria (Bonner et al., 2011; White et al., 2011) and the provision of free medical treatments (Rutherford, Mulholland and Hill, 2010). Many countries in SSA have invested in subsidizing these services.

In addition to interventions directed at mortality reduction, other public investments focus on supporting production activities that have a direct linkage to income and consumption. For instance, in the agricultural sector, where most people across SSA support their livelihood (World Bank, 2019; Collier & Dercon, 2014; Christiaensen et al., 2011), public investment in agricultural extension services (AES) and Agricultural Input Subsidies (AIS) can increase the use of productivity-enhancing technologies such as fertilizer and improved seeds, which in turn, can increase farm productivity (Ali, 2013; Feder et al., 1987), and potentially translate into poverty reduction (Wossen *et al.*, 2017). Similarly, public investment in AES can enhance proper farming practices and land management, leading to higher farm productivity and poverty reduction (Dercon et al., 2009; Ali, 2013).

Similarly, access to finance can play a key role in development. To ensure that the poorest members of society are financially served, access to pro-poor finance has relied on various microfinance lenders. Access to microfinance can increase and smoothen household consumption, which leads to poverty reduction, particularly in rural areas (Imai et al., 2012; Imai et al., 2010; Khandker, 2005). In addition to providing direct consumption benefits, microfinance is also key to supporting productive works and rural businesses, which can equally lead to higher household income and poverty reduction (Abate *et al.*, 2016).

In this thesis, I examine the effects of public investments on farm labour productivity, rural poverty among farmers, and mortality for children under the age of five (Under-fives). I also compare the effect of public interventions and microfinance on poverty reduction to examine whether microfinance can potentially complement, and if possible, replace AIS as a key poverty reduction strategy in Tanzania. These discussions are presented in the next three chapters of the thesis.

Chapter 2 focuses on how public investment in the agricultural sector can increase farm labour productivity. This chapter estimates the effects of AIS and AES on farm labour productivity. Previous studies in this area have shown that AIS and AES are effective in improving crop yields across SSA (Ricker-Gilbert & Jayne, 2017; Wossen et al., 2017; Arndt et al., 2016) and farm wages (Ricker-Gilbert, 2014). I extend the literature in two ways. First, I examine the effects of AIS and AES on farm labour productivity. Second, I examine whether AIS and AES differently affect labour and crop yields (land productivity). I apply the control function and instrumental variable approaches to control for endogeneity of the two programmes. Generally, estimates in this chapter show that AIS and AES are effective in raising farm labour productivity and land productivity, which in turn, suggests that AIS and AES have wide effects on farm productivity. Furthermore, estimates in this paper show that the effects of AIS on labour and land productivity are comparable. Similarly, AES have comparable effects on labour productivity and land productivity.

Chapter 3 focuses on the effects of AIS and microfinance on rural poverty reduction. This paper has two objectives. First, Chapter 3 estimates the effects of AIS and microfinance on household consumption. Second, the chapter compares the effects of AIS and microfinance on household consumption. This chapter helps to understand whether compared to AIS, the use of microfinance is more effective or at least equally effective in raising household consumption and thus reducing rural poverty. The key policy contribution in Chapter 3 is to examine whether

microfinance can complement, and if possible, replace AIS as the lead poverty reduction strategy in rural Tanzania, and potentially in other countries in SSA. Using control function and instrumental variable approaches to control for the endogeneity of the two programmes, estimates in this chapter show that microfinance and AIS are effective in increasing household consumption, and thus reducing poverty among farmers involved in maize and rice production. However, among low-income farmers, both programmes are not effective. Among middle-income households, however, both programmes are effective in raising household consumption. Among high-income households, microfinance is effective while AIS is not effective. Moreover, in the comparative analysis, estimates in Chapter 3 show that microfinance and AIS have comparable effects on household consumption. A similar analysis also shows that the effects of microfinance and AIS are comparable among low-income households as well as among middle-income and high-income households.

Chapter 4 focuses on the effects of public investment in health interventions on child mortality in Tanzania. This chapter specifically examines the child mortality effects of two major state-funded health interventions in the country: subsidies on insecticide-treated nets (ITNs) and free medicare. Despite being two of the largest health interventions, their effects on child mortality have not been adequately evaluated. In addition to estimating the effects of subsidized ITNs and free medicare on malaria-caused child mortality, this paper helps understand whether preventive interventions using ITNs are more effective than free medicare in reducing malaria-caused child mortality. The chapter applies the two-stage residual inclusion in the proportional hazard model to control for endogeneity of subsidized ITNs and free medicare. Estimates in Chapter 4 show that the use of subsidized ITNs significantly reduced child mortality associated with malaria. For free medicare, estimates show negative but statistically insignificant effects on malaria-caused child mortality. This suggests that free medicare is not effective in reducing malaria-caused child mortality. However, when deaths

from all diseases are considered, subsidized ITNs and free medicare are significantly effective in reducing overall child mortality. Furthermore, the comparative analysis shows that the effects of subsidized ITNs on malaria-cause child mortality are statistically comparable to that of free medicare. However, when deaths from all diseases are accounted for, subsidized ITNs are more effective than free medicare in reducing child mortality.

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CHAPTER 2

AGRICULTURAL INPUT SUBSIDIES, EXTENSION SERVICES, AND FARM LABOUR PRODUCTIVITY NEXUS: EVIDENCE FROM MAIZE FARMERS IN TANZANIA

2.1. Introduction

Elimination of poverty requires productive use of labour, which is the poor's most abundant asset (World Bank, 1990). In sub-Saharan Africa (SSA), where agriculture is labour-intensive and employs most of the rural labour force (Christiaensen et al., 2011; Dercon et al., 2009), growth in farm labour productivity is a key contributor to rural poverty reduction (McCullough, 2017; Thirtle et al., 2003). However, farm labour productivity in SSA is lower than anywhere in the world (McCullough, 2017; McMillan et al., 2014). Owing to this, raising farm labour productivity is a key development target in the region. To reduce rural poverty in SSA, (Collier and Dercon, 2014) proposed two ways: relocating rural labour from farm to non-farm jobs or raising farm labour productivity. This suggestion is also echoed in SSA countries, particularly Tanzania, where development policies suggest that rural poverty reduction requires enhancing non-farm sectors in rural areas and increasing farm labour productivity (Ministry of Finance [Tanzania], 2011). While the former requires long time structural transformation programmes (McMillan, Rodrik and Verduzco-Gallo, 2014), the latter can be achieved through short-term agricultural productivity-enhancing interventions. This chapter focuses on how to raise farm labour productivity.

Public investment in agriculture can play a key role in improving agricultural productivity (Dercon *et al.*, 2009). For instance, to ensure that farmers can buy modern technologies such as fertilizers, governments in SSA have been implementing various agricultural input subsidies (AIS) (Jayne & Rashid, 2013; World Bank, 2014). AIS reduces the cost of farm inputs, leading to farmers using more of these inputs, which in turn, increases agricultural productivity (Ricker-Gilbert, Jayne and Shively, 2013). Owing to this, in 2008, Tanzania introduced the National Agricultural Inputs Subsidy Scheme (NAIVS), a scheme that subsidized fertilizers and improved seeds for smallholder farmers involved in maize and rice production (World Bank, 2014). At the same time, the country has been providing free agricultural extension services (AES). AES promotes the use of better farming practices and assists farmers deal with adverse shocks such as insect infestations and crop diseases (Dercon

et al., 2009). In this chapter, I examine the effects of these interventions on farm labour productivity in Tanzania. I focus on maize, the country's most popular staple crop that received over 80% of input subsidies from NAIVS (Pan & Christiaensen, 2011).

Estimating the effects of these investments is not straightforward due to identification challenges. For instance, when using observational data, the researcher must control for the endogeneity caused by the non-random nature of how AIS and AES are distributed. Moreover, because the two interventions often target the same farmers at the same time, researchers and policymakers would prefer to estimate the effect of one intervention while controlling for the effect of the other. When using observational data, this requires controlling for the endogeneity of both interventions, compounding further the estimation issues. Because of these complexities, most evaluation studies focused on the effect of one of these interventions (Pan & Singhal, 2019; Ricker-Gilbert & Jayne, 2017; Wossen et al., 2017; Dionne & Horowitz, 2016). In this chapter, I estimate the effects of both interventions, thus accounting for the potential interplay between the two programmes. I use the control function and instrumental variable approaches to control for the endogeneity of the two interventions.

In the existing literature, only Ragasa & Mazunda (2018) estimated the interplay between AIS and AES. Ragasa & Mazunda (2018) observed inconsistent impacts of AIS on yields and insignificant impacts for AES. I extend the literature, particularly (Ragasa and Mazunda, 2018), in two ways. First, I estimate the effect of AIS and AES on labour productivity. Most previous studies focused on the effects of AIS and AES on crop yields (Ricker-Gilbert & Jayne, 2017; Wossen et al., 2017; Karamba & Winters, 2015; Awotide et al., 2013). This has resulted in assuming that improvements in yields would always lead to similar effects on labour productivity. This assumption is unrealistic. In part, this is because, in most SSA countries, growth in labour productivity lags behind yield growth (Collier & Dercon, 2014; Timmer, 1988) and, therefore, yields and labour productivity might not be equally impacted by policy interventions. Moreover, because development policies in Tanzania specifically target raising labour productivity in agriculture (Ministry of Finance [Tanzania], 2011), direct estimation of farm labour productivity, therefore, has important policy application. Second, I examine whether the two interventions differently affect land productivity and farm labour productivity. Because growth in farm labour productivity is the major driver of poverty reduction among farmers (McCullough, 2017; Collier & Dercon, 2014), understanding whether the effects of policy interventions on yields are equally (or

unequally) reflected in labour productivity would help policymakers choose interventions that not only raise crop yields but also enhance farm labour productivity.

In the literature, this chapter contributes to two streams of empirical studies. The first focuses on the effect of AIS on labour-related outcomes. In this stream, this chapter is closely related to three studies. The first is Dorward et al., (2008), which showed that Malawi's farm inputs subsidy programme reduced poor households' need to hire out their labour and increased the ability of beneficiary households to hire from the rural labour market. The second is (Dorward and Chirwa, 2011), which showed that the farm input subsidy programme in Malawi contributed to higher real wages in farm activities. Lastly, Ricker-Gilbert (2014) observed that due to the benefits of input subsidy in Malawi, beneficiaries supplied fewer days to the rural agricultural labour market and that subsidized fertilizers boosted agricultural wages. Despite providing very useful findings on the labour effects of AIS, these studies did not estimate the direct effect of AIS on farm labour productivity.

The second stream consists of studies focusing on the effects of AES on farm productivity. The evidence on the effect of AES on farm productivity remains contested. While some studies have reported positive and significant effects, others have found no significant effects. For instance, in Pakistan, Ali & Rahut (2013) observed that the use of AES increased crop yields. Similar results have also been reported in Ghana by Danso-Abbeam et al., (2018). In Brazil, Patrick & Kehrberg (1973) also observed positive effects of AES on farm productivity, albeit with smaller effects in less modernized areas compared to modernized areas. On the contrary, Ragasa et al., (2013) found that access to AES had no significant effect on land productivity in Ethiopia. In this stream, no study has estimated the effect of AES on farm labour productivity.

This chapter merges these two streams by examining the effects of AIS and AES on labour productivity in plots planted with maize. The chapter presents estimates showing that the use of AIS and AES significantly increased labour productivity in maize-planted plots. Further estimates show that AIS and AES also increased land productivity in these plots. This shows that in maize farms, AIS and AES are effective in increasing land and labour productivity. Furthermore, each programme has comparable effects on land productivity and farm labour productivity, which suggests that both programmes affect land productivity as much as they affect farm labour productivity. This further implies that the effects of AIS and AES are widely shared across different measures of agricultural productivity.

The remaining parts of this chapter are organized as follows. Section 2.2 discusses the policy context. Section 2.3 presents the data sets and descriptive statistics whereas Section 2.4 presents the methodology. The results are discussed in Section 2.5. Section 2.6 presents the conclusions and policy implications.

2.2. Policy Context

(a) Agricultural Input Subsidies (AIS) in Tanzania

The use of AIS in Tanzania dates back to 1967 when the country formed the Tanzania Fertilizer Company, a state-owned company that distributed subsidized agricultural inputs (Minot, 2000). However, due to economic crises in the 1980s, fertilizer subsidies were eliminated in 1994 (Minot, 2000). Consequently, by the end of 1997/98, about 89.5% of farmers had abandoned the use of fertilizers (Cagley, Gugerty and Plotnick, 2009), resulting in farm productivity decline (World Bank, 2014). The subsequent low farm productivity exacerbated by a severe food shortage between 2006 and 2008, pushed the government to introduce NAIVS, which subsidized fertilizers and improved seeds for smallholders involved in the production of maize and rice.

NAIVS was implemented through multistage procedures which determined the number of vouchers allocated to local areas and individual farmers. A voucher committee was formed at the region, district, and village levels. At the ministry level, regional voucher committee members first met with relevant officers at the Ministry of Agriculture once a year to discuss the allocation of vouchers by region, and similar meetings were held at the regional level to decide on the district, and district meetings decided voucher allocation to villages (World Bank, 2014). Actual beneficiaries were determined at the village level based on established criteria. NAIVS particularly targeted smallholder farmers who should be able to pay 50% of the cost of a subsidy package¹ as the government covered the remaining 50% (Pan & Christiaensen, 2011). Other participation criteria included farmers' willingness to work with agricultural extension officers, not having used fertilizers in the previous five years, and special preference for women (World Bank, 2014). Farmers meeting these criteria were selected by the village voucher committee and after paying 50% of the input cost, they received input vouchers, which were exchanged for the inputs at the participating retailer in the local area.

¹ There were three subsidy packages: (1) One bag of urea (2) one bag of Di-ammonium Phosphates or two bags of Minjingu Rock Phosphate with nitrogen supplement (3) 10 kg of hybrid or maize seeds or 16 kg of rice seeds.

At the beginning of the programme in 2008 only a few regions with high productivity potential were selected. For instance, when the NAIVS pilot programme was scaled up in 2008 Table 1 shows that only 730,667 households from 11 regions benefited. Thanks to grants from the World Bank, the coverage was increased, reaching 1.5 million households across 12 regions in 2009/10 (World Bank, 2014). By the end of 2010, however, NAIVS had been scaled up across all regions in the country. The programme peaked in 2010/11, benefitting 2,040,000 households in that year. Each beneficiary received a voucher package that was calculated to be sufficient to cultivate between ½-1 hectare of land and each beneficiary received one voucher per year, coinciding with the start of the long rainy season (Pan & Christiaensen, 2011).

(b) Agricultural Extension Services (AES)

Agricultural extension is a mechanism by which information on new technologies, more effective farm management options, and better farming practices can be transmitted to farmers (Owens, Hoddinott and Kinsey, 2003). AES is one of the key public investments in Tanzania's agricultural sector, where the government accounts for up to 88% of AES (National Bureau of Statistics [Tanzania], 2012). Between 2008 and 2013, AES accounted for 10% of all expenditures in the Ministry of Agriculture (MAFAP, 2013). The budget has fluctuated over time, raising from TZS 15,100 (\$12.1) million in 2006/07 to 24,400 (\$20.00) million in 2007/8 and then remained comparable in the subsequent years: TZS 22,200 (\$17.74) million in 2008/9, TZS 21,800 (\$16.13) million in 2009/10, and TZS 19,800 (\$14.66) million in 2010/11 (MAFAP, 2013).

Broadly, there are various extension services provided by agricultural extension officers, including information about cropping techniques, optimal input use, and the development of farmers' managerial skills (Birkhaeuser, Evenson and Feder, 1991). Extension officers also can consult directly with farmers on specific production problems, thus facilitating a shift to more efficient methods of production (Dinar, Karagiannis and Tzouvelekas, 2007). In Tanzania, to ensure equitable access to AES, the government provides free AES. To achieve this, the government targets to ensure that every village has a stationed agricultural extension officer. By the end of 2014, there were 9,558 government extension officers employed to serve 15,802 villages (Ministry of Agriculture [Tanzania], 2016). This suggests that about 40% of the villages had no stationed extension officers.

Generally, in Tanzania, the farmer can have access to AES in three main ways. First, the farmer can request an official visit from the stationed extension officer. This often happens

when the farmer faces some specific challenges that can be addressed by the extension officer AES (National Bureau of Statistics [Tanzania], 2012). Second, the extension officer may choose to visit farmers in certain areas to address challenges that are specific to farmers in the local area. During such visits, the extension officer will normally meet farmers in the fields and advice/train them regarding various aspects of farming ranging from general issues to very specific topics AES (National Bureau of Statistics [Tanzania], 2012). The last, which is more popular, involves group training. In this approach, a group of farmers are invited to attend specific training to enhance their skills, particularly relating to the use of new farming inputs such as insecticides during crop disease outbreaks, crop storage technologies, availability of government interventions, etc AES (National Bureau of Statistics [Tanzania], 2012).

Table 1: Household Beneficiaries of NAIVS

	2008/9	2009/10	2010/11	2011/12	2012/13	2013/14
Planned	740,000	1,500,000	2,040,000	1,800,000	1,000,000	500,000
Actual	730,667	1,511,900	2,011,000	1,779,867	940,783	932,100

Source: World Bank, 2014

2.3. Data, Variables Measurement, and Descriptive Statistics

(a) Data and Variables Measurement

I use data from the National Panel Survey (NPS) in Tanzania. NPS is conducted by the National Bureau of Statistics (Tanzania) in collaboration with the World Bank. The data can be freely downloaded from the World Bank's website. The survey follows a stratified multi-stage sampling procedure. In each stratum, designated clusters are chosen randomly, with the probability of selection proportional to their population size, and from each cluster, households were selected randomly. The baseline sample in 2008/9 (Wave 1) was calculated to be sufficient to produce national estimates. Wave 1 was followed by Wave 2 (2010/11), Wave 3 (2012/13), Wave 4 (2014/15), and Wave 5 (2019/20). I use only the first three waves because the sampling framework was changed in Wave 4, leaving only about 800 households from previous waves linked to Waves 4 and 5. Equally important, NAIVS was implemented between 2008 and 2014 thus covering only the first three waves.

From the data, I focus on plots planted with maize, which is the most popular staple crop in the country (World Bank, 2014). Importantly, maize farmers received 80% of the subsidy vouchers (Pan & Christiaensen, 2011). For intercropped plots, the NPS collected only the outputs and inputs of the main crop. Therefore, the sample consists of plots in which maize was either the only or the main crop. I focus on the outputs and inputs during the long rainy

season, which is experienced across all regions in the country. Moreover, input vouchers were distributed to coincide with the start of the long rainy season and, therefore, they were mainly used during this season. Based on these criteria, the number of maize-planted plots was 1,861 in Waves 1 and respectively 2,281 and 2,865 in Waves 2 and 3, thus giving unbalance panel of 7,007 total observations.

Variables relating to agricultural outputs and inputs are constructed from the agricultural module of NPS. The agricultural module collects data regarding agricultural production. For each plot, household members who worked in the plot were identified and interviewed. To ensure accurate recall of outputs and inputs, agricultural data was collected one month after the end of the harvest period (Arthi *et al.*, 2018). Collecting information immediately after harvesting is likely to give accurate recalls. Nevertheless, the accuracy of the information provided depends on how accurately farmers recalled their inputs and outputs. This is particularly a concern for inputs with high frequency such as labour. (Arthi *et al.*, 2018) observed that compared to short recall periods such as weekly interviews, end-of-farming season interviews can bias reported labour upwards. To address this bias, NPS data is thoroughly checked and corrected for reporting errors before publication. Moreover, each variable with at least five standard deviations from the sample means was checked and corrected for outliers (National Bureau of Statistics [Tanzania], 2009).

The outcome variable of interest is labour productivity. Following McCullough (2017) and Baily *et al.*, (2001), I measure farm labour productivity as farm output divided by labour. Farm output is self-reported by the farmer and is measured in kilograms (kg) of quantity harvested in each plot. Labour represents the total household labour and hired-labour days in each plot. During data collection, each farmer provided details on the number of days spent on the plot. It was not possible to use other measures of farm labour such as the number of workers because the household workforce is shared across many plots and other crops. Equally important, hired labour is only reported in terms of labour days. Similar studies have also relied on similar measurements of labour (Kang *et al.*, 2020; McCullough, 2017). Alternatively, I measure labour productivity by using only household labour, thus ignoring hired labour. In the sample, hired labour was only used in 31% of all plots and, therefore, most plots relied on household labour. Therefore, it may be informative to compute household-labour productivity, which is measured as quantity harvested (kilograms) divided by household labour days. Another measure of farm productivity used in this chapter is land productivity, which is defined as the quantity harvested divided by the area planted.

The explanatory variables of interest are AIS and AES. NAIVS used input vouchers, the value of which is reported in the agricultural questionnaire. The costs of inputs are provided for each plot. For subsidized fertilizers, the value recorded reflects only the amount paid to redeem the input vouchers, which accounts for 50% of the cost of the subsidy package as the government covered the remaining 50% (World Bank, 2014). Therefore, the amount paid by the beneficiary (50%) equals the amount of subsidy received from the government. Second, farmers were asked whether they received AES during the farming season. Because I use unprocessed crop outputs, I focus on AES relating to agricultural production and ignore AES relating to processing and marketing. AES is a binary variable taking the value of 1 if the farmer received AES on crop production, and 0 otherwise.

There are plot-level control variables generated from the agricultural questionnaire. These include organic fertilizers, unsubsidized inorganic fertilizers, labour (days), the area planted, and characteristics of the plots (soil type, fallowing, soil quality, and intercropping). There are also household-level control variables, namely, workforce size, age and sex of the household head, farm implements, livestock, and distance to the district headquarters. These are constructed from the household questionnaire.

(b) Descriptive Statistics

This section presents the descriptive statistics of the variables. Table 2 presents the trends of selected key policy variables, namely, AIS and AES. In Table 3, I present the descriptive statistics of the full sample (column 1), and comparable statistics based on voucher usage status (column 2) and use of AES (column 3). Moreover, it is important to note that this chapter uses panel data models, which among other things, uses within variations. For reference purposes, within variations of the variables used are presented in Table 4 for the full sample and in Table A6 (appended) for comparative statistics. Nonetheless, the main discussions in this focus on statistics in Tables 2 and 3, which is consistent with other studies in similar evaluation studies (Chibwana, Fisher and Shively, 2012; Mason and Ricker-Gilbert, 2013; Ragasa *et al.*, 2013; Ragasa and Mazunda, 2018; Pan and Singhal, 2019).

Table 2 shows that the rate of use in each programme is very low. For AIS, Table 2 shows that during the three waves of the survey, participation in NAIVS started in Wave 2, which was also the peak and then dropped in Wave 3. Due to the delay in voucher distribution in 2008/9, vouchers arrived after the planting months have passed and, therefore, there were no beneficiaries in the 2008/9 long rainy season (Wave 1) (World Bank, 2014). On the other

hand, the low participation rate in Wave 3 (2012/13) is because, by the beginning of 2013, NAIVS had started winding down and, therefore, graduating farmers were not being replaced with new beneficiaries (World Bank, 2014). This trend is comparable to what is reported in World Bank (2014), which shows that NAIVS peaked in 2010/11, benefitting 2,011,000 farmers in that year, and was concluded in 2014.

For AES, Table 2 shows that AESs usage dropped from 18.7% in Wave 1 to 12.7% and 12.2% in Wave 2 and Wave 3, respectively. Table 2 further shows that most of the AESs in the sample were provided by the government, which declined from 15% of maize farmers in wave 1 to 9%, and 8% in Wave 2 and Wave 3, respectively. AESs from non-governmental providers were only received by 0.4%, 1.6%, and 2.4% of maize farmers during Wave 1, Wave 2, and Wave 3, respectively. The percentage of farmers benefiting from both programmes is far smaller, dropping from 3.9% in Wave 2 to 2.1% in Wave 3. Generally, these low use rates of AIS and AES are contrary to the expectation of the government, which targets to ensure that each farmer uses AES. It must, however, be observed that the AES usage rate in the data is lower than the availability of extension officers, which reported estimates that 60% of villages in the country have at least one stationed agricultural extension officer (Ministry of Agriculture (Tanzania), 2016). For AIS, Table 2 suggests that NAIVS did not benefit most of its intended beneficiaries.

The comparative statistics are presented in Table 3. Comparative discussion is particularly important in this case to provide a brief understanding of how beneficiaries differed from non-beneficiaries in each programme. The data contains 7007 plots, 6.4% of which used input vouchers and 14.1% were cultivated by farmers that received AES. Moreover, beneficiaries of AES significantly used more vouchers than non-beneficiaries and input voucher beneficiaries used more AES than non-beneficiaries. This shows a significant interplay between the use of AIS and AES which was encouraged by NAIVS (World Bank, 2014). The average labour productivity in the full sample is 8.77 kilograms per labour (day) and land productivity is 492 kg/ha. The estimated land productivity is smaller than 779 kg/ha reported in other national reports (Table A5). The land productivity difference between these two tables could be related to the fact that Table 3 uses plot level estimates while Table A5 uses household-level aggregates. Beneficiaries of input vouchers and AES have higher labour productivity than non-beneficiaries. Similarly, beneficiaries of input vouchers and AES have higher land productivity than non-beneficiaries. Moreover, for AES, beneficiaries have higher

household-labour productivity, but voucher beneficiaries and non-beneficiaries have comparable household-labour productivity.

I control for organic fertilizers, unsubsidized inorganic fertilizers, the characteristics of the plot, and the characteristics of the household. Compared to non-beneficiaries, beneficiaries of input vouchers used fewer unsubsidized inorganic fertilizers, but AES beneficiaries used more unsubsidized inorganic fertilizers. Equally, AES beneficiaries used more organic fertilizers than non-beneficiaries. Plots for non-beneficiaries in both programmes were more intercropped than among beneficiaries. Table 3 further shows that voucher beneficiaries were significantly closer to district headquarters than non-beneficiaries. This reinforces the placement bias of NAIVS. For household characteristics, input voucher beneficiaries and non-beneficiaries have a comparable percentage of female household heads and the age of the household head as well as workforce size.

Finally, there are important differences between beneficiaries and non-beneficiaries in the two programmes regarding the four instruments. Compared to non-beneficiaries, households among voucher beneficiaries had a longer residence time in the village. For village assemblies, AES beneficiaries have higher rates of attending village meetings but no difference between input vouchers beneficiaries and non-beneficiaries. In each programme, beneficiaries have a significantly higher rate of access to farm input retailer(s) and a higher proportion of smallholder farmers in the village.

Table 2: Trend in AES and Input Vouchers Usage

Variables	Wave 1 (2008/9)	Wave 2 (2010/11)	Wave 3 (2012/13)
Input voucher (%)	0.0	11.7	6.3
Extension services-all sources (%)	18.7	12.7	12.2
Extension services-government (%)	15.0	9.0	8.0
Extension services-non-government (%)	0.4	1.6	2.4
Extension services-all sources * input voucher (%)	0.0	3.9	2.1
Total observations	1,861	2,281	2,865

Source: Author's computation from NPS (2008/9, 2010/11, and 2012/13)

Table 3: Descriptive Statistics

Variables	Full sample (N=7007)		Used Input Vouchers			Used AES		
			Yes (N=449)	No (N= 6558)	Mean Difference	Yes (N= 988)	No (N= 6019)	Mean Difference
	Mean	Std	Mean	Mean		Mean	Mean	
Received input vouchers (%)	6.40	24.5	100	0	100***	15.3	5.0	10.3***
<i>asinh</i> Value of Input vouchers	0.68	2.62	10.63	0	10.63***	1.63	0.53	1.10***
Received AES (%)	14.10	34.8	33.6	12.8	20.8***	100	0.0	100
Labour productivity (quantity harvested/total labour days)	8.77	0.34	12.03	8.55	3.48**	12.06	8.23	3.82***
Household-labour productivity	20.31	3.62	19.93	20.33	0.41	41.28	16.87	24.41***
Land productivity (quantity harvested/area planted)	492.01	5201	642	482	160**	523	487	36*
Unsubsidized inorganic fertilizer(kg)	23.02	673.9	7.85	24.06	16.21***	34.85	21.07	13.78*
Organic fertilizer(kg)	125.7	734.8	107.9	126.87	18.92	187.64	115.48	72.16***
Land planted with maize(hectares)	1.48	2.17	1.33	1.49	0.16	1.53	1.47	0.05
Soil type: clay (%)	15.4	36.0	20.5	15.0	5.0***	17.10	15.1	2.0
Soil type: sandy (%)	17.8	38.0	12.0	18.0	6.0***	17.40	17.9	0.5
Fallowing (%)	0.13	0.76	0.12	0.13	0.01	0.14	0.13	0.01
Intercropping (%)	65.5	47.0	57.90	66.0	8.1***	62.7	65.9	3.2**
Poor soil quality (%)	6.2	24.0	7.60	6.1	1.5	6.6	6.1	0.4
Distance from home to the plot (km)	4.75	26.79	4.29	4.78	0.49	4.84	4.74	0.10
Distance-home to district headquarters(km)	93.16	1.23	80.68	94.01	13.33***	96.77	92.57	4.20
Number of livestock	6.84	20.4	5.32	6.95	1.63	7.65	6.71	0.95
Small agricultural implements	3.44	0.02	3.84	3.61	0.22	4.06	3.64	0.42
Large agricultural implements	0.38	0.01	0.37	0.38	0.00	0.52	0.36	0.16
Female household head (%)	22.4	41.0	20.3	22.5	0.2	20.0	23.5	0.5
Age of the household head (years)	49.0	16.00	48.29	48.89	0.60	47.98	49.00	1.02
Education of the head (years)	1.32	0.03	1.40	1.32	0.08	1.48	1.30	0.18
Workforce size	2.79	1.70	2.91	2.78	0.13	3.11	2.93	0.18
IV1: Years of stay in the village	37.9	23.3	48.9	37.9	11.0***	36.9	38.1	1.2
IV2: Attending village meetings (%)	72.0	0.01	76.0	73.0	3.0	79.0	71.0	8.0***
IV3: Availability of farm input retailers in the village (%)	45.0	0.0	49.5	43.3	6.2*	49.1	34.3	14.8***
IV4: Smallholder maize farmers in the village (%)	47.0	1.0	59.0	36.0	23.0***	21.0	50.0	29.0***

Note: * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Sources: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

Table 4: Descriptive Statistics (Within Variations)

Variable	Mean	Std. Dev.	Min	Max
Received input vouchers (1/0)	0.00	0.174	-0.67	0.67
<i>asinh</i> Value of Input vouchers	0.00	1.86	-7.77	9.70
Received AES (1/0)	0.00	0.24	-0.67	0.67
Labour productivity	0.00	20.57	-333.20	665.78
Household-labour productivity	0.00	49.18	-792.40	1581.57
Land productivity	0.00	4244.74	-133320	266580
Unsubsidized inorganic fertilizer(kg)	0.00	42.82	-566.67	1033.33
Organic fertilizer(kg)	0.00	534.86	-8000	16000
Labour (days)	0.00	59.70	-359	645.67
Land planted with maize(hectares)	0.00	1.28	-14.08	25.79
Soil type: clay (1/0)	0.00	0.24	-0.67	0.67
Soil type: sandy (1/0)	0.00	0.26	-0.67	0.67
Fallowing (1/0)	0.00	0.17	-0.67	0.67
Intercropping (1/0)	0.00	0.32	-0.67	0.67
Poor soil quality (1/0)	0.00	0.16	-0.67	0.67
Distance to the plot (km)	0.00	11.76	-238	472
Reported preharvest loss (1/0)	0.00	0.29	-0.67	0.67
Total rainfall in the wettest quarter (mm)	0.00	103.54	-389.67	515
Distance to district headquarters(km)	0.00	71.65	-321.23	376.97
Small agricultural implements	0.00	1.44	-9.67	18.33
Large agricultural implements	0.00	0.79	-15.33	30.67
Cost of seeds/workforce size	0.00	2590.43	-30000	53000
Farm assets/ workforce size	0.00	0.69	-7.88	14.32
Land holding/ workforce size	0.00	0.47	-3.42	6.458
Age of the household head	0.00	10.40	-41.33	42
Female household head (1/0)	0.00	0.29	-0.67	.667
Education of the head	0.00	1.90	-7.67	10.67
Workforce size	0.00	1.07	-6.67	13.33
IV1: Years of stay in the village	0.00	12.59	-47	50
IV2: Attending village meetings (1/0)	0.00	0.30	-0.67	0.67
IV3: Availability of farm input retailers in the village (1/0)	0.00	0.34	-0.67	0.67
IV4: Smallholder maize farmers in the village (1/0)	0.00	0.11	-0.67	0.67

Sources: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

2.4. Methodology

(a) Conceptual framework

The mechanisms conceptualized here follow a production function-based approach in which AIS and AES are considered as production inputs and, therefore, have direct effects on farm outputs (Owens et al., 2003; Pudasaini, 1983; Moock, 1981; Ashenfelter, 1978; Patrick & Kehrberg, 1973). I apply a modified version of the theoretical model specified in Patrick & Kehrberg (1973). For simplicity, I assume that the value of farm output, Y , is a function of two factors: agricultural input subsidy, S , and farmer's access to agricultural extension scheme, E . The relationship between the output and these inputs will thus take the following form.

$$Y = f(S, E) \quad (1)$$

Assume further that E affects the decision and the choice of input, S . This relationship can be expressed as follow.

$$S = g(E) \quad (2)$$

Deriving from equations (1) and (2) we obtain equation (3) below.

$$\frac{dY}{dE} = \frac{\partial Y}{\partial E} + \frac{\partial Y}{\partial S} \cdot \frac{\partial S}{\partial E} \quad (3)$$

Where; $\frac{\partial S}{\partial E}$ is derived from equation (2), $\frac{\partial Y}{\partial E}$ is the direct effect of E on farm output, $\frac{\partial Y}{\partial S}$ is the marginal value of S . The second term on the right of equation (3), $\left(\frac{\partial Y}{\partial S} \cdot \frac{\partial S}{\partial E}\right)$, captures the indirect effect of E , which is experienced through its effects on the farm input, S . Patrick & Kehrberg (1973) observed that at the optimal point of input use, $\frac{\partial Y}{\partial S}$ would represent the price, P_s , of input S , provided that S is measured in value terms. At this point, the net indirect effect of extension service can be presented as follows.

$$\left(\frac{\partial Y}{\partial S} - P_s\right) \cdot \frac{\partial S}{\partial E} \quad (4)$$

Therefore, the net marginal product of extension is thus given as follows.

$$\frac{dY}{dE} = \frac{\partial Y}{\partial E} + \left(\frac{\partial Y}{\partial S} - P_s\right) \left(\frac{\partial S}{\partial E}\right) \quad (5)$$

Equation (5) presents both the direct and indirect effects of extension services. In cases like this, where agricultural extension has a direct effect and indirect effect through S , reducing the price (P_s) of input S would increase the indirect effect of E . From the agricultural policy perspective, this can be achieved by farmers' participation in farm input subsidy schemes.

In the spirit of Huffman (1978), Feder, Slade and Lau (1987), Owens, Hoddinott and Kinsey (2003), and Pan and Singhal, (2019), I focus on the direct effect. Notice that in the absence of relation expressed in equation (2), which gives rise to an indirect effect of S , estimates for the direct effect of extension ($\frac{\partial Y}{\partial E}$) and input S ($\frac{\partial Y}{\partial S}$) will be obtained by estimating equation (1) directly (Patrick and Kehrberg, 1973). According to equation (1), farm output, Y , is directly affected by E and S . Therefore, policies intended to enhance the consumption of E and S , which mainly consists of public-funded AIS and free provision of AES, would lead to higher direct effects.

There are several mechanisms through which AIS and AES directly affect farm productivity as presented in equation (1). Primarily, AIS directly affects farm productivity through enhanced soil fertility (Carter et al., 2021; Wossen et al., 2017; Ricker-Gilbert & Jayne, 2017; Arndt, Pauw and Thurlow, 2016). AIS reduces the price of fertilizers, which in turn, encourages farmers to use an adequate quantity of fertilizers on their farms (Ricker-Gilbert, Jayne and Shively, 2013). When inorganic fertiliser is adequately applied to the plot, the soil gets the required level of soil nutrients such as nitrogen and phosphorous, which in turn, would enhance farm output in these plots (Ricker-Gilbert and Jayne, 2017).

On the other hand, AES affect farm productivity through various direct routes. Following Welch (1970), I conceptualize two mechanisms, namely, a worker effect and an allocative effect. The worker effect arises when increased education improves the quality of labour and can be defined as an ability to produce more given the same resources other than labour (Patrick and Kehrberg, 1973). In crop production, AES enhances the quality of labour when farmers learn key skills needed in crop production such as soil management strategies and better farming practices (Owens et al., 2003). The use of soil management strategies such as land fallowing, proper use of organic fertilizers, and prevention of soil erosion, directly enhances soil fertility, which in turn, would enhance farm output in the respective plots.

The allocative effect is realized through allocation of resources and determination of the quantity and quality of resources used in production. For allocation of resources, farmers apply allocative techniques when there is more than one line of production and, therefore, resources must be optimally allocated among various lines. Because this chapter focuses on one crop (maize), the discussion focuses entirely on determination of resources. To this end, AES is important in helping farmers determine the qualities and quantities of resources needed in crop farming. For instance, as the core objective of AES, extension officers train farmers on the proper application of modern inputs such as fertilizers, improved seeds, and insecticides (Dercon *et al.*, 2009). The optimum application of these inputs could result in enhanced farm productivity (Patrick and Kehrberg, 1973). Importantly, trained farmers may flexibly adjust their input mix to reflect new input prices and availability (Welch, 1970).

(b) Empirical Approach

(i) Model Specification

The model used to estimate the effects of AIS and AES is analogous to equation (1). I extend equation (1) by including more relevant and standard control variables. The choice of the

function form is guided by the literature on this topic. I apply a linear function that is commonly applied when estimating the effects of these interventions on farm productivity (Carter et al., 2021; Wossen et al., 2017; Ricker-Gilbert & Jayne, 2017).

Consider a plot, i , cultivated at time, t , using subsidized fertilizers, S , and cultivated by a farmer that received agricultural extension services, E . The plot-level labour productivity, y , is expected to depend on plot, household, and community characteristics, and participation in these productivity-enhancing programmes. The function estimated takes the following linear form.

$$y_{it} = \alpha_1 S_{it} + \alpha_2 E_{it} + \alpha_3 x_{it} + \mu_i + \epsilon_{it} \quad (6)$$

Where, α_1 and α_2 are parameters to be estimated representing respectively the effect of S and E on labour productivity. Because S and E are designed to increase farm productivity (Ragasa and Mazunda, 2018), α_1 and α_2 , therefore, are expected to be positive, indicating that S and E increase farm labour productivity.

X is a vector of plot, household, and community factors that affect labour productivity and α_3 is a vector for respective parameters. The characteristics of the plot include soil type, intercropping, soil quality, and distance to the household. Compared to sandy and clay soil, loam is most favourable in maize production and, therefore, sandy and clay soil are expected to have negative effects on labour productivity. Intuitively, farmers would not use plots with poor soil quality for crop cultivation. However, when used for crop production, plots with poor soil quality would record low farm productivity. Intercropping and long distance from the household inhibit productivity and, therefore, they are expected to have negative effects. I also control for other productivity-enhancing strategies and inputs, including the amount of unsubsidized inorganic fertilizers, organic fertilizers, and land fallowing, which are expected to have positive effects. The control for the characteristics of the household includes the age, sex, and education of the household head, workforce size, and membership in farm-related groups. The age of the household head is expected to have negative effects implying that farm labour productivity declines as the household head gets older. Because households headed by women tend to be poor (National Bureau of Statistics [Tanzania], 2019), the variable for the female household head is thus expected to have a negative effect. Similarly, education of the head should have positive effects as educated farmers tend to use better farming technologies and practices (National Bureau of Statistics [Tanzania], 2014). Workforce size represents the ability of the household to supply farm labour and, therefore, excessive supply of labour would

have negative effect on labour productivity. Membership in farm-related groups such as cooperatives is expected to have positive effects as group members often have access to key information that can enhance farm productivity.

I also control for farm-related capital including livestock and farm implements (small agricultural implements and large agricultural implements). Livestock is an important source of farm power and manure (Dercon, 1998), and, therefore, it is expected to have positive effect. Following Dercon (1996), I also include key asset ratios, mainly, farm assets/worker, landholding/worker, and cost of seeds/worker. Because of the direct positive effects associated with farm assets, land, and seeds, these ratios, therefore, should have positive effects. There are controls for local area variables including rainfall and distance to the district headquarters. Rainfall is expected to have positive effect because farming in Tanzania is mostly rain-fed (Dercon, 1996; World Bank, 2019). Distance from the household to the district headquarters represents the remoteness of the household from key services and infrastructure. Because remote households tend to be poor (National Bureau of Statistics [Tanzania], 2014), long distance, therefore, is expected to have negative effects on labour productivity.

There are also unobserved factors represented by the time-invariant unobserved heterogeneity, μ_i , which accounts for time-constant unobservables, and ϵ_{it} representing time-varying unobservables.

One of the limitations in estimating equation (6) is that the details on the use of AES before Wave 1 (2008) are not reported. Therefore, like most studies in this area, only the contemporaneous effects of AES are estimated (Ragasa et al., 2013; Dercon et al., 2009; Feder et al., 1987). Nonetheless, this ignores the long-lasting nature of some aspects of AES such as soil fertility and land management training.

(ii) Identification Strategy

Establishing the causal effect of policy interventions such as AIS and AES using observational data is a challenging task. For instance, in equation (6), a researcher can confidently conclude that α_1 and α_2 are respectively the effects of S and E on labour productivity only if access to S and E is random. However, governments do not randomly distribute public interventions. For example, to ensure positive results, governments allocate AIS and AES to areas with productivity potential (Dercon *et al.*, 2009). This implies that allocations of AIS and AES are potentially biased across and within locations, resulting in placement bias. Following Ragasa

& Mazunda (2018), I control for placement bias by controlling for regional fixed effects and time fixed effects in equation (6).

However, even within locations, participation in these programmes is potentially related to endogenous household factors, such as income, which is also related to farm productivity. For instance, AIS targeted smallholder farmers, who tend to be poor and have a history of low farm productivity (World Bank, 2014). Moreover, participation in AIS and AES can also be related to various factors that cannot be measured by the researcher. For example, the desire and willingness to seek AES and AIS can be related to unmeasured factors such as aspirations and political/social capital of farmers. Reports across SSA have documented evidence of biased allocations of AIS based on social and political connections (Mason & Ricker-Gilbert, 2013; Pan & Christiaensen, 2011; Banful, 2010). This suggests that even after controlling for the placement bias, S and E would still be endogenous because of unobservables. The current chapter addresses these issues as follows.

(a) Controlling for time-invariant unobservables

One of the concerns in equation (6) is that the time-invariant unobservable heterogeneity, μ_i , is potentially related to S and E . If the unobserved heterogeneity is time-invariant, differencing or applying fixed effects would eliminate μ_i . However, differencing and fixed effects also eliminate every time-invariant variable in the model. Because receipt of AES repeats over time, differencing and fixed effects would also eliminate AES for most plots. One way of avoiding this is to use the Correlated Random Effects (CRE) approach, known as the Mundlak-Chamberlain device (Mundlak, 1978; Chamberlain, 1982). CRE is implemented by including the time means of all time-varying covariates in the model. By including the time means, CRE controls for time-invariant unobserved heterogeneity, as with fixed effects, but it estimates the effect of time-constant covariates, just like in the conventional random effect (Wooldridge, 2010).

After including the mean variables, equation (6) takes the following form.

$$y_{it} = \alpha_1 S_{it} + \alpha_2 E_{it} + \alpha_3 x_{it} + \alpha_4 \bar{x}_i + \mu_i + \epsilon_{it} \quad (7)$$

Where $\bar{x}$ is a vector of time averages for all time-varying exogenous covariates.

(b) Controlling for correlation between endogenous variables and time-varying unobservables

The estimation of CRE assumes that the unobservables are time-invariant. However, in policy interventions, some unobservables vary over time. For instance, unmeasured factors such as

ambitions which tend to decline as the farmer gets older, affect the willingness to seek AIS and AES. Therefore, even after using CRE, endogeneity would persist because AIS and AES are potentially correlated with the time-varying unobservables. Furthermore, equation (6) also includes a control for unsubsidized inorganic fertilizers. This is equally endogenous as the quantity of fertilizers is non-random and is potentially related to unobservables such as income and ambitions.

To control for the relationship between endogenous regressors and time-varying unobservables, researchers have relied on instrumental variable (IV) and control function (CF) approaches (Ragasa and Mazunda, 2018; Wossen et al., 2017; Ricker-Gilbert & Jayne, 2017; Bezu et al., 2014). The two approaches are similar as they use two-stage regression procedures. However, they differ in implementing the second-stage regression. IV uses predicted values of the endogenous variables instead of the true values (Wooldridge, 2010) while CF uses the true value of endogenous variables but includes generalized residuals from the first-stage regression (Wooldridge, 2015). Generally, the preference for any of these approaches depends on whether the endogenous variable is binary or continuous. IV produces more consistent estimates than CF but when dealing with binary endogenous regressors, CF is more efficient than IV (Ragasa and Mazunda, 2018). Because the model includes both continuous and binary endogenous variables, for robustness purposes, I apply both IV and CF approaches. In this chapter, I estimate CRE with IV and CF, which are respectively referred to as CRE-IV and CRE-CF.

One concern when estimating the first-stage regressions is choosing the right functional form. First, very few plots in the sample used input vouchers or unsubsidized fertilizers and, therefore, input vouchers and unsubsidized inorganic fertilizers assume the distribution and properties of corner solution variables (Mason and Ricker-Gilbert, 2013). The Tobit model exploits these properties better than other functions. Second, AES is a binary variable and, therefore, requires the use of non-linear models. The three first-stage functions, therefore, are of the following forms.

$$S_{it} = \alpha_1 \gamma_{it} + \alpha_2 z_{it} + v_{sit} \quad (8.1)$$

$$f_{it} = \alpha_1 \gamma_{it} + \alpha_2 z_{it} + v_{fit} \quad (8.2)$$

$$Pr(E = 1|x, z) = Pr(\rho_1 \gamma + z\rho_2 + v_{mit} > 0) \quad (8.3)$$

Where S and f respectively represent the value of input vouchers and quantity of unsubsidized inorganic fertilizers, and E represents the use of AES. γ includes all exogenous covariates and

the time means from equation (7) and z is a vector for the instruments. Equations (8.1) - (8.2) are estimated using Tobit models and equation (8.3) is estimated using the Probit Model.

For CRE-IV, the final equation includes the predicted value of input vouchers, $\hat{S}$, the predicted probability of receiving extension services, $\hat{E}$, and predicted quantity of unsubsidized inorganic fertilizers, $\hat{f}$, generated from equations 8.1-8.3. This equation takes the following log-linear form.

$$y_{it} = \alpha_1 \hat{S}_{it} + \alpha_2 \hat{E}_{it} + \alpha_3 \hat{f}_{it} + \alpha_4 x_{it} + \alpha_5 \bar{x}_i + \mu_i + \epsilon_{it} \quad (9)$$

For CRE-CF, the generalized residuals, $\hat{v}_{sit}$, $\hat{v}_{mit}$, and $\hat{v}_{fit}$ from equations (8.1) - (8.3) are included in the second-stage regression. Therefore, the CRE-CF takes the following form.

$$y_{it} = \alpha_1 S_{it} + \alpha_2 E_{it} + \alpha_3 f_{it} + \alpha_4 x_{it} + \alpha_5 \bar{x}_i + \alpha_6 \hat{v}_{sit} + \alpha_7 \hat{v}_{mit} + \alpha_8 \hat{v}_{fit} + \mu_i + \epsilon_{it} \quad (10)$$

By including $\hat{v}_{mit}$, $\hat{v}_{sit}$, and $\hat{v}_{fit}$ in equation (10), the error term becomes uncorrelated with S , E , and f (Wooldridge, 2015). To obtain more accurate residuals, all estimations are bootstrapped with 200 repetitions.

In this chapter, I use four instruments to control for the endogeneity of AIS, AES, and unsubsidized fertilizers. Because AIS and AES are free public-funded services, I argue that the use of these services is largely influenced by their availability in the local area and farmers' access to relevant information. Unfortunately, the availability of AIS and AES in the local area is equally endogenous. Therefore, for AIS and AES, I rely on instruments that increase access to information while carrying no direct effects on farm productivity. The first instrument is the number of years the household head has lived in the village (IV1). Previous studies have observed that a long residence time in the village creates social capital, which in turn, increases the household's access to relevant information and the likelihood of being selected by the subsidy committee in the village (Wossen et al., 2017; Bezu et al., 2014; Chibwana et al., 2012).

Second, I construct a dummy variable for attending village meetings, taking a value of 1 if a member of the household attended village meetings during the year and 0 otherwise (IV2). Village meetings are used as information dissemination media in rural areas during which village officers would inform villagers about the availability of public programmes such as input vouchers and AES. Due to access to relevant information, attending village meetings, therefore, increases the likelihood of farmers using input vouchers and AES. However, attending village assemblies does not directly affect farm productivity.

The third instrument is a binary variable for the availability of input retailer(s) in the village. This variable takes the value of 1 if the village has input retailer(s) and 0 otherwise. Convenient access to input sellers reduces the transaction cost, which in turn, reduces the price of inputs, thus increasing the likelihood for farmers to purchase and use such inputs. The fourth instrument is the proportion of smallholder maize farmers in the village (IV4). NAIVS mainly targeted smallholder maize farmers in the country (World Bank, 2014). Likewise, governments allocate more extension officers in agricultural areas to help smallholders that cannot afford cash purchases. Therefore, areas with many smallholder maize farmers were more likely to receive more input vouchers and AES.

In applied research, instruments are valid if they correlate with at least one of the endogenous regressors but must have no significant relationship with the outcome variable. The former is established in the first-stage regression while the latter is tested using the exogeneity test. (Wooldridge, 2013) observed that an instrument is exogenous if it fulfils the following exogeneity test.

$$cov(z, e) = 0 \quad (11)$$

Where e is a residual from the naïve estimation of outcome function (i.e., equation 7) and z is a vector for instruments. In this chapter, all instruments are tested for these conditions.

(iii) Controlling for Attrition Bias

Estimating causal effects using unbalanced panel data can be affected by sample attrition. In the data used in this chapter, for instance, 243 plots from Wave 1 were not observed in subsequent waves. This could lead to attrition bias. If the attrition is random, there are no serious estimation issues. However, estimation issues arise when attrition is non-random. I apply the pooling test popularized by Beckett et al., (1988) to examine the randomness of attrition. The pooling test involves regressing the outcome variable from the first wave of a survey on explanatory variables, the attrition dummy, and the attrition dummy interacted with the explanatory variables (Beckett *et al.*, 1988). An F-test of the joint significance of the attrition dummy and the interaction variables is then conducted to determine whether the coefficients differ between retained and attrited observations (Baulch and Quisumbin, 2011). The null hypothesis is that the attrition is random. The pooling test estimated in this chapter is reported at the end of Table A1 (appended) and shows non-significant F-statistics. Therefore, I fail to reject the null hypothesis and conclude that the attrition is random. This means that further attrition controls are not necessary.

iv) Estimation of Elasticities and Accounting for Zero-Valued Observations

To produce easily interpretable coefficients, I estimate elasticities using the inverse hyperbolic sine transformation (IHS). Previous empirical researchers often used natural logarithm transformation to make the interpretation of parameters easier, approximate a normal distribution, reduce heteroscedasticity, or reduce the effect of outliers (Bellemare and Wichman, 2020). Unfortunately, taking the logarithm of a variable drops zero-valued observations because $\ln(0)$ is undefined. But when dealing with microeconomics data, meaningful zero-valued observations are common. Allowing these observations to disappear is econometrically unacceptable. Fortunately, IHS transformation approximates the natural logarithm of a variable while retaining zero-valued (and negative-valued) observations (Bellemare & Wichman, 2020; Bahar & Rapoport, 2018; MacKinnon & Magee, 1990). In this chapter, most farmers did not participate in NAIVS and did not use unsubsidized fertilizers and, therefore, for most plots, the value of these variables is zero. To retain zero-valued observations, therefore, I apply IHS.

IHS is analogous to logarithmic transformation and, therefore, the estimated coefficients of IHS-transformed and log-transformed variables should have similar interpretations (Bahar & Rapoport, 2018; Clemens & Tiongson, 2017)). For instance, consider a random variable x , whose IHS is given by $\text{arsinh}(x)$.

$$\frac{\partial}{\partial x} \text{arsinh}(x) = \frac{1}{\sqrt{x^2+1}}, \quad \lim_{x \rightarrow \infty} \frac{1}{\sqrt{x^2+1}} = \frac{1}{x} \quad (12)$$

Similarly

$$\frac{\partial}{\partial x} \ln(x) = \frac{1}{x} \quad (13)$$

$$\text{Thus, for large values of } x, \frac{\partial}{\partial x} \text{arsinh}(x) = \frac{\partial}{\partial x} \ln(x) = \frac{1}{x} \quad (14)$$

In this paper, I use stata algorithm ‘*asinh*’, which returns inverse hyperbolic sine. In the result tables, therefore, *asinh* refers to an IHS-transformed variable.

2.5. Empirical Results

Estimated models in this section include time means of time-varying variables that are not reported. However, full results are reported in Table A4 (appended). Time means included in the models are kilograms of organic fertilizers, labour days, area planted, land fallowing, poor soil quality, intercropping, reported pre-harvest loss, age and education of the household head, workforce size, total rainfall, livestock, small agricultural implements, large agricultural implements, cost of seeds/worker, farm assets/worker, landholding/worker, and membership in farm cooperatives. These variables tend to change over time. I do not include the time means

of variables that do not change over time, namely, soil type, distance to the district headquarters, distance from the plot to the household, sex of the household head, and regional and time dummies.

(a) Determinants of Input Vouchers, AES, and Unsubsidized Fertilizers

The first-stage regression is presented in Table 5, which presents determinants of input vouchers, AES, and unsubsidized fertilizers. First and foremost, I focus on the relevance and economic intuition of the instruments. To be relevant an instrument must be strongly correlated with at least one of the endogenous variables. This can be established in the first-stage regression in two ways. First, Bound et al., (1995) suggested a significance level of $p < 0.05$. Second, Stock & Yogo (2002) suggested at least an F-statistics of 10. The F-statistics of each instrument are presented at the end of Table 4². Table 4 shows that for each endogenous variable, at least one instrument has $p < 0.05$ and an F-statistics of more than 10. This means that each instrument is strongly correlated with at least one of the endogenous variables.

The coefficient signs of relevant instruments are consistent with the hypotheses in section 2.4. First, the household head's years of residence in the village have a positive and significant effect on input vouchers. This suggests that households headed by heads who have lived in the village for a long time used more input vouchers. This is intuitive because a long stay in the village creates social capital, which increases the likelihood of being selected by the village voucher committee. Years of residence have also been used as an instrument for AIS in other studies in SSA (Wossen et al., 2017; Bezu et al., 2014; Chibwana et al., 2012). Second, attending village meetings significantly increased the likelihood of receiving AES. This is also intuitive as village meetings are important communication media in rural areas. During village meetings, officers disseminate relevant information, which as per these results, might have included the availability and use of AES.

Third, the availability of input retailer(s) in the village significantly increased the kilograms of unsubsidized fertilizers and the likelihood of receiving AES. For unsubsidized fertilizers, this is intuitive as the availability of input retailer(s) in the village potentially reduces transaction costs, which lowers input prices, which in turn, increases the use of farm inputs. The positive effect of input retailer(s) on AES could be related to the fact that among other activities, extension officers train and encourage farmers to use modern inputs. Lastly, the

² F-statistics in Table 5 were estimated from a Wald test for the null hypothesis that an instrument, z , is not strongly correlated with the endogenous variable, w , [i.e. $Cov(z, w) = 0$]. I used stata algorithm *test*, which returns F-statistics from Wald Test of these hypotheses.

proportion of smallholder farmers in the village has a positive and significant effect on the value of input vouchers and the use of AES and a negative effect on unsubsidized fertilizers. This suggests that farmers in villages that have many smallholders tended to receive more input vouchers and have a higher likelihood of receiving AES. The significance of smallholder farmers on the value of input vouchers and AES is consistent with the targets of agricultural policies in the country, particularly NAIVS, which among other criteria, targeted smallholder farmers (World Bank, 2014). For unsubsidized fertilizers, negative effects imply that farmers in villages with more smallholders tended to use less unsubsidized fertilizers. This is also intuitive as smallholders tend to be poor, which affects their ability to buy unsubsidized inputs.

In addition to the instruments, Table 5 also shows significant control variables that need highlighting. Labour has a positive and significant effect on the value of input vouchers, suggesting that plots with more input vouchers also tended to have more labour days. Intuitively, this implies that farmers were willing to spend more time in their subsidized plots, perhaps to benefit more from the acquired fertilizers. Organic fertilizers have a significant positive effect on AES. This shows that plots managed by farmers that received AES tended to use more organic fertilizers. This highlights the relevance of AES in influencing farmers to use various soil fertility management strategies, including traditional methods such as organic fertilization.

The size of land planted has a positive effect on the quantity of unsubsidized inorganic fertilizers. This suggests that large plots tended to have more unsubsidized inorganic fertilizers than small plots. This could be related to the fact that farmers with large plots tend to be economically well-off (National Bureau of Statistics [Tanzania], 2012) and, therefore, they can afford to pay for unsubsidized farm inputs. Moreover, there are also relevant plot characteristics. For instance, plots with clay soil received less unsubsidized fertilizers. One implication for this is that clay soil tends to be dark and nutritious, which makes farmers reluctant to apply soil fertility-enhancing inputs such as fertilizers. Similarly, land fallowing has a negative effect on the quantity of unsubsidized fertilizers. This is intuitive as land fallowing is one of the traditional strategies used to enhance soil fertility and, therefore, fallowed plots are viewed to have the required level of nutrients needed to support crop production. The negative effect of intercropping on input vouchers can also have a similar meaning. On one hand, in some cases, intercropping is meant to improve soil fertility when nitrogen-rich crops such as legumes are intercropped with maize (Ebelhar, Frye and Blevins, 1984; Blevins, Herbek and Frye, 1990). Therefore, farmers relying on intercropping as a

strategy for enhancing soil fertility would tend to use less fertilizers, even if it is subsidized. On the other hand, however, intercropping may imply a lack of land and, therefore, a small plot is used to produce several crops in a single farming season. This may apply to poor farmers, which in turn, means that they are unable to acquire modern farm inputs, even if they are subsidized.

There are also significant community and household variables. The distance from the household to the headquarters of the district of residence has positive effects on AES, suggesting that plots farther from the district headquarters were more likely to receive AES. This is intuitive because farms are often located away from urban areas such as district headquarters and extension officers work with farmers in rural areas. The negative effect of rainfall on AES is counter intuitive. Perhaps this could be related to the possibility that high rainfall in rural areas where the transport infrastructure is poor would make most farmers unreachable by agricultural extension agents. The number of livestock has a negative effect on the quantity of unsubsidized fertilizers. This could be related to the fact that livestock provides manure, which is a key source of organic fertilizers and, therefore, farmers with more livestock would rely on manure than inorganic fertilizers. Small farm implements have positive effects on unsubsidized fertilizers. More small farm implements imply more involvement and commitment to farming activities. This level of commitment can also be reflected in other investments including unsubsidized fertilizers.

The age of the household head has a negative effect on the value of input vouchers and unsubsidized inorganic fertilizers, suggesting that older heads tended to use fewer input vouchers and fewer unsubsidized inorganic fertilizers. This could be related to the fact that households headed by old heads tend to be poor (National Bureau of Statistics [Tanzania], 2014) and less ambitious, thus affecting their ability to pay for modern agricultural inputs. The workforce size has a positive effect on input vouchers, implying that households with a large workforce received more input vouchers.

Table 5: Determinants of Input Vouchers, the use of AES, and Unsubsidized Fertilizers

Estimation Model	(1) Tobit	(2) Probit	(3) Tobit
Dependent variable	<i>asinh</i> input vouchers	Received AES (1/0)	<i>asinh</i> unsubsidized inorganic fertilizers
IV1: Years of stay in the village	0.116*** (0.022)	-0.001 (0.002)	0.227 (0.128)
IV2: Attending village meeting (1/0)	0.467 (0.805)	0.237*** (0.059)	-0.332 (0.279)
IV3: Input retailer in the village (1/0)	-0.468 (1.628)	3.604*** (0.108)	3.853*** (0.499)

IV4: Proportion of smallholder maize farmers in the village	37.024***	0.468***	-2.780***
	(1.916)	(0.154)	(0.708)
<i>asinh</i> Labour days	1.882***	0.038	0.254
	(0.664)	(0.044)	(0.220)
<i>asinh</i> organic fertilizer(kg)	-0.018	0.034**	-0.027
	(0.201)	(0.014)	(0.073)
<i>asinh</i> area planted (hectares)	2.112	0.086	1.069*
	(1.804)	(0.114)	(0.581)
Soil type: Clay (1/0)	1.367	0.104	-0.703*
	(0.878)	(0.067)	(0.366)
Soil type: Sandy (1/0)	1.330	-0.023	0.551*
	(1.002)	(0.066)	(0.327)
Land fallowing (1/0)	-1.793	0.033	-1.599**
	(2.064)	(0.132)	(0.690)
Intercropped with other crops (1/0)	-1.838*	-0.068	0.663
	(1.035)	(0.073)	(0.474)
Bad soil quality (1/0)	-0.750	-0.003	-0.031
	(1.262)	(0.099)	(0.470)
Distance to the plot	0.113	0.028	0.224**
	(0.295)	(0.022)	(0.103)
Reported preharvest loss (1/0)	-0.796	-0.120	-0.511
	(1.690)	(0.088)	(0.452)
<i>asinh</i> total rainfall-wettest quarter	-3.251	-0.308*	-0.986
	(2.460)	(0.161)	(0.866)
Distance to district headquarters(km)	-0.007	0.001***	0.002
	(0.004)	(0.000)	(0.002)
Number of livestock	0.010	-0.001	-0.067***
	(0.026)	(0.002)	(0.017)
Small agricultural implements	-0.551	0.024	0.416***
	(0.448)	(0.029)	(0.147)
Large agricultural implements	-0.923	-0.024	-0.090
	(0.582)	(0.046)	(0.193)
Cost of seeds/workforce size	0.000***	0.000	0.000***
	(0.000)	(0.000)	(0.000)
Farm assets/ workforce size	1.474	0.059	-0.230
	(0.912)	(0.062)	(0.314)
Land holding/ workforce size	-1.690	-0.175*	-0.227
	(1.727)	(0.106)	(0.527)
<i>asinh</i> age of the head	-8.681***	-0.085	-4.723***
	(1.859)	(0.121)	(0.651)
Education of the head (Years)	-0.056	0.005	0.069
	(0.188)	(0.013)	(0.063)
Female household head (1/0)	0.199	-0.234***	0.080
	(0.914)	(0.066)	(0.323)
Workforce size	1.426***	0.043	-0.303
	(0.527)	(0.037)	(0.189)
Membership in farm cooperatives (1/0)	0.236	0.014	0.546
	(0.956)	(0.069)	(0.350)
Constant	-16.125	-0.598	-12.706
	(919.142)	(1.236)	(726.759)
Pseudo R2	0.3129	0.3642	0.1862
N	7007	7007	7007
IV1: F-Statistics	29.25	0.565	1.80
IV2: F-Statistics	0.760	15.01	2.49
IV3: F-Statistics	0.864	3.00	73.20
IV4: F-Statistics	87.61	9.70	12.20

Note: Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%
Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

(b) The Effects of Input Vouchers and AES on Farm Labour Productivity

The determinants of farm labour productivity are presented in four columns in Table 6. Column 1 excludes the control variables whereas column 2 includes all relevant control variables. Columns 1-2 present naïve estimates as time-invariant unobservables are not controlled. Because of the endogeneity of input vouchers, AES, and unsubsidized fertilizers (confirmed by statistically significant generalized residuals in column 4), I rely on results in columns 3-4, which are more robust as CRE-IV and CRE-CF address both fixed and time-varying unobservables.

The estimated models in columns 3-4 require valid instruments. In addition to the relevance criterion discussed in section 2.5(a), instruments must also be exogenous. Table A2 (appended) shows that all instruments are not statistically significant when regressed against farm labour productivity. Furthermore, following Wooldridge (2013), an instrument is exogenous if the covariance between the instrument and residuals from naïve estimates is close to zero. The covariances between each instrument and the residual in Table 6 (column 2) are close to zero, indicating that the instruments are exogenous. Additional tests are provided in Table A3 (appended), estimated using stata algorithm *ivreg2*. First, the very large Cragg-Donald Wald F-statistic (150.551) and Kleibergen-Paap Wald F-statistic (102.382) suggest that the instruments are not weak. Second, using the Hansen J statistic, I fail to reject the null hypothesis and, therefore, conclude that the instruments are valid (i.e., uncorrelated with the error term and that the excluded instruments are correctly excluded). Overall, these tests suggest that the instruments used are valid.

Results in Table 6 show that input vouchers and AES have positive and statistically significant coefficients. This suggests that both programmes are effective in increasing farm labour productivity in maize plots. For input vouchers, columns 3-4 show that the effect of input vouchers on labour productivity is 3.9% in the CRE-IV approach and 4.1% in the CRE-CF approach. The effect of AES is 13.5% in the CRE-IV approach and 12.0% in the CRE-CF approach. Generally, Table 6 shows that CRE-IV and CRE-CF present comparable estimates. In subsequent discussions, I rely on CRE-CF because it is simple to estimate, and for binary endogenous variables, it produces more efficient estimates (Imbens & Wooldridge, 2007, quoted in (Ragasa and Mazunda, 2018)).

For input vouchers, estimates in column 4 mean that *ceteris paribus*, a 1% increase in the value of input vouchers would increase labour productivity by 4.1%. This suggests that the

use of AIS was effective in raising farm labour productivity in maize plots. Since earlier results in Tanzania showed that NAIVS had significant effects on crop yields (Aloyce et al., 2014; World Bank, 2014), these estimates, therefore, suggest that the effect of NAIVS was also reflected on farm labour productivity. Equally important, these results suggest that in addition to the effects on farm employment and wages (Ricker-Gilbert, 2014; Dorward et al., 2008), AISs also have direct effects on farm labour productivity.

For AES, results in column 4 mean that *ceteris paribus*, receiving AES increased labour productivity by 12.0%. This means that AES was effective in raising labour productivity in maize-planted plots. This is not consistent with the findings in Ragasa & Mazunda (2018), which found a lack of consistent significant effect of AES in a heavily subsidized environment in Malawi. It is important to note that this chapter differs from Ragasa & Mazunda (2018) in two major ways: (1) it estimates the effects on labour productivity instead of land productivity, and (2) it uses plot-level observations instead of household-level measurements of productivity. However, it is important to note that these results are consistent with results in other studies, including Ali & Rahut (2013) in Pakistan, Feder et al., (1987) in India, and Danso-Abbeam et al., (2018) in Ghana.

Column 4 also contains significant control variables that deserve highlighting. Unsubsidized inorganic fertilizers have a positive effect, suggesting that the use of unsubsidized inorganic fertilizers increases farm labour productivity. Labour has negative effect, indicating that plots with more labour days tended to have low labour productivity. Organic fertilizers and fallowing have positive effects. This shows that even traditional soil fertility-enhancing strategies have a significant role to play in enhancing farm labour productivity. The size of the plot has a positive effect, indicating that large plots tended to have higher labour productivity. This is against the inverse farm size-productivity relationship reported in SSA countries (Larson et al., 2014; Barrett, 1996). However, some studies have shown positive farm size-productivity relationships in some SSA countries (Kevane, 1996; Zaibet & Dunn, 1998). On the other hand, sandy soil type, bad soil quality, and intercropping have negative effects, suggesting that they inhibit labour productivity in maize-planted plots. The distance between the plot and the household is positive, suggesting that plots farther from the household tended to have higher labour productivity. This is contrary to the hypothesis. However, this could be related to the fact that households tend to live in populated centres and not in their farms. The amount of rainfall has a positive effect. This could be related to the fact

that farming in Tanzania is rain-fed (Dercon, 1996; World Bank, 2019) and, therefore, areas with high rainfall tend to have high farm labour productivity.

Both small and large agricultural implements have positive effects, suggesting that farmers with many farm implements have high labour productivity. This could be related to the fact that farmers with many agricultural implements invest more and are more committed in farm production. The cost of seeds per workforce has a positive effect, suggesting using more seeds per worker increases labour productivity. On the other hand, land holding per workforce has a negative effect, suggesting that farmers with a large land/worker ratio have low labour productivity. Because large landholding/worker indicates that the household has large land relative to labour, a large landholding/worker ratio suggests that household labour is insufficient to appropriately cultivate the available land. This may lead to low farm productivity unless the household can afford hired labour.

The age and sex of the household head have negative effects. This suggests that plots managed by older household heads tended to have lower labour productivity. The negative effect for female household heads shows that plots managed by women have lower labour productivity compared to those managed by their male counterparts. This could be related to the fact that compared to men, women tend to be poor and less educated (National Bureau of Statistics [Tanzania], 2014). Finally, the size of the workforce has a negative effect, suggesting that plots managed by households with large workforces tended to have low labour productivity. This could be related to the fact that in agriculture-dependent areas, most of the workforce is allocated to farm activities, which in turn, as Lewis (1954) suggested, might imply an oversupply of the household workforce in agricultural activities.

Table 6: Determinants of Labour Productivity in Maize Plots

Estimation Method	(1) CRE	(2) CRE	(3) CRE-IV	(4) CRE-CF
Dependent Variable	<i>asinh</i> Labour productivity (output in kg/labour days)			
<i>asinh</i> input vouchers	0.061** (0.005)	0.044*** (0.004)	0.039*** (0.005)	0.041*** (0.004)
Received AES (1/0)	0.196*** (0.038)	0.120*** (0.027)	0.135*** (0.050)	0.120*** (0.028)
<i>asinh</i> unsubsidized inorganic fertilizers		0.092*** (0.007)	0.082*** (0.015)	0.081*** (0.007)
<i>asinh</i> Labour days		-0.723*** (0.017)	-0.718*** (0.018)	-0.728*** (0.018)
<i>asinh</i> organic fertilizer(kg)		0.022*** (0.006)	0.022*** (0.006)	0.023*** (0.006)
Land fallowing (1/0)		0.121** (0.055)	0.118** (0.056)	0.126** (0.055)
<i>asinh</i> area planted (hectares)		0.907*** (0.044)	0.914*** (0.045)	0.906*** (0.045)
Soil type: Clay (1/0)		-0.011	-0.011	-0.032

Soil type: Sandy (1/0)	(0.026)	(0.027)	(0.027)	
	-0.180***	-0.176***	-0.178***	
Intercropped with other crops (1/0)	(0.026)	(0.026)	(0.026)	
	-0.163***	-0.161***	-0.142***	
Bad soil quality (1/0)	(0.029)	(0.030)	(0.030)	
	-0.217***	-0.216***	-0.211***	
Distance to the plot	(0.038)	(0.039)	(0.039)	
	0.063***	0.065***	0.065***	
Reported preharvest loss (1/0)	(0.008)	(0.008)	(0.008)	
	-0.027	-0.026	-0.027	
<i>asinh</i> total rainfall-wettest quarter	(0.035)	(0.036)	(0.035)	
	0.165***	0.168***	0.179***	
Distance to district headquarters(km)	(0.061)	(0.062)	(0.061)	
	-0.000**	-0.000**	-0.000	
Number of livestock	(0.000)	(0.000)	(0.000)	
	0.001*	0.001*	0.000	
Small agricultural implements	(0.001)	(0.001)	(0.001)	
	0.022*	0.022*	0.030**	
Large agricultural implements	(0.012)	(0.012)	(0.012)	
	0.046***	0.045***	0.050***	
Cost of seeds/workforce size	(0.015)	(0.015)	(0.015)	
	0.000***	0.000***	0.000***	
Farm assets/ workforce size	(0.000)	(0.000)	(0.000)	
	0.026	0.026	0.010	
Land holding/ workforce size	(0.025)	(0.026)	(0.026)	
	-0.131***	-0.133***	-0.120***	
<i>asinh</i> age of the head	(0.039)	(0.040)	(0.039)	
	-0.275***	-0.286***	-0.270***	
Education of the head (Years)	(0.047)	(0.048)	(0.049)	
	0.002	0.002	0.003	
Female household head (1/0)	(0.005)	(0.005)	(0.005)	
	-0.088***	-0.089***	-0.086***	
Workforce size	(0.024)	(0.024)	(0.024)	
	-0.017	-0.017	-0.031**	
Membership in farm cooperatives (1/0)	(0.015)	(0.015)	(0.015)	
	0.012	0.012	0.012	
Probit residual-AES	(0.028)	(0.028)	(0.028)	
			-0.026*	
Tobit residual-input vouchers			(0.014)	
			-0.005**	
Tobit residual-unsubsidized fertilizers			(0.002)	
			0.013***	
			(0.004)	
Time fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Constant	2.066***	5.756***	5.812***	5.596***
	(0.014)	(0.454)	(0.464)	(0.468)
R-sq: within	0.0319	0.5073	0.4859	0.5057
N	7007	7007	7007	7007
Cov(residual, IV1)		-0.025		
Cov(residual, IV2)		-0.006		
Cov(residual, IV3)		0.000		
Cov(residual, IV4)		0.002		

Note: Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

(c) Effects of Input Vouchers and AES on Land and Household-labour Productivity

This section examines if AIS and AES were also effective on other measures of farm productivity. I use CRE-CF to estimate the effects of AIS and AES on land productivity and household-labour productivity. The results are presented in Table 7.

Results in column (1) show that *ceteris paribus*, a 1% increase in the value of input vouchers would increase land productivity by 4.3% and receiving AES would increase land productivity by 13.4%. Column (2) shows that *ceteris paribus*, a 1% increase in input vouchers would increase household-labour productivity by 4.3%, and receiving AES would increase household-labour productivity by 16.5%. These estimates are statistically significant at a 1% significance level, suggesting that input vouchers and AES are effective in raising land and household-labour productivity. This shows that AIS and AES have wider effects on different types of farm productivity.

Table 7: Effects of Input Vouchers and AES on Land and Household-labour Productivity

Estimation Method	(1) CRE-CF	(2) CRE-CF
Dependent Variable	<i>asinh</i> Land productivity (Crop output-kg/area planted)	<i>asinh</i> home-labour productivity (output in kgs/labour days)
<i>asinh</i> input vouchers	0.043*** (0.005)	0.043*** (0.005)
Received AES (1/0)	0.134*** (0.033)	0.165*** (0.032)
<i>asinh</i> unsubsidized inorganic fertilizers	0.078*** (0.009)	0.098*** (0.008)
<i>asinh</i> Labour days	0.151*** (0.021)	-0.781*** (0.020)
<i>asinh</i> organic fertilizer(kg)	0.024*** (0.007)	0.023*** (0.007)
<i>asinh</i> area planted (hectares)	-0.644*** (0.053)	0.985*** (0.051)
Soil type: Clay (1/0)	-0.058* (0.032)	-0.027 (0.031)
Soil type: Sandy (1/0)	-0.212*** (0.031)	-0.192*** (0.030)
Fallowing (1/0)	0.091 (0.065)	0.121* (0.063)
Intercropped with other crops (1/0)	-0.146*** (0.035)	-0.146*** (0.034)
Bad soil quality (1/0)	-0.235*** (0.046)	-0.233*** (0.044)
Distance to the plot	0.063*** (0.010)	0.127*** (0.009)
Reported preharvest loss (1/0)	-0.059 (0.041)	0.024 (0.040)
<i>asinh</i> total rainfall-wettest quarter	0.153** (0.072)	0.259*** (0.070)
Distance to district headquarters(km)	-0.000* (0.000)	-0.000 (0.000)
Number of livestock	0.001 (0.001)	0.002** (0.001)
Small agricultural implements	0.061*** (0.015)	0.027* (0.014)

Large agricultural implements	0.088*** (0.018)	0.058*** (0.017)
Cost of seeds/workforce size	0.000*** (0.000)	0.000*** (0.000)
Farm assets/ workforce size	-0.040 (0.030)	0.037 (0.029)
Land holding/ workforce size	0.061 (0.046)	-0.125*** (0.045)
<i>asinh</i> age of the head	-0.298*** (0.058)	-0.258*** (0.056)
Education of the head (Years)	0.007 (0.006)	0.009 (0.006)
Female household head (1/0)	-0.069** (0.028)	-0.071*** (0.027)
Workforce size	-0.033* (0.018)	-0.038** (0.017)
Membership in farm cooperatives (1/0)	0.007 (0.033)	0.006 (0.032)
Probit residual-AES	-0.026 (0.017)	-0.037** (0.016)
Tobit residual-input vouchers	-0.005** (0.003)	-0.003 (0.002)
Tobit residual-unsubsidized fertilizers	0.019*** (0.005)	0.014*** (0.005)
Time fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
Constant	7.336*** (0.553)	5.725*** (0.537)
R-sq: within	0.245	0.484
N	7007	7007

Note: Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%
Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

(d) Heterogeneity on Farm Labour and Land Productivity

The discussion thus far has shown that both input vouchers and AES are effective in raising labour and land productivity. Estimates in Tables 6 and 7, however, show slightly different levels of effects of both programmes on these two measures of farm productivity. The question briefly addressed in this section is whether this heterogeneity is statistically significant. Table 8 presents Wald tests on the difference between the effects on labour and land productivity. All the Chi-squares of the Wald tests in column (3) are not statistically significant. This suggests that there is no significant difference between the effect of the two variables (input vouchers and AES) on labour productivity and land productivity. This means that AIS has statistically comparable effects on land productivity and labour productivity. Similarly, AES has comparable effects on labour productivity and land productivity. This suggests that the effects of both programmes on land productivity are equally reflected in farm labour productivity.

Table 8: The heterogeneity between farm labour productivity and land productivity

Dependent variables	(1) Labour productivity (CRE-CF)	(2) Land productivity (CRE-CF)	(3) Wald test for coefficient difference: chi2(1)
<i>asinh</i> value of input voucher	0.041*** (0.004)	0.043*** (0.005)	1.46
Received AES (yes=1)	0.120*** (0.028)	0.134*** (0.033)	1.08

NB: (1) Standard errors in parentheses * = significant at 10%; ** = significant at 5% and *** = significant at 1%
 (2) Column (1) is extracted from column (4) Table 5 and column (2) is extracted from column (1) in Table 6
 Source: Author's estimation from NPS (2008/9, 2010/11 and 2012/13)

2.6. Conclusions and Policy Implications

Farm labour productivity is an important development target in Tanzania. Because of the linkage of agriculture with the income of the poor, in an agrarian economy such as Tanzania, growth in farm labour productivity is a key predictor of rural poverty reduction (Collier & Dercon, 2014; Thirtle et al., 2003; Timmer, 1988). Reflecting this, the country has been implementing various interventions to enhance agricultural productivity. These initiatives include public-funded AIS and free AES. This chapter applied the control function and instrumental variable approach to examine the effects of AIS and AES on farm labour productivity in maize plots.

This chapter presents three main findings. First, estimates show that a 1% increase in the value of input vouchers respectively increased labour and land productivity in maize-planted plots by 4.1% and 4.3%. This suggests that NAIVS was effective in increasing both crop yields and farm labour productivity in maize-planted plots. These estimates are consistent with findings in similar studies in SSA showing that AIS increases farm labour outcomes (Ricker-Gilbert, 2014; Dorward & Chirwa, 2011) and crop yields (Ricker-Gilbert & Jayne, 2017; Wossen et al., 2017). Second, estimates in this chapter show that AES respectively increased labour and land productivity by 12.0% and 13.4% in maize-planted plots. This suggests that receiving AES is effective in increasing both farm labour and land productivity. This is consistent with other similar estimates in SSA (Danson-Abbeam, Ehiakpor and Aidoo, 2018).

Third, further estimates show that each programme has comparable effects on land and labour productivity. This suggests that the effect of each programme on crop yields was equally reflected in farm labour productivity. Because growth in farm labour productivity in SSA has been slower than growth in crop yields (Collier and Dercon, 2014), these estimates, therefore, are encouraging as they suggest that yields and labour productivity in maize plots are equally

impacted by AIS and AES. Equally important, this suggests that public investment in these interventions can be used to enhance both crop yields and farm labour productivity.

From the public policy perspective, the positive effects of AIS and AES on farm productivity suggest that NAIVS achieved its main objective, which was to improve farm productivity (World Bank, 2014). It is important to note that while the provision of free AES continued uninterrupted, NAIVS ended in 2014. Although about 30% of input voucher beneficiaries continued to buy fertilizers from commercial markets (Cameron, Derlagen and Pauw, 2017), the lack of an alternative subsidy scheme disproportionately affects fertilizer usage among poor farmers. Given the significance of AIS on farm productivity, the lack of subsidized fertilizers negatively affects the farm productivity of poor farmers. To enhance higher farm labour and land productivity among poor farmers, productivity-enhancing interventions such as AIS and AES remain relevant.

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Appendices

Table A1: Attrition Pooling Test

Dependent variable	Labour productivity (Output in kg/labour days)
Received AES (1/0)	0.112* (0.059)
<i>asinh</i> unsubsidized inorganic fertilizer	0.102*** (0.015)
<i>asinh</i> Labour days	-0.989*** (0.032)
<i>asinh</i> organic fertilizer(kg)	0.036*** (0.011)
<i>asinh</i> area planted (hectares)	1.042*** (0.078)
Soil type: Clay (1/0)	0.055 (0.076)
Soil type: Sandy (1/0)	-0.158** (0.070)
Land Fallowing (1/0)	0.080 (0.073)
Intercropped with other crops (1/0)	-0.197*** (0.052)
Bad soil quality (1/0)	-0.430*** (0.106)
Distance to the plot	0.196 (0.223)
Reported preharvest loss (1/0)	0.064 (0.052)
<i>asinh</i> total rainfall-wettest quarter	0.099 (0.197)
Distance to district headquarters(km)	-0.001 (0.001)
Number of livestock	0.005*** (0.002)
Small agricultural implements	0.040 (0.119)
Large agricultural implements	0.018 (0.015)
Cost of seeds/workforce size	0.000 (0.000)
Farm assets/ workforce size	0.005 (0.034)
Land holding/ workforce size	-0.111 (0.162)
<i>asinh</i> age of the head	-0.069 (0.082)
Education of the head (Years)	0.022** (0.009)
Female household head (1/0)	-0.131 (0.161)
Workforce size	-0.035 (0.024)

Membership in farm cooperatives (1/0)	0.012 (0.055)
Attrition	0.744 (1.815)
Attrition*all covariates	Yes
Full regional dummies	Yes
Constant	10.535*** (1.381)
R ²	0.520
N	1,861
F-Tests for joint significance F (19, 1792)	1.12

Note: (i) Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%

(ii) The estimated model does not include input vouchers as NAIVS had not started operation in Wave1

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

Table A2: Determinants of Labour Productivity (for IVs exogeneity test), CRE regression

Dependent variable	<i>asinh</i> Labour productivity (output in kg/labour days)
IV1: Years of stay in the village	0.002 (0.003)
IV2: Attending village meeting (1/0)	-0.011 (0.026)
IV3: Input retailer in the village (1/0)	0.213 (0.353)
IV4: Proportion of smallholder maize farmers in the village	0.463 (0.585)
<i>asinh</i> Labour days	-0.845*** (0.021)
<i>asinh</i> organic fertilizer(kg)	0.022*** (0.007)
<i>asinh</i> area planted (hectares)	1.069*** (0.055)
Soil type: Clay (1/0)	0.018 (0.033)
Soil type: Sandy (1/0)	-0.167*** (0.032)
Fallowing (1/0)	0.053 (0.068)
Intercropped with other crops (1/0)	-0.166*** (0.036)
Bad soil quality (1/0)	-0.283*** (0.048)
Distance to the plot	0.090*** (0.010)
Reported preharvest loss (1/0)	-0.049 (0.043)
<i>asinh</i> total rainfall-wettest quarter	0.038 (0.075)
Distance to district headquarters(km)	-0.000 (0.000)
Number of livestock	0.002** (0.001)
Small agricultural implements	0.023 (0.015)
Large agricultural implements	0.037** (0.018)
Cost of seeds/workforce size	0.000*** (0.000)
Farm assets/ workforce size	0.031 (0.031)

Land holding/ workforce size	-0.204*** (0.048)
<i>asinh</i> age of the head	-0.270*** (0.058)
Education of the head (Years)	0.009 (0.006)
Female household head (1/0)	-0.083*** (0.030)
Workforce size	-0.020 (0.018)
Membership in farm cooperatives (1/0)	0.039 (0.034)
Constant	12.086*** (0.578)
R ²	0.4729
N	7007

Note: (i) Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%

(ii) The estimated model does not include input vouchers as NAIVS had not started operation in Wave1

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

Table A3: Determinants of Labour Productivity, IV regression (ivreg2)

Dependent variable	<i>asinh</i> Labour productivity (output in kg/labour days)
<i>asinh</i> input vouchers	0.056*** (0.006)
Received AES (1/0)	0.193*** (0.055)
<i>asinh</i> unsubsidized inorganic fertilizer	0.043* (0.024)
<i>asinh</i> Labour days	-0.718*** (0.013)
<i>asinh</i> organic fertilizer(kg)	0.020*** (0.004)
<i>asinh</i> area planted (hectares)	0.934*** (0.034)
Soil type: Clay (1/0)	-0.020 (0.026)
Soil type: Sandy (1/0)	-0.177*** (0.026)
Fallowing (1/0)	0.066* (0.038)
Intercropped with other crops (1/0)	-0.176*** (0.020)
Bad soil quality (1/0)	-0.218*** (0.036)
Distance to the plot	0.066*** (0.009)
Reported preharvest loss (1/0)	-0.024 (0.026)
<i>asinh</i> total rainfall-wettest quarter	0.070 (0.056)
Distance to district headquarters(km)	-0.000* (0.000)
Number of livestock	0.002*** (0.001)
Small agricultural implements	0.007 (0.008)
Large agricultural implements	0.008 (0.011)
Cost of seeds/workforce size	0.000*** (0.000)

Farm assets/ workforce size	0.071*** (0.018)
Land holding/ workforce size	-0.154*** (0.031)
<i>asinh</i> age of the head	-0.287*** (0.032)
Education of the head (Years)	-0.001 (0.003)
Female household head (1/0)	-0.088*** (0.024)
Workforce size	0.008 (0.010)
Membership in farm cooperatives (1/0)	-0.006 (0.020)
Time fixed effects	Yes
Region fixed effects	Yes
Constant	5.401*** (0.410)
R ²	0.518
N	7007
Underidentification test: (Kleibergen-Paap rk LM statistic)- Chi-sq (2)	360.04***
Weak identification test (Cragg-Donald Wald F statistic)	150.551
Weak identification test (Kleibergen-Paap rk Wald F statistic)	102.382
Hansen J statistic (overidentification test): Chi-sq (1)	1.352

Note: (i) Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%

(ii) The estimated model does not include input vouchers as NAIVS had not started operation in Wave1

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

Table A4: Determinants of Labour productivity (full results including time means)

Estimation Method	(1) CRE	(2) CRE	(3) CRE-IV	(4) CRE-CF
Dependent Variable	<i>asinh</i> Labour productivity (output in kg/labour days)			
<i>asinh</i> input vouchers	0.061** (0.005)	0.044*** (0.004)	0.039*** (0.005)	0.041*** (0.004)
Received AES (1/0)	0.196*** (0.038)	0.120*** (0.027)	0.135*** (0.050)	0.120*** (0.028)
<i>asinh</i> unsubsidized inorganic fertilizers		0.092*** (0.007)	0.082*** (0.015)	0.081*** (0.007)
<i>asinh</i> Labour days		-0.723*** (0.017)	-0.718*** (0.018)	-0.728*** (0.018)
<i>asinh</i> organic fertilizer(kg)		0.022*** (0.006)	0.022*** (0.006)	0.023*** (0.006)
Land fallowing (1/0)		0.121** (0.055)	0.118** (0.056)	0.126** (0.055)
<i>asinh</i> area planted (hectares)		0.907*** (0.044)	0.914*** (0.045)	0.906*** (0.045)
Soil type: Clay (1/0)		-0.011 (0.026)	-0.011 (0.027)	-0.032 (0.027)
Soil type: Sandy (1/0)		-0.180*** (0.026)	-0.176*** (0.026)	-0.178*** (0.026)
Intercropped with other crops (1/0)		-0.163*** (0.029)	-0.161*** (0.030)	-0.142*** (0.030)
Bad soil quality (1/0)		-0.217*** (0.038)	-0.216*** (0.039)	-0.211*** (0.039)
Distance to the plot		0.063*** (0.008)	0.065*** (0.008)	0.065*** (0.008)

Reported preharvest loss (1/0)	-0.027 (0.035)	-0.026 (0.036)	-0.027 (0.035)
<i>asinh</i> total rainfall-wettest quarter	0.165*** (0.061)	0.168*** (0.062)	0.179*** (0.061)
Distance to district headquarters(km)	-0.000** (0.000)	-0.000** (0.000)	-0.000 (0.000)
Number of livestock	0.001* (0.001)	0.001* (0.001)	0.000 (0.001)
Small agricultural implements	0.022* (0.012)	0.022* (0.012)	0.030** (0.012)
Large agricultural implements	0.046*** (0.015)	0.045*** (0.015)	0.050*** (0.015)
Cost of seeds/workforce size	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Farm assets/workforce size	0.026 (0.025)	0.026 (0.026)	0.010 (0.026)
Land holding/workforce size	-0.131*** (0.039)	-0.133*** (0.040)	-0.120*** (0.039)
<i>asinh</i> age of the head	-0.275*** (0.047)	-0.286*** (0.048)	-0.270*** (0.049)
Education of the head (Years)	0.002 (0.005)	0.002 (0.005)	0.003 (0.005)
Female household head (1/0)	-0.088*** (0.024)	-0.089*** (0.024)	-0.086*** (0.024)
Workforce size	-0.017 (0.015)	-0.017 (0.015)	-0.031** (0.015)
Membership in farm cooperatives (1/0)	0.012 (0.028)	0.012 (0.028)	0.012 (0.028)
<u>Mean Covariates</u>			
Mean (<i>asinh</i> Labour days)	0.007 (0.023)	0.005 (0.024)	-0.000 (0.023)
Mean (<i>asinh</i> organic fertilizers)	-0.004 (0.008)	-0.005 (0.008)	-0.004 (0.008)
Mean (<i>asinh</i> area planted)	0.030 (0.059)	0.033 (0.060)	0.040 (0.059)
Mean (land fallowing, 1/0)	-0.085 (0.074)	-0.087 (0.075)	-0.107 (0.074)
Mean (Intercropped with other crops, 1/0)	-0.023 (0.039)	-0.022 (0.040)	-0.046 (0.040)
Mean (Reported preharvest loss, 1/0)	0.006 (0.046)	0.003 (0.047)	0.028 (0.047)
Mean (<i>asinh</i> total rainfall-wettest quarter)	-0.151*** (0.058)	-0.161*** (0.059)	-0.133*** (0.058)
Mean (Number of livestock)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Mean (<i>asinh</i> age of the head)	-0.014 (0.061)	-0.013 (0.062)	-0.025 (0.061)
Mean (Education of the head)	-0.006 (0.007)	-0.006 (0.007)	-0.007 (0.007)
Mean (Workforce size)	0.054*** (0.020)	0.054*** (0.020)	0.064*** (0.020)
Mean (Large agricultural implements)	-0.068*** (0.020)	-0.069*** (0.020)	-0.069*** (0.020)
Mean (Small agricultural implements)	-0.029* (0.016)	-0.030* (0.016)	-0.034** (0.016)
Mean (Cost of seeds/workforce size)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000** (0.000)
Mean (Farm assets/ workforce size)	0.085** (0.035)	0.087** (0.035)	0.092*** (0.035)
Mean (Land holding/workforce size)	-0.037	-0.038	-0.044

	(0.052)	(0.053)	(0.052)
Mean (Membership in farm cooperatives, 1/0)	-0.045	-0.043	-0.023
	(0.037)	(0.038)	(0.038)

Residuals from first-stage regressions

Probit residual-AES				-0.026*
				(0.014)
Tobit residual-input vouchers				-0.005**
				(0.002)
Tobit residual-unsubsidized fertilizers				0.013***
				(0.004)
Time fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Constant	2.066***	5.756***	5.812***	5.596***
	(0.014)	(0.454)	(0.464)	(0.468)
R-sq: within	0.0319	0.5073	0.4859	0.5057
N	7007	7007	7007	7007

Note: (i) Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%

(ii) The estimated model does not include input vouchers as NAIVS had not started operation in Wave1

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

Table A5: Comparable Descriptives Statistics from other National Data

Variables	Mean
Land productivity (quantity harvested/ha)	779
Inorganic fertilizer (kg/ha)	38
Organic fertilizer (kg/ha)	113
Poor soil quality (%)	18.7%
Female household head (%)	26.2
Age of the household head	46.1
Workforce size	2.7

Sources: National Bureau of Statistics [Tanzania] (2014)

Table A6: Descriptive Statistics (Within Variations)

Variable	Use of Subsidized Fertilizers			Use of AES		
	No (N= 6558)	Yes (N=449)	Difference	No (N= 988)	Yes (N= 6019)	Difference
Received input vouchers (1/0)	0.00	0.47	0.47***	0.00	0.04	0.04***
asinh Value of Input vouchers	0.00	5.04	5.04***	-0.07	0.42	-0.49***
Received AES (1/0)	-0.01	0.09	0.10***	0.00	0.41	0.41***
Labour productivity	-0.10	1.54	-1.65*	-0.27	1.68	-1.95***
Household-labour productivity	-0.19	2.79	-2.98	-1.04	6.35	-7.39***
Land productivity	-5.23	76.4	-81.67**	-6.47	39.47	-45.94**
Unsubsidized inorganic fertilizer(kg)	0.19	-2.81	3.00	-1.92	11.73	-13.65***
Organic fertilizer(kg)	1.30	-19.00	20.30*	-4.53	27.62	-32.15**
Labour (days)	0.27	-3.90	4.17	-0.44	2.69	-3.13
Land planted with maize(hectares)	0.00	-0.04	-0.04***	0.00	0.01	-0.01
Soil type: clay (1/0)	0.00	-0.04	-0.04***	0.00	0.00	0.00
Soil type: sandy (1/0)	0.00	-0.04	-0.04***	0.00	0.02	-0.02
Fallowing (1/0)	0.00	-0.01	-0.01	0.00	0.01	-0.01
Intercropping (1/0)	0.00	-0.05	-0.05***	0.00	0.01	-0.01
Poor soil quality (1/0)	0.00	0.02	-0.02	0.00	0.00	0.00
Distance to the plot (km)	0.00	0.00	0.00	0.00	0.00	0.00
Reported preharvest loss (1/0)	0.01	-0.10	0.11	0.00	0.00	0.00
Total rainfall in the wettest quarter (mm)	-3.68	53.74	-57.42***	-0.06	0.35	-0.41*
Distance to district headquarters(km)	0.00	0.00	0.00	0.00	0.00	0.00
Small agricultural implements	-0.01	0.17	-0.18	-0.04	0.28	-0.32**
Large agricultural implements	0.00	-0.04	-0.04	0.00	0.04	-0.05**

Cost of seeds/workforce size	-32.61	476.29	-508.90***	-22.74	138.57	-161.31*
Farm assets/ workforce size	0.00	0.06	-0.06**	-0.01	0.08	-0.09***
Land holding/ workforce size	0.00	-0.01	0.01	0.00	0.00	0.00
Age of the household head	0.05	-0.76	0.81***	0.14	-0.87	1.01**
Female household head (1/0)	0.00	0.00	0.00	0.00	0.00	0.00
Education of the head	0.00	0.01	-0.01	-0.02	0.10	-0.12*
Workforce size	-0.01	0.07	-0.08	-0.01	0.10	-0.11**
IV1: Years of stay in the village	0.04	-0.64	0.68	0.17	-1.02	1.19***
IV2: Attending village meetings (1/0)	0.00	0.02	-0.02	0.00	0.03	-0.03
IV3: Availability of farm input retailers in the village (1/0)	0.00	0.11	-0.11	0.00	0.00	0.00
IV4: Smallholder maize farmers in the village (1/0)	-0.01	0.21	-0.22	0.00	0.03	-0.03

Note: (i) Standard errors in parentheses * = significant at 10% ** = significant at 5% *** = significant at 1%

(ii) The estimated model does not include input vouchers as NAIVS had not started operation in Wave1

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

CHAPTER 3

RURAL POVERTY REDUCTION STRATEGIES FOR FARMERS IN SUB-SAHARAN AFRICA: MICROFINANCE AS AN ALTERNATIVE TO STATE-FUNDED INPUT SUBSIDIES IN TANZANIA

3.1. Introduction

In sub-Saharan Africa (SSA), anti-poverty interventions represent a major part of development policies and public budgets. In rural areas where most households rely on agriculture for livelihood (Collier & Dercon, 2014; Christiaensen et al., 2011), such interventions focus on enhancing agricultural productivity through agricultural input subsidies (AISs). AISs were prominent rural development strategies in SSA in the 1960s (Morris *et al.*, 2007). Due to their unpopularity among donors and the economic crises that affected most SSA countries in the 1970s, most of these AISs were abandoned across SSA as part of the IMF and World Bank structural transformation and liberalization programmes (Wossen *et al.*, 2017; Ricker-Gilbert et al., 2013). However, in the 2000s, AISs re-surfaced again in public policymaking in SSA in a new wave of market-smart subsidies³ (Minot & Benson, 2009; Morris et al., 2007), and by the mid-2000s, most SSA countries were implementing various AISs as vehicles for agricultural and welfare development (Mason & Ricker-Gilbert, 2013; Banful, 2010). Reflecting this new wave, in 2008, Tanzania introduced the National Agricultural Inputs Vouchers Scheme (NAIVS) to subsidize fertilizer and improved seeds for farmers involved in maize and rice production.

Across SSA, AISs have recorded positive results in improving farm productivity and rural poverty reduction (Harou, 2018; Wossen et al., 2017; Arndt et al., 2016; Jayne & Rashid, 2013). Due to public funds attached to AISs, nonetheless, they are unpopular amongst development finance lenders, donors, and pro-market economists (Minot & Benson, 2009; Morris et al., 2007). Owing to this, some SSA countries, including Tanzania, have ended their market smart AISs (Cameron et al., 2017; World Bank, 2014). Because AISs are used by states to raise farm productivity and in reducing rural poverty, their suspension inevitably leaves poor farmers helpless, and unless genuine alternatives are made available, these farmers risk prolonged stay in chronic poverty. One argument that has been frequently raised is that owing

³ Market-smart subsidies are subsidies designed to target the poor and to support, rather than undercut, the development of private input distribution markets (Minot and Benson, 2009).

to the huge funds needed to run AISs, in financially constrained SSA countries, AISs should be complemented, and if possible, replaced with non-state pro-poor programmes (Morris *et al.*, 2007). To achieve this, one question needs to be addressed first: what are non-state programmes that can complement, and possibly, replace AISs as a rural development strategy? In the empirical literature, this question remains unanswered.

In this chapter, I focus on answering this question by empirically examining effective non-state options that can potentially replace AISs in Tanzania. Although the debate remains contested, one alternative that has been frequently suggested is the use of pro-poor credits (microfinance) (Benson *et al.*, 2013; Morris *et al.*, 2007). Arguably, access to microfinance would allow farmers to obtain affordable credit, which can be invested in modern farm inputs and other income-generating activities, which in turn, would make AISs less needed, eventually saving public funds. From the development perspective, this leads to a more specific question: is microfinance more effective or at least as effective as AISs in reducing poverty among farmers? Unfortunately, this question has not been empirically examined. In this chapter, I fill this gap by comparing the effect of microfinance against that of AISs on the consumption of households involved in agriculture.

To this end, I use empirical data to advance and examine two policy-related novel arguments. First, I argue that because microfinance represents pro-poor loans from the non-state sector, which are refundable at maturity plus some interests, borrowers are thus incentivized to seek optimal returns from these loans, which in turn, increases their effects on household consumption. Owing to this, microfinance is likely to be more effective than AISs in the overall poverty reduction among farmers. The second argument arises from recent developments in the microfinance sector whereby microfinance lending has shifted considerably from social finance objectives to the financial system approach in which microfinance lenders focus on financial sustainability and, therefore, demand collateral assets and charge interest rates (Imai, Arun and Annim, 2010). This essentially excludes the poorest farmers in rural areas, who ought to have been the focus of microfinance. Therefore, although microfinance can be effective in reducing overall rural poverty, it might not work well among very poor farmers whose access to microfinance is limited by the collateral asset requirements and high borrowing costs (Lipton and Ravallion, 1995). State-funded AISs on the other hand, tend to target and reach very poor farmers. Owing to this, I argue that because of its ability to target poor farmers, AIS is potentially more effective than microfinance among poor farmers.

In this chapter, I use household data from Tanzania to examine these arguments. Despite the lack of empirical evidence in this area, in the existing empirical literature, however, this chapter relates to two strands of empirical studies. The first focuses on the effect of AIS on poverty reduction. In this strand, this chapter closely relates to three studies. In Nigeria, Awotide et al., (2013) examined the effect of the supplementary seed voucher programme (SVS) on poverty reduction. They observed that SVS had a positive impact on annual household income and total per capita expenditure. Their findings have been confirmed by Wossen et al., (2017), which also concluded that SVS improved both productivity and the welfare of the households in Nigeria. In Malawi, Bezu et al., (2014) assessed the effect of subsidized improved maize varieties in Malawi and observed a stronger impact on the welfare of poorer households.

The second strand of literature related to the effect of microfinance on poverty. Despite receiving great attention among researchers, the effect of microfinance on poverty remains contested. In Tanzania, published studies on the microfinance-poverty nexus can hardly be found. Moreover, findings in international studies present mixed evidence. One of the famous early studies was Pitt & Khandker (1998), which observed that microfinance had a large impact on income in Bangladesh, particularly for female borrowers. Their results, however, were contested by Morduch (1998), which suggested that the change in income was the result of other income-smoothing techniques that are unrelated to microfinance. Despite re-affirming similar findings in the reply paper Khandker (2005), the lack of significant causal effect between microfinance and household consumption/income in Bangladesh continued to be reported (Roodman & Morduch, 2014; Duvendack & Palmer-Jones, 2012). Experience from other countries also provides inconclusive findings. In India for instance, Imai et al., (2010) established that access to microfinance services significantly reduced poverty. Similar results have been reported in Bolivia (Mosley, 2001). However, in Thailand, a study by Coleman (1999) observed that microfinance has little impact on the proxies of wealth.

In this chapter, I merge these two strands of literature by estimating the effects of microfinance and AIS and then examining which of the two programmes is more effective in poverty reduction. I found that AISs and microfinance have significant positive effects on household consumption among maize and rice farmers in Tanzania. This suggests that AISs and microfinance significantly reduce poverty among these farmers. I also found that both microfinance and AIS are not effective in raising the consumption of low-income households, but both are effective on the consumption of middle-income households. However, for high-

income households, only microfinance is effective. Finally, I observe that compared to AISs, microfinance is more effective in reducing the overall poverty among farmers. I also observe bigger effects of microfinance than that of AISs among low-income and middle-income farmers.

The remaining part of the chapter is organized as follows. Section 3.2 presents the context and aspects of NAIVS and microfinance in Tanzania. Section 3.3 discusses the data and descriptive statistics. Section 3.4 lays out the empirical approach and identification issues. Section 3.5 discusses the empirical results and Section 3.6 presents robustness tests. Section 3.7 presents the conclusions and policy recommendations.

3.2. Policy Perspective

(a) Aspects of Agricultural Input Subsidies in Tanzania

Large-scale AISs were first implemented in Tanzania in the 1960s to promote agricultural development and reduce rural poverty (World Bank, 2014). However, due to economic crises in the 1980s, AISs were phased out in the 1990s (Putterman, 1995; Nicholas Minot, 2000). Consequently, the real price of fertilizer increased pushing 89.5% of farmers to abandon fertilization (Cagley, Gugerty and Plotnick, 2009). By the early 2000s, fertilization in the country stood at 8kg/ha and only 5.7% of rice farmers and 0.7% of maize farmers used improved seed varieties together with fertilizers (Kenneth and Henrik, 2012). This resulted in a decline in crop yields in the country (World Bank, 2014).

To counter the falling farm productivity, the government in Tanzania launched NAIVS in 2008. The need for NAIVS was further reinforced by high food and fertilizer prices prevailing in 2007/8 (Pan and Christiaensen, 2011). That is why NAIVS targeted to increase the yields of 2.5 million smallholders involved in maize and rice production, the two most popular staple crops, estimated to be important to ensure food security. The pilot programme was first scaled up to 11 regions in 2008. However, by 2011, the peak year of the programme, NAIVS had effectively been turned into a nationwide programme (World Bank, 2014).

Each beneficiary household received a package⁴ suitable for about ½ha (Kenneth and Henrik, 2012). The package subsidized 50% of the cost and, therefore, recipients were required to contribute the remaining 50% (Pan and Christiaensen, 2011). When the NAIVS pilot programme was scaled up to 11 regions in 2008, Table 1 shows that 730,667 farmers benefited. The number of beneficiaries increased drastically in the subsequent waves, reaching 1.5 million

⁴ One bag of urea; 2) one bag of Di-ammonium Phosphates or two bags of Minjungu Rock Phosphate with nitrogen supplement; and 3) 10 kg of hybrid or OPV maize seeds or 16 kg of rice seeds.

households (45% of all smallholders in Tanzania) across 12 regions in 2009/10. By the end of 2010, NAIVS had been scaled up across all regions in the country and peaked in 2010/11, benefitting 2,011,000 farmers. The programme was concluded in 2014. Table 2 constructed from the sample confirms this trend, showing that NAIVS peaked at 12% in Wave 2 before dropping to 5.8% in Wave 3 as NAIVS started to wind down. Due to the delay in voucher distribution in 2008/9, vouchers arrived after the planting months have passed and, therefore, there were no beneficiaries in the 2008/9 long rainy season (wave 1) (World Bank, 2014). On the other hand, the low rate of usage in Wave 3 (2012/13) is associated with the fact that by the beginning of 2013, NAIVS had started winding down and, therefore, graduating customers were not being replaced with new beneficiaries around this time (World Bank, 2014).

The selection and distribution of input vouchers followed a four-stage process. At the national level, regional voucher committee members first met with relevant officers at the Ministry of Agriculture once a year to discuss the allocation of vouchers by region, and similar meetings were held at the regional level to decide on the district, and district meetings decided voucher allocation by village (World Bank, 2014). Actual beneficiaries were determined at the village level based on established criteria. NAIVS particularly targeted smallholder farmers. Participating farmers had to meet some criteria including the ability to pay 50% of the cost of a subsidy package as the government covered the remaining 50% (Pan & Christiaensen, 2011). Other participation criteria included farmers' willingness to work with agricultural extension officers, not having used fertilizers in the previous five years, and a special preference given to women (World Bank, 2014). Farmers meeting these criteria were selected by the village voucher committee and after paying 50% of the input cost, they received input vouchers, which were exchanged for the inputs at the participating retailer in the local area.

(b) Microfinance Services in Tanzania

Microfinance is the provision of financial services, particularly credit, to the poor (World Bank, 2001). Although various forms of microfinance in Tanzania existed since 1967 when Village Savings & Credit Associations were allowed to operate, formal microfinance institutions, however, started their operations after the financial liberalization in 1991 (Utz, 2008). After these reforms, banks and non-governmental organizations (NGOs) were allowed under the Banking and Financial Institutions Act of 1991 to provide microfinance services (Randhawa and Gallardo, 2003). Furthermore, the Cooperative Societies Act of 1991 allowed the formulation of Savings and Credit Cooperative Societies (SACCOs) as privately-owned and

equity-based institutions that provide microfinance services to members (Randhawa and Gallardo, 2003).

Despite these reforms, the microfinance sector remained weak (Ministry of Finance [Tanzania], 2000). To address various sources of weakness, the National Microfinance Policy (2000) was introduced. Key achievements of this policy are the marked increase in the number of microfinance providers. By 2013, the last year covered in this study, 48.6% of the labour force was served by various MFIs compared to only 16.7% served by banks (FinScope, 2013). By 2015, microfinance providers included 22 banks, 4,093 SACCOS (with a total membership of 733,876), and over 150 financial NGOs and microfinance companies (Ministry of Finance [Tanzania], 2017). There are also numerous self-help groups providing loans to members on a rotational basis. In the sample used, the proportion of microfinance borrowers increased throughout the covered period, rising from 4.2% in Wave 1 to 5.8% and 6.5% in Wave 2 and Wave 3, respectively. These low participation rates highlight the fact that very few farmers participate in the microfinance sector.

Across the developing world, microfinance is considered the key source of small financial services for the poor. The provision of small financial services makes microfinance less attractive to rich people. The amount borrowed from microfinance sources is needed for different purposes. For instance, access to microfinance allows poor people to invest in various income-generating investments, farm and non-farm businesses, buy farm inputs, and smoothing household consumption, and it may contribute to better education, health, and housing of the borrower (Hermes and Lensink, 2011). In the sample used, borrowers used their microfinance loans to finance various activities, including consumption smoothing (subsistence credit), agricultural production, medical cost, school fees, business finance, and asset accumulation (see Table A1, appended).

Table 1: Household Beneficiaries of NAIVS

Year	2008/9	2009/10	2010/11	2011/12	2012/13	2013/14
Planned	740,000	1,500,000	2,040,000	1,800,000	1,000,000	500,000
Actual	730,667	1,511,900	2,011,000	1,779,867	940,783	932,100

Source: World Bank, 2014

Table 2: Trends in input vouchers usage and microfinance borrowing.

Year/wave	Wave1	Wave2	Wave3	Total
Used input vouchers (%)	0.0	12.0	5.8	6.7
Borrowed microfinance (%)	4.2	5.8	6.5	5.6
Observations	1,600	1,812	2,310	5722

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

3.3. Data, Variables, and Descriptive Statistics

(a) Data and Variables

(i) Source and structure of Data

The source of data used in this chapter is Tanzania's National Panel Survey (NPS). NPS is a panel survey conducted in a one-year interval covering various microeconomic variables. The NPS survey is conducted by the National Bureau of Statistics (NBS) of Tanzania in collaboration with the World Bank to track the dynamics of poverty in the country. By design, NPS follows a stratified, multi-stage cluster sampling procedure. The principal strata are Mainland and Zanzibar, and within these, rural versus urban areas, with a special stratum set aside for Dar es Salaam which is the most urban region in the country (National Bureau of Statistics [Tanzania], 2009). In each stratum, designated clusters were chosen randomly, with the probability of selection proportional to their population size. The baseline sample in 2008/9 was calculated to be sufficient to produce national estimates (National Bureau of Statistics (Tanzania), 2009).

NPS collects information regarding the welfare of its baseline sample in 2008/9. Currently, panel data is available for five waves: Wave 1 (2008/2009), Wave 2 (2010/2011), Wave 3 (2012/2013), Wave 4 (2014/2015), and Wave 5 (2019/20). I only use panel data from the first three waves because during Wave 4 the sampling frame was altered making it and the subsequent waves unlinked to the past three waves. Equally important, NAIVS was implemented between 2008 and 2014, thus coinciding with the first three waves.

NAIVS targeted farmers involved in maize and rice farming. Therefore, variables constructed related only to households involved in maize and rice production. The sample has 1,600 households from Wave 1, 1,812 from Wave 2, and 2,310 from Wave 3, giving a total of 5,722 unbalanced observations. Of all the respondents in Wave 1, 235 were not re-interviewed in the subsequent waves, resulting in 14.69% attrition. Generally, attrition caused by households leaving the sample can be a major source of concern. For instance, if the cause of attrition is systematic (non-random), it can result in the loss of significant information about the participants, which in turn, can result in unrepresentative and potentially biased estimates. On the other hand, if the cause of households leaving the sample is unsystematic (random), the subsequent attrition cannot cause a significant bias.

Fortunately, there are statistical methods to test whether attrition is random or non-random. Following Fitzgerald et al., (2007), I use the attrition probits to estimate the effect of

non-random attrition in the sample. Furthermore, in the spirit of (Beckett *et al.*, 1988), I use the pooling test to examine whether attrition is random or non-random. These tests are reported in the appended table (Table A2). Column (1) presents the attrition probit while column (2) presents the pooling test. The pseudo R² in the probit model shows the proportion of attrition that is non-random (Outes-Leon and Dercon, 2008). Therefore 0.076 Pseudo R² in column (1) suggests that 7.6% of the attrition is non-random, which in turn, suggests that about 92.4% of attrition is entirely random. This implies that the effect of attrition is very small. On the other hand, the joint significance test from the Wald test presented at the end of column (2) is not statistically significant. This means that I fail to reject the null hypothesis of random attrition, thus concluding that attrition was non-random. Because non-random attrition is small (7.6%) and is statistically not significant, further control of attrition bias is thus not necessary.

(ii) Measurement and Construction of Variables

Measurement and Construction of Poverty Proxy Variables

I use household expenditure (consumption) as the main proxy of poverty. This is consistent with other literature on this topic (Dercon and Krishnan, 2000; Khandker, 2005; Dercon *et al.*, 2009; Dercon and Christiaensen, 2011; Paxson, 2018). For robustness purposes, however, I also provided additional estimates when poverty is proxied by household food consumption and income, which have also been used in poverty measurement. Moreover, each of these proxies are divided by adult equivalent consistent with conventional practices in poverty measurement (Dercon and Krishnan, 2000; Imai, Arun and Anjum, 2010). In the data sets, household total and food consumption are constructed from the individual/household module. On the other hand, household income is constructed from various modules. Employment and business income are constructed from the employment and business modules in the household and individual questionnaire. The crop and livestock income is constructed from the agricultural questionnaire whereas fishing income is constructed from the fishery questionnaire.

Explanatory Variables

The explanatory variables of interest are input vouchers and microfinance. Input subsidies from NAIVS are measured using the value of input vouchers received by the household, which is contained in the agricultural module. If the farmer used an input voucher to purchase subsidized inputs, the module recorded only the amount spent by the farmer (National Bureau of Statistics [Tanzania], 2011). Because NAIVS required beneficiaries to contribute 50% of the subsidized input cost, the amount paid by the farmer, therefore, represents 50% of the cost of subsidized

input (World Bank, 2014), which in turn equals the amount of subsidy received. Microfinance is constructed from the individual and household module, which contains credit details. Microfinance used here includes the amount of loan borrowed from microfinance institutions, Saving and Credit Cooperative Organizations (SACCOs), and self-help groups.

Other explanatory variables include household assets, temperature, distance from the household to the main road, and distance to the nearest agricultural market. The agricultural income and inputs are constructed from the agricultural module. From the community module, I construct community-level variables such as farm inputs retailer(s) in the village.

(b) Descriptive Statistics

This section presents the descriptive statistics of key variables. In Table 3, I present the descriptive statistics of the full sample (column 1), and comparable statistics based on voucher usage status (column 2) and microfinance borrowing status (column 3). Additional statistics for selected variables are also presented in Table 4 for the three income quantiles (full summary statistics for each quantile are appended in Table A5). Moreover, because econometric regressions in this chapter depend on fixed effect, for reference purposes, within variations of variables are presented in Table 5 for the full sample and Table A6 (appended) for comparative statistics. The descriptive statistics discussion, however, focuses on the descriptive statistics in Table 3.

The average consumption per adult equivalent in the sample is TZS 684,686. In both programme, beneficiaries have higher consumption than non-beneficiaries, suggesting that beneficiaries tended to be richer than non-beneficiaries. Similar observations can be made when looking at food consumption. Equally, microfinance borrowers have significantly higher incomes compared to non-borrowers. However, I do not find a significant difference between the income of voucher recipients and non-recipients. Moreover, the welfare status differs markedly across the three income quantiles presented in Table 4. The average total consumption and food consumption per adult equivalent in the middle-income group is 1.8 times that of the low-income and that of the high-income group is 2.0 times that of the middle-income group. The income distribution also follows similar patterns.

The participation rate in both programmes is very low. Table 3 shows that the use of input subsidy and microfinance borrowing in the sample is respectively 6.7% and 5.6%. These very low participation rates suggest that these programmes have not reached many farmers in the country. Looking at the differences between beneficiaries and non-beneficiaries, I found

that the percentage of microfinance borrowing is higher among subsidy beneficiaries than among non-beneficiaries. Equally, subsidy usage is significantly higher among microfinance borrowers than among non-borrowers. This interplay suggests that microfinance borrowers participated more in the NAIVS than non-borrowers. Moreover, Table 4 shows that the use of input vouchers and microfinance varied considerably across income quantiles. Only 4.7% of the low-income quantile used input vouchers. This is considerably lower compared to 7.4% and 8.0% in middle and high-income quantiles, respectively. For low-income and middle-income groups, the borrowing rates are respectively 2.3% and 5.0%, which are lower than the use of input vouchers in these groups. On the contrary, the 9.6% rate of borrowing from microfinance lenders is higher than similar rates in the low-income and middle-income quantiles. Overall, low-income farmers have the lowest participation rates in input voucher receipt and microfinance borrowing while high-income farmers have the highest participation rates in both programmes.

Table 3 also shows that households headed by women were significantly fewer among subsidy beneficiaries than among non-beneficiaries but no significant differences between microfinance borrowers and non-borrowers. This is opposite to the targets of NAIVS, which among other criteria sought to prioritize female farmers (World Bank, 2014). Regarding other household characteristics, I do not find a significant difference in the average age of the household between beneficiaries and non-beneficiaries in both programmes. Similarly, I do not find a significant difference in the education of the head and average household size between subsidy beneficiaries and non-beneficiaries. However, microfinance borrowers have on average significantly higher education levels and larger household sizes compared to non-borrowers. Regarding the asset ratios, Table 3 shows that beneficiaries in both programmes have larger landholding and farm asset per worker ratios, indicating that these beneficiaries are more equipped to do farm activities than non-beneficiaries.

In Table 3, I also include the distance from the household to the nearest major road, agricultural markets, and populated centres. Compared to beneficiaries, non-beneficiaries in both programmes are significantly farther from the major road, agricultural markets, and populated centres, which suggests that households in remote areas used fewer input vouchers and borrowed less microfinance than those in less remote areas. For AIS, this aligns with NAIVS participation criteria which included a condition of accessibility (Aloyce, Gabagambi and Hella, 2014). For microfinance, this shows that more borrowing takes place in populated and well-connected centres, which could also be related to the accessibility of the households.

I also observe that compared to non-beneficiaries, beneficiaries in both programmes experienced significantly lower levels of rainfall.

Finally, I also present summary statistics of the three instruments. The availability of input retailers in the village of residence is significantly higher among subsidy beneficiaries than in non-beneficiaries but not significantly different between borrowers and non-borrowers. For the number of smallholder farmers, Table 3 shows that the proportion of the number of smallholder farmers in the village is significantly larger among beneficiaries in both programmes than among non-beneficiaries. I further observe that the number of borrowers from any credit source in the village is significantly higher among subsidy beneficiaries than among non-beneficiaries and it is also significantly bigger among microfinance borrowers than among non-borrowers.

Table 3: Descriptive Statistics of Key Variables⁵

	(1) Whole Sample (N=5722)		(2) Used input Voucher			(3) Microfinance borrowing		
			Yes N= 383	No N= 5339	Difference	Yes N= 321	No N=5401	Difference
Variables	Mean	Std. Dev.	Mean	Mean		Mean	Mean	
Consumption per adult equivalent	684686.2	6721.8	769292.1	678616.9	90675***	1029133	664215	364918***
<i>asinh</i> Consumption per adult equivalent	13.2	0.00	13.4	13.2	0.2***	13.63	13.22	0.41***
Food consumption per adult equivalent	417170.6	3883.8	450075	414810.1	35265**	564118.6	408437	155682***
<i>asinh</i> Food consumption per adult eq	12.9	0.00	13.04	12.95	0.09**	13.22	12.94	0.28***
Income per adult equivalent	1296577	146687.1	845123.4	1328963	483840	4138850	1127651	3011198***
<i>asinh</i> income per adult equivalent	13.15	0.01	13.46	13.14	0.32***	14.00	13.11	0.89***
Used input vouchers (%)	6.70	0.25	100	0	100	12.50	6.40	6.10%***
Value of vouchers (TZS)	4428.69	446.07	59805.59	0	59806***	8966.21	4159.01	4807.20**
<i>asinh</i> value of vouchers	0.79	0.04	10.37	0	10.37***	1.45	0.75	0.70***
Microfinance Borrowing (%)	5.60	23	10.44	5.26	5.18***	100	0	100***
Amount of microfinance (TZS)	28442.47	4997.9	33314.86	28092.94	5222	507002.5	0	507002.5***
<i>asinh</i> amount of microfinance	0.71	0.03	1.36	0.67	0.69***	12.76	0	12.76***
Female household head (%)	23.50	0.42	19.30	23.80	4.50**	24.90	23.40	1.50
Age of the household head	48.61	15.65	47.76	48.68	0.92	49.32	48.57	0.75
Education of the head (Years)	1.33	0.26	1.57	1.31	0.26	1.89	1.29	0.60***
Adult equivalent	4.50	0.03	4.57	4.50	0.07	5.38	4.45	0.93***
Landholding per workforce	0.97	0.01	1.09	0.96	0.12**	0.97	0.86	0.11**
Farm assets per workforce	1.39	0.01	1.60	1.38	0.22***	1.46	1.39	0.07*
Livestock	5.76	18.11	5.26	5.80	0.54	6.05	5.75	0.30
Number of poultry	7.85	0.19	8.55	7.80	0.75	12.32	10.58	2.74
Distance to nearest major road (km)	21.90	13.0	16.58	22.28	5.70***	16.56	22.21	5.65***
Distance to agricultural market (km)	86.14	55.99	75.60	86.89	11.29***	69.02	87.16	18.14***
Distance to nearest populated centre (km)	51.27	0.52	40.22	52.07	11.84***	39.73	51.95	12.22***
Average Temperature °C in wettest quarter	22.80	2.508	20.81	22.94	2.13***	22.41	22.82	0.41***
Farm cooperatives in the village (%)	44.1	0.6	47.3	43.8	3.4	41.1	44.2	3.1
IV1: Farm input retailer in the village (%)	41.10	0.492	62.0	40.0	22.00***	43.9	40.90	3.00
IV2: Number of smallholders in the village	0.57	0.939	0.77	0.56	0.21***	1.78	0.50	1.28***
IV3: Number of borrowers in the village	1.96	2.03	1.90	1.96	0.06	1.77	1.96	0.19

NB: (1) Where * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

⁵ The value of consumption, food consumption, income, input vouchers, and microfinance are constant at 2008's prices.

Table 4: Input voucher usage and microfinance borrowing across the income groups.

Income Groups	Low-Income	Middle-Income	High-Income
Real consumption per adult equivalent (TZS)	314138.9	555381.3	1184732.7
Real food consumption per adult equivalent (TZS)	197373.5	350302.9	703950.6
Real income per adult equivalent (TZS)	468465.2	741197.7	2680503.1
Used input vouchers (%)	4.7	7.4	8.0
Borrowed microfinance (%)	2.3	5.0	9.6
N	1,908	1,907	1,907

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

Table 5: Descriptive Statistics (Within Variations)

Variable	Mean	Std. Dev.	Min	Max
Consumption per adult equivalent	0.00	247757.87	-2376942.3	2376942.3
<i>asinh</i> Consumption per adult equivalent	0.00	0.32	-1.54	1.42
Food consumption per adult equivalent	0.00	159265.96	-1182577.5	1475703.1
<i>asinh</i> Food consumption per adult equivalent	0.00	0.34	-1.69	1.48
Income per adult equivalent	0.00	6416483.3	0.00	1.896e+08
<i>asinh</i> income per adult equivalent	0.00	0.86	-4.98	5.49
Value of vouchers (TZS)	0.00	24217.30	-614775	657900
<i>asinh</i> value of vouchers	0.00	1.87	-8.61	9.66
Amount of microfinance (TZS)	0.00	85545.59	-2841775	2841775
<i>asinh</i> amount of microfinance	0.00	1.59	-10.25	10.13
Age of the household head	0.00	4.67	-37.33	38
Female household head (1/0)	0.00	0.14	-0.67	0.67
Education of the head (Years)	0.00	1.56	-8.00	10.67
Adult equivalent	0.00	0.90	-8.28	8.28
Livestock	0.00	6.84	-106.00	106
Number of poultry	0.00	6.82	-96.00	94
Landholding per workforce	0.00	0.487	-6.33	12.67
Farm assets per workforce	0.00	0.53	-4.25	5.47
Distance to agricultural market (km)	0.00	11.62	-116.83	116.97
Distance to nearest major road (km)	0.00	4.21	-42.8	41.13
Distance to nearest populated centre (km)	0.00	0.00	0.00	0.00
Average Temperature °C in wettest quarter	0.00	0.00	0.00	0.00
Farm cooperatives in the village (1/0)	0.00	0.29	-0.67	0.67
IV1: Farm input retailer in the village (%)	0.00	0.32	-0.67	0.67
IV2: Number of smallholders in the village	0.00	0.44	-3.33	3.333
IV3: Number of borrowers in the village	0.00	0.93	-6.66	6.00

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

3.4. Methodology

(a) Conceptual Framework

This conceptual framework adapts a slightly modified theoretical model from Campbell & Deaton (1989), Deaton (1992), Dercon (1996), Christiaensen et al. (2007) and Dercon & Christiaensen (2011). This model has been used extensively to estimate the effects of social safety nets, including microcredit (Islam & Maitra, 2012). The model assumes that households pursue stable consumption paths, which is possible if credit and insurance markets are perfect.

To illustrate the mechanisms, assume that at time ' t ', a risk-averse household maximizes intertemporal expected utility ' u ' defined by equation (1).

$$u_t = E_t \sum_{\tau=t}^T (1 + \delta)^{\tau-t} u(c_\tau) \quad (1)$$

Where; δ is the rate of time preference, T is the end of the business cycle, and c_t is the household consumption at time t .

Assume further that households face risky income $y_t(s_t)$ which is subject to idiosyncratic shocks, s_t . Income can be used to obtain consumption c_t at price p_t . Households can accumulate or draw on assets A_t , which generates return r . Then, the constraints linking assets between two periods t and $t + 1$ can be written as:

$$A_{t+1} = (1 + r)(A_t + y_t - p_t c_t) \quad (2)$$

If households have access to perfect credit market/insurance, or substitutes, the optimal consumption path between two periods t and $t + 1$ will satisfy equation (3)⁶. Overall, equation (3) implies that the two discounted marginal utilities will balance subject to the relative prices.

$$\frac{u'_t c_t}{p_t} = \frac{(1+r)}{(1+\delta)} E_t \left[\frac{u'_{t+1} c_{t+1}}{p_{t+1}} \right] \quad (3)$$

Following Hall (1978), assume further that a risk-averse household has an instantaneous marginal utility u_t at time t defined as:

$$u_t = c_t^{-\rho} e^{\theta_t} \quad (4)$$

With ρ being the coefficient of relative risk aversion and θ_t a vector for taste shifters. Solving equations (3) and (4) gives the following equation:

$$\frac{c_t^{-\rho} e^{\theta_t}}{p_t} = \frac{(1+r)}{(1+\delta)} \left(\frac{c_{t+1}^{-\rho} e^{\theta_{t+1}}}{p_{t+1}} \right) \quad (5)$$

Taking the natural logarithmic of equation (5) and then rearranging gives an equation of the following form:

$$\ln c_{t+1} - \ln c_t = \frac{1}{\rho} [\ln(1 + r) - \ln(1 + \delta) + \ln(p_t - \ln p_{t+1}) + (\theta_{t+1} - \theta_t)] \quad (6)$$

If $r = \delta$ then equation (6) can be reduced to equation (7). For simplicity, ignore the sign for natural logarithm.

$$\Delta c_t = \Delta p_t + \Delta \theta_t \quad (7)$$

⁶ Equation (3) is obtained after solving equations (1) and (2) using envelop conditioning method (Dercon and Christiaensen, 2011; Hall, 1978; Christiaensen, Hoffmann and Sarris, 2007)

According to equation (7), if there are no credit constraints, the consumption path is only affected by prices of consumption and taste shifters. This is true under the hypothesis of perfect credit/insurance markets where the consumption paths are not affected by idiosyncratic shocks (Christiaensen et al., 2007).

Therefore, if households have access to perfect credit and insurance markets, households will experience stable consumption paths. If this is true, access to finance can directly affect household consumption in equation (7) in two major ways. The first, which is a direct mechanism, is through increased household income. Microfinance gives the household the much-needed financial resource needed to invest in income-generating activities. This can be through the purchase of tradable merchandise, business inputs, and payment of business bills. Microfinance can provide farmers with the finance needed to invest in farm activities such as farm inputs and technologies and farm products storage and processing (Benson et al., 2013; Morris et al., 2007). This has been found to directly increase both farm income and household food consumption (Wossen et al., 2017; Harou, 2018).

The assumption of perfect credit/insurance markets, however, may not apply under some settings. For instance, in rural Africa, poor households have limited access to credit and insurance. These households, therefore, rely on alternative schemes. For poor households with limited access to credit markets, government interventions, such as AIS can enhance crop income directly by subsidizing productivity-enhancing technologies such as fertilizers (Ricker-Gilbert & Jayne, 2017; Arndt et al., 2016). Owing to this route, governments across SSA, including Tanzania, have been implementing AISs to ensure food security and stable food consumption. Productivity-enhancing interventions such as AIS increase crop income, leading to enhanced total consumption (Wossen et al., 2017).

Therefore, both microfinance and IAS directly affect household consumption. Following Dercon and Christiaensen (2011), Imai, Arun and Annim (2010), and Christiaensen, Hoffmann and Sarris (2007), variables with direct effects enter directly into the consumption function by overidentifying equation (7), giving the following equation.

$$\Delta c_{it} = \Delta p_{it} + \Delta \theta_{it} + \Delta m_{it} + \Delta AIS_{it} \quad (8)$$

Where m and AIS represent the amount of microfinance and AIS received by the household, and the subscript i refers to the household.

The second mechanism, which is particularly applicable to microfinance is consumption smoothing. Consumption smoothing strategies are sought after household consumption has been negatively affected by the occurrence of major shocks such as crop failure, death of a key household member, and droughts. Following Dercon & Christiaensen (2011) and Islam & Maitra (2012), equation (8) can be further overidentified to include the effect of shocks on consumption, giving the following equation.

$$\Delta c_{it} = \beta_0 + \beta_1 \Delta p_{it} + \beta_2 \Delta \theta_{it} + \beta_3 \Delta m_{it} + \beta_4 \Delta AIS_{it} + \beta_5 \Delta s_{it} \quad (9)$$

According to equation (9), in addition, to changes in prices, test shifters, and the two policy programmes (microfinance and AIS), the change in consumption is also affected by shocks, s . If households have access to the credit and insurance market, the value of β_5 will be zero, implying that the consumption path will not be affected by shocks (Dercon & Christiaensen, 2011). However, if the household has no access to credit, the path of consumption will be susceptible to these shocks (Dercon & Krishnan, 2000), resulting in a fall in welfare and, therefore, $\beta_5 < 0$.

To consider the effect of microfinance as a consumption smoothing strategy, the amount of microfinance can be interacted with the shock variable to capture the mitigation effect of microfinance as presented in equation (10).

$$\Delta c_{it} = \beta_0 + \beta_1 \Delta p_{it} + \beta_2 \Delta \theta_{it} + \beta_3 \Delta m_{it} + \beta_4 \Delta AIS_{it} + \beta_5 \Delta s_{it} + \beta_6 (\Delta s_{it} \times m_{it}) \quad (10)$$

Because microfinance is intended to enhance the welfare of the household, the effect of the interaction term, β_6 , is thus expected to be positive ($\beta_6 > 0$), implying that microfinance has a mitigating effect on consumption against shocks. However, if the receipt of microfinance has no mitigation effect, $\beta_6 < 0$.

The mechanisms behind the consumption smoothing effects of microfinance depend on the nature of the shock experienced. For instance, crop failure can make it difficult for the household to sustain its expenditure. In this case, the household can opt for personal loans, which can help the household to sustain its current level of expenditure. On the other hand, if the shock results in the loss of a productive asset or business, microfinance borrowing can help the household re-acquire the asset or re-finance the business. In turn, access to business finance through microfinance lending can ensure that the income of the household, and hence the consumption, is maintained.

(b) Empirical Approach

The empirical approach presented here is an extension of equation (10). However, to avoid identification difficulties associated with endogeneity, this chapter does not estimate the mitigating effect of microfinance ($\beta_6[\Delta s_{it} \times m_{it}]$). Therefore, I estimate the direct effects of microfinance and AIS. This approach is consistent with other studies on this topic, which focused only on direct effects (Imai et al., 2010; Khandker, 2005; Pitt & Khandker, 1998).

This chapter estimates and compares the direct effects of microfinance and AISs on household consumption. The comparison is motivated by the fact that microfinance and AISs are pro-poor programmes and, therefore, share poverty reduction objectives amongst poor households. I examine whether these programmes have comparable poverty reduction outcomes amongst farmers in Tanzania. I estimate a linear function commonly adapted when evaluating these programmes (Arndt, Pauw and Thurlow, 2016; Wossen et al., 2017; Malimi, 2023; Mosley, 2001; Khandker, 2005; Coleman, 2006; Imai, Arun and Annim, 2010; Duvendack and Palmer-Jones, 2012).

Assume that one household participates in a government-funded subsidy programme by receiving agricultural input vouchers, *AIS*, and another household borrows microfinance, *m*, from microfinance lenders. At any time, *t*, the household consumption, *c*, is expected to depend on household and community characteristics, *x*, and participation in these antipoverty programmes. This relationship takes the following linear form.

$$c_{it} = \alpha_1 m_{it} + \alpha_2 AIS_{it} + \alpha_3 x_{it} + \varepsilon_{it} \quad (11)$$

$$\varepsilon_{it} = \mu_i + \epsilon_{it} \quad (12)$$

Where; α_1 and α_2 are parameters to be estimated, measuring respectively the treatment effect of microfinance and AISs on household consumption. Because microfinance and AIS are antipoverty, they are expected to increase household consumption (Imai et al., 2010; Khandker, 2005; Wossen et al., 2017). Therefore, α_1 and α_2 are expected to be positive. In equation (11) I do not specifically specify the taste shifters as they can be controlled through other variables such as the age of the household head.

AISs are partly or fully funded by the state while microfinance operates in private and non-government settings. I maintain that because borrowers of microfinance are expected to re-fund the loan plus interest, they are thus incentivized to use the borrowed money more productively and, therefore, microfinance is expected to have a bigger effect on household

consumption than state funded AISs. Therefore, the effect of microfinance is expected to be significantly bigger than that of agricultural input vouchers satisfying the following condition.

$$\alpha_1 > \alpha_2 \quad (13)$$

If the condition in equation (13) is met, providing microfinance would have a bigger poverty reduction impact than implementing AISs. However, if $\alpha_1 < \alpha_2$, public investment in AISs would produce bigger poverty reduction outcomes and, therefore, distributing more agricultural input vouchers would result in a higher poverty reduction.

x is a vector of control variables that affect the welfare of the households. These variables include the characteristics of the households including age, sex, and education of the household head, and household size (adult equivalent). In Tanzania, as in other countries in the region, large households and households headed by women and old household heads tend to be poor and, therefore, age, sex, and household size are expected to have negative effects on consumption (Dercon, 1996, 1998; National Bureau of Statistics [Tanzania], 2014, 2019). In this group, I also control for household membership in social groups, particularly farm cooperatives, which is expected to enhance household welfare due to access to farm production information and technology.

x also included liquid assets and relevant asset ratios. Liquid asset mainly includes livestock and poultry. Cattle and poultry are the most liquid assets in rural areas in Tanzania and, therefore, are sold to enhance household consumption and are bought as a saving strategy (Dercon, 1998). Therefore, these assets should have positive effects on consumption. Moreover, following Dercon (1996), I include landholding/worker and farm assets/works to control for household heterogeneity regarding productive asset holding relative to household labour size. Both landholding/worker and farm assets/worker imply household wealth relative to labour and, therefore, should have a positive effect on consumption.

The last group of variables includes remoteness and accessibility of the area of residence. This group includes distances to the nearest major road, agricultural market, and nearest populated centre. Because these distances indicate the accessibility of the area, and hence, the availability of key social services and infrastructure, they are, therefore, expected to have negative effects on households' consumption. There is also control for rainfall in the local area. Because most crop production in Tanzania is rain-fed (Dercon, 1996, 1998), the quantity of rainfall is thus expected to have a positive effect on household consumption.

(i) Identification Strategy

The main objective of this chapter is to estimate the effect of microfinance and AIS in equation (11) and test for the condition in equation (13). However, estimating (11) is not straightforward due to the potential endogeneity of AISs and microfinance. For AISs, one of the endogeneity concerns comes from the non-random nature of the selection process through which beneficiaries are selected. In most subsidy programmes, such as NAIVS, authorities often target regions with high farm productivity potential. Moreover, governments may also target a specific group of farmers based on some underlying characteristics, such as poor smallholders. Because of this bias, the amount of subsidy that households receive is likely to vary across and within locations and be correlated with poverty status, or underlying features that influence these outcome variables (Wossen et al., 2017; Bezu et al., 2014; Awotide et al., 2013; Ricker-Gilbert, Jayne and Shively, 2013). Similarly, the effect of microfinance is likely to suffer from various potential sources of biases. Notably, the placement of microfinance programmes is non-random as they often target poor areas (Imai et al., 2012; Imai et al., 2010; Khandker, 2005). Therefore, the distribution of these programmes suffers from placement bias. In the spirit of Ragasa & Mazunda (2018), I control for the potential placement bias by including region and time dummies in the regression models.

(a) Controlling for correlation between endogenous variables and time-fixed unobservables

One of the challenges in estimating the effects of non-random interventions such as AIS and microfinance is that participation in the programme may be correlated with time-constant unmeasured factors that cannot be included in the model. For instance, participation in AIS programmes can be related to the beneficiary's social capital (being a well-known person in the village) which increases the beneficiary's chance of being selected by the village voucher committee. For microfinance, unmeasured village and household attributes, such as the infrastructure development, environment, and ability to pay would equally influence the availability and access to microfinance (Pitt & Khandker, 1998).

Because these factors are unmeasured and not included in equation (11), the time-fixed unobserved heterogeneity, μ , is potentially correlated with the policy variable, m and s , the following exogeneity condition, therefore, is violated (Wooldridge, 2002).

$$cov(AIS, \varepsilon) = cov(m, \varepsilon) = 0 \quad (14)$$

If equation (14) is violated, using OLS to estimate equation (11) will produce biased estimates even if the placement bias is controlled. One way to deal with this is to use panel data models such as fixed effects or differencing, and the time-fixed heterogeneity, μ , will be

effectively eliminated. This chapter applies the fixed effect approach to control for the effects of time-invariant unobservables.

(b) Controlling for correlation between endogenous variables and time-varying unobservables

One of the limitations of fixed effect is that it assumes that the unobserved factors are time-invariant. However, in cases like access to AISs and microfinance borrowing, it is difficult to rule out the possibility that some unobservables vary over time. For instance, participation in microfinance and AISs could be related to income, entrepreneurial ambition, hardworking, and preferences that vary depending on household income and potentially decline over time due to aging. Therefore, condition (14) would still be violated even if the researcher controls for the time-invariant unobservables.

To address the effects of time-varying unobservables, researchers have often relied on the instrumental variable approach (IV) and control function (CF) (Harou, 2018; Wossen et al., 2017); Chibwana et al., 2012; Imai et al., 2012). Compared to IV, CF requires fewer assumptions and, therefore, is simpler to estimate (Wooldridge, 2015). Owing to this, my main results rely on CF. However, for robustness purposes, I also apply IV to provide additional estimates. CF applies a two-stage regression process. In the first stage, determinants of the endogenous variables are estimated, with the endogenous variables being the outcome variables, and then, generalized residuals are extracted. In the second stage, CF uses the true values of endogenous variables but includes generalized residuals from the first-stage regression (Wooldridge, 2015)

One important issue when estimating the first-stage regression is choosing the correct functional form. Many households in the sample did not receive input vouchers or borrow from microfinance lenders. Therefore, input vouchers and microfinance take on the properties of a corner solution variable (Mason & Ricker-Gilbert, 2013). In a case like this, estimating the first-stage regression using OLS estimators may still produce biased estimates even if I control for endogeneity. To account for the corner solution nature of the endogenous variables, I estimate the first-stage regressions using Tobit Model.

Because I have two endogenous variables, I estimate separately the reduced form for input vouchers and microfinance using Tobit models. The first stage regressions, therefore, take the following forms.

$$m_{it} = \alpha_1 \gamma_{it} + \alpha_2 z_{it} + v_{mit} \quad (15.1)$$

$$AIS_{it} = \alpha_1 \gamma_{it} + \alpha_2 z_{it} + v_{sit} \quad (15.2)$$

Where m and AIS respectively refer to the amount of microfinance and input vouchers. γ includes all exogenous covariates from equation (11), and z is a vector for the instruments. Therefore, the final CF takes the following form.

$$Y_{it} = \alpha_1 m_{it} + \alpha_2 AIS_{it} + \alpha_3 x_{it} + \alpha_4 \hat{v}_{mit} + \alpha_4 \hat{v}_{sit} + \mu_i + \epsilon_{it} \quad (16)$$

Where $\hat{v}_{mit}$ and $\hat{v}_{sit}$ are generalized residuals from equations (15.1) and (15.2), respectively. Equation (16) is estimated using fixed effect with control function (CF-FE). The use of fixed effect will eliminate μ_i and the only job of the instruments is to control for the relationship between the endogenous covariates, m and AIS , and the time-varying error term, ϵ_{it} . By including the generalized residuals in equation (16), m and AIS become uncorrelated with the error term, ϵ (Wooldridge, 2015). To produce accurate residuals, all estimates are bootstrapped with 200 repetitions.

Because I have two endogenous variables, at least two instruments are needed. In this chapter, I use three instruments. The choice of instruments is based on their potential to influence the availability and access to input vouchers and microfinance while carrying no direct effect on household consumption. The first instrument is a dummy variable for the availability of farm input retailer(s) in the village. NAIVS required beneficiaries to collect their input vouchers from their local input retailers (World Bank, 2014) and, therefore, the availability of farm-input retailers in the village would strongly correlate with the value of input vouchers. However, having an input retailer in the village does not directly increase household consumption.

The second instrument is the number of smallholder farmers in the village. Because NAIVS targeted smallholder farmers, it is expected that villages with many smallholder farmers would receive more input vouchers (Malimi, 2023). I maintain that the number of smallholder farmers in the village does not directly affect household consumption. The third instrument captures the demand and supply of credit in the village. I construct the total number of borrowers from all sources of credit in the village, including both formal and informal lenders. Total borrowers in the village reflect the level of demand and supply of the loanable fund in the village. I maintain that demand and supply for credit in the village strongly correlate with the household's likelihood to obtain microfinance but do not directly increase the household's consumption in any way other than through borrowing.

One condition when using the CF is to ensure that the instruments used are exogenous. To establish the exogeneity, I provide statistical tests using the covariance between the residual

from the naïve estimation of the main function and the instruments. According to Wooldridge (2013), an instrument is exogenous if it meets the exogeneity test of zero covariance as follows:

$$cov(z, \hat{\omega}) = 0 \quad (17)$$

Where cov refers to the covariance between the instrumental variable, z , and the residuals, $\hat{\omega}$, from naïve estimation of the outcome equation. I estimate the naïve equation using the fixed effect (FE-Naïve).

(b) Limitations

Despite having a robust methodology, the interpretation and application of the findings in this chapter have some limitations. One of the potential concerns in comparing α_1 and α_2 in equation (13) is that AISs and microfinance potentially target households of different economic statuses. For instance, microfinance borrowing carries interest and refunding of the principal amount, and often, microfinance borrowers must secure their loans with collateral assets or collective liability (Cull, Demirgüç-Kunt and Morduch, 2009). This makes it less likely for the poorest to borrow (Imai *et al.*, 2012). On the contrary, AISs are sponsored by the government, not refunded, and target smallholders who are often very poor. This is likely to be a concern when comparing the effects of microfinance and AISs especially if the households in the sample differ markedly by occupation and income. To ensure that the households are comparable, I only selected households that are full-time involved in cultivating maize and rice, the two crops targeted by NAIVS. Besides, NAIVS required beneficiaries to co-finance the subsidy package by 50% of the subsidy package value, a condition that negatively affected the participation of the poorest (World Bank, 2014; Pan & Christiaensen, 2011).

Equally important, the comparison between microfinance and AIS in equation (13) centres on the assumption that AISs are introduced to enhance farmers' welfare through enhanced farm income. Although this is the primary focus of most AISs in SSA (Jayne & Rashid, 2013); (Morris *et al.*, 2007), in some cases, however, governments may implement AISs for other reasons. For instance, one of the objectives in support of the smart subsidies in the 2000s across SSA has been to stimulate and enhance weak agricultural input markets in most SSA countries. In cases like these, where the agricultural input markets are non-existent or very weak, policymakers would still find it economically reasonable to implement state funded AISs even if $\alpha_1 > \alpha_2$. Therefore, the interpretation of these results should be limited to the extent that AISs largely focus on enhancing farmers' welfare.

3.5. Empirical Results

(a) Determinants of the Value of Input Vouchers and Microcredit

The first-stage regression estimates factors determining the value of input vouchers and the amount of microfinance using Tobit models. These results are presented in Table 6. First, I focus on the relevance and economic intuition of the instruments. The significance levels in Table 6 suggest that all instruments meet the cut-off point of $p < 5\%$ for relevant (strong) instruments as suggested by Bound et al., (1995). Moreover, the F-Statistics presented at the end of Table 6 shows that for each endogenous variable, at least one instrument has an F-statistics of more than 10, which indicates a strong correlation (Stock & Yogo, 2002).

Results in Table 6 show that all the instruments have the hypothesized relationship with the respective endogenous variable. The presence of agricultural input retailer(s) in the village (IV1) has a positive and significant effect on the value of input vouchers but not on microfinance. This suggests that the presence of input retailers in the village significantly increases the value of input vouchers used by the households. This is intuitive because input vouchers were distributed through village-based farm input retailers (Pan and Christiaensen, 2011). The number of smallholder farmers in the village (IV2) has a positive effect on the value of input vouchers and a negative effect on the amount of microfinance. The positive effect on the value of input vouchers suggests that farmers in the villages with more smallholder maize and rice farmers used significantly more input vouchers. This is consistent with the participation criteria in NAIVS, which among other criteria, prioritized smallholder farmers (World Bank, 2014). The negative effect of smallholder farmers on the amount of microfinance suggests that farmers in villages with many smallholder farmers borrowed less microfinance. This is also intuitive because microfinance requires collateral assets, which is difficult for smallholder farmers, who tend to be poor (National Bureau of Statistics [Tanzania], 2019). The number of borrowers from all sources of credit in the village (IV3) has a positive and significant effect on microfinance. This means that the number of borrowers in the village increased the amount of microfinance received by the households. For microfinance, the total number of borrowers is a proxy of the availability and demand for loanable funds in the village. Therefore, its significance shows that farmers in villages with more borrowers tended to borrow more from microfinance lenders.

In addition to these instruments, Table 6 also contains control variables that have statistical relevance. The sex of the household head has a negative and statistically significant effect on the value of input vouchers, which suggests that households headed by women used

significantly fewer input vouchers than those headed by men. Because NAIVS preferred female farmers (World Bank, 2014), the negative effect, in this case, suggests that this criterion was not strictly observed (Pan and Christiaensen, 2011). For microfinance, the education of the head has a significant positive effect, implying that households headed by educated parents tended to borrow more from microfinance lenders. The household size (adult equivalent) has a positive and significant effect on the value of vouchers and the amount of microfinance. This could be related to the fact that large households tend to have a large workforce, which increases the need and likelihood of seeking subsidized farm inputs and microfinance borrowing. Farm assets per worker have positive effects on input vouchers and microfinance, suggesting that households with more farm assets per worker had more input vouchers and tended to borrow more from microfinance sources. This could be related to the fact that households heavily involved in farm activities, as proxied by farm assets, would seek more investments in farm inputs including subsidized inputs and those which are funded through microfinance borrowing.

The distance to the agricultural market has a significant negative effect on microfinance and distance to major roads has a significant negative effect on the value of input vouchers and microfinance. For AIS, this could be related to the fact that accessibility of farmers was an important factor in NAIVS implementation (Aloyce, Gabagambi and Hella, 2014) and, therefore, staying farther from reliable transport systems increases transaction costs, making farmers in these areas less likely to receive input vouchers. Similarly, because of transaction costs and accessibility, microfinance lenders tend to provide their services to accessible communities. The average temperature has negative effects on both input vouchers and microfinance, suggesting that households in areas with high temperatures used fewer vouchers and borrowed less from microfinance sources. This is intuitive as high temperatures inhibit farm productivity, thus negatively affecting the return to farm inputs and microfinance, which in turn, hinders farmers' willingness to borrow or use modern farm inputs. Lastly, the availability of farm cooperatives in the village has a positive effect on input vouchers, which suggests that households in villages with farm cooperatives used more vouchers. This is also intuitive because farm cooperatives give farmers the benefits of collective bargaining, thus increasing the likelihood that areas with cooperatives will receive more attention from policymakers, which in turn, results in more vouchers.

Table 6: Tobit Estimation of the Determinants of Input Vouchers and Microcredit

Dependent variable	(1) <i>asinh</i> Real value of input vouchers	(2) <i>asinh</i> Real value of microfinance
IV1: Access to farm input retailer in the village (Yes=1)	2.040*** (0.197)	1.436 (1.332)
IV2: Proportion of smallholder farmers in the village	3.893*** (0.250)	-1.692*** (0.482)
V3: Number of borrowers in the village	0.096 (0.080)	3.094*** (0.224)
Female household head (Yes=1)	-2.062* (1.179)	0.575 (1.379)
Age of the head (years)	-0.047 (0.034)	-0.014 (0.045)
Education of the head (Years)	0.236 (0.154)	0.420** (0.190)
Adult equivalent	0.694*** (0.219)	1.281*** (0.266)
Number of Livestock	-0.025 (0.034)	0.002 (0.040)
Number of Poultry	0.009 (0.029)	0.063 (0.528)
Landholding per worker	-0.889 (0.612)	0.519 (0.798)
Farm assets per worker	1.472*** (0.460)	1.392** (0.614)
<i>asinh</i> distance to market (km)	-0.450 (0.587)	-1.243* (0.697)
<i>asinh</i> distance to the major road (km)	-0.697* (0.361)	-1.290** (0.525)
<i>asinh</i> distance to the populated center (km)	-0.010 (0.018)	-0.027 (0.022)
<i>asinh</i> average temperature (wettest quarter) (km)	-9.611* (5.585)	-20.435** (8.606)
Cooperatives in the village (Yes=1)	2.543*** (0.970)	0.000 (1.267)
Time fixed effects	Yes	Yes
Regions fixed effects	Yes	Yes
Constant	3.608 (21.917)	26.226 (34.785)
Pseudo R2	0.191	0.271
N	5722	5722
IV1: F-Statistics (1, 5678)	19.20	1.14
IV2: F-Statistics (1, 5678)	24.81	12.22
IV3: F-Statistics (1, 5678)	1.45	19.59

NB:(1) Bootstrapped standard errors in parentheses (with 200 repetitions)

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

(b) The Consumption Effects of Input Vouchers and Microfinance

The estimated determinants of household consumption are presented in Table 7 using IV-FE and CF-FE. The sample used in this study contains 40 households that used both input vouchers and microfinance. Because these households account for a small proportion (0.6%), they do not have a big influence on the estimated results. For instance, if the model is re-estimated without the 40 households with both programmes, the estimated effects, as shown in Table A3

(appended), are comparable to the main results in Table 7. Therefore, no further actions are needed, and the main estimates rely on the full sample.

Because the results are estimated using models that rely on instruments, it is necessary to verify that the instruments are valid. Here, I highlight validity tests, in addition to the tests of relevance presented in section 5.1. First, I test for the exogeneity condition imposed in equation (17) by estimating the covariance between residuals from naïve estimation and the instruments. The three covariances presented at the end of column (1) are very small, equivalent to zero, suggesting that the instruments are considerably exogenous. Second, additional validity tests are presented at the end of Table A4 (appended) estimated using *stata* algorithm *xtivreg2*. From Table A5, the under-identification test (Anderson canon. corr. LM statistic) has a significant Chi-square suggesting that the model is not under-identified. The weak identification test (Cragg-Donald Wald F statistic) is 74.64, which confirms that I do not have the problem of weak identification. Finally, the Sargan statistic (overidentification test of all instruments) has a Chi-square that is not statistically significant at the conventional levels of significance, which in turn, suggests that I fail to reject the null hypothesis and, therefore, conclude that the instruments are valid (i.e., the instruments are uncorrelated with the error term and that the excluded instruments are correctly excluded).

The primary focus of this chapter is estimating the effects of microfinance and AIS on household consumption and then comparing the effects of the two programmes. Therefore, the main discussion focuses on microfinance and AIS (input vouchers). Estimates in Table 7 show that the amount of microfinance has a positive effect of 0.023 (2.3%) based in the IV-FE approach and 0.014 (1.4%) in the CF-FE approach. In both approaches, the effect of microfinance is statistically significant at the highest level of statistical significance. Similarly, the value of input vouchers has significant effects on household consumption. These results show that input vouchers have a positive effect of 0.014 (1.4%) based on the IV-FE and 0.010 (1.0%) in the CF-FE approach. One of the key observations from these estimates is that estimates in both approaches are comparable in terms of size and the direction of the effects (positive effects). For simplicity, I rely on the CF-FE approach because it is simple to estimate.

Therefore, the main results are presented in column (3). For microfinance, estimates in column (3) show that *ceteris paribus*, a 1% increase in the amount of microfinance would increase household consumption per adult equivalent by 1.4%. This suggests that microfinance is effective in reducing poverty among farmers in the country. While these estimates present

rare findings in Tanzania, they are, nonetheless, comparable to results reported in other international studies (Imai et al., 2010; Khandker, 2005; Mosley, 2001; Pitt & Khandker, 1998). However, it is important to note that some studies have observed that microfinance lacked significant effects on consumption (Roodman and Morduch, 2014) and other proxies of household welfare (Duvendack and Palmer-Jones, 2012).

For input vouchers, these estimates show that *ceteris paribus*, a 1% increase in the value of input vouchers would increase household consumption per adult equivalent by 1.0%. This suggests that NAIVS was effective in reducing poverty among farmers involved in maize and rice. Although evidence in the existing literature remains limited, these estimates are comparable to the findings of Awotide et al., (2013) and Wossen et al., (2017) who observed significant effects of AISs on income and consumption in Nigeria. Similarly, in Malawi, Bezu et al., (2014) found that the area planted with subsidized improved maize seeds increased per adult equivalent income.

Next, I examine whether the effect of microfinance on household consumption is significantly bigger than that of input vouchers. I use the Wald Test to test the null hypothesis that the difference between the two coefficients is not significantly different from zero. The Wald Test presented at the end of column (3) is not statistically significant. This means that I fail to reject the null hypothesis and conclude that the effect of microfinance on household consumption is statistically comparable to that of input vouchers. Therefore, these estimates show that both programmers have comparable effects in reducing the overall poverty among these farmers.

Table 7 also contains significant control variables that deserve some highlights. Estimates in column (3) show that *ceteris paribus*, the average consumption in households headed by women is 13.3% lower than the average consumption in households headed by men. This is consistent with estimates in other reports in Tanzania which indicate that households headed by women tend to be poorer (World Bank, 2019; National Bureau of Statistics [Tanzania], 2014). For household size, estimates in column (3) show that *ceteris paribus*, increasing the household size by one adult equivalent would reduce household consumption per adult equivalent by 7.8%, which suggest that large household tend to be poor (National Bureau of Statistics [Tanzania], 2012).

Column (3) further shows that *ceteris paribus*, increasing the livestock and poultry by one would increase household consumption per adult equivalent by 0.3%. Because livestock

and poultry are the most liquid asset in rural Tanzania (Dercon, 1998), their positive effects are thus economically intuitive as they can be sold to sustain household consumption. For asset ratios, column (3) shows that *ceteris paribus*, increasing landholding per worker by 1 would reduce consumption per adult equivalent by 2.7%. This could be related to the possibility that high landholding per worker implies that the household has more land than the available workforce. For farmers, an inadequate household workforce implies the household's inability to produce adequately, unless the household can pay for hired labour, which is less likely for most farmers. On the other hand, the estimated effect of farm assets/worker shows that *ceteris paribus*, increasing assets/worker by 1 would increase household consumption per adult equivalent by 2.4%. This is intuitive as households with more farm assets would be able to experience high farm productivity, which in turn, would result in high income and household consumption. Finally, column (3) shows that *ceteris paribus*, a 1% increase in the kilometres from the major road would reduce household consumption per adult equivalent by 3.9%. Since the distance from the major roads represents the rurality of the households, its negative effects mean that households in rural and remote areas tend to be poor.

Table 7: Determinants of Household Consumption

Estimation model	(1) FE-Naïve	(2) IV-FE	(3) CF-FE
Dependent variable	<i>asinh</i> Real consumption per adult equivalent		
<i>asinh</i> Real value of microfinance	0.014*** (0.004)	0.023*** (0.008)	0.014*** (0.004)
<i>asinh</i> Real value of input vouchers	0.006** (0.003)	0.014** (0.006)	0.010*** (0.003)
Female household head (Yes=1)	-0.142*** (0.042)	-0.142*** (0.042)	-0.133*** (0.042)
Age of the head (years)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Education of the head (Years)	0.001 (0.004)	0.001 (0.004)	-0.000 (0.004)
Adult equivalent	-0.072*** (0.007)	-0.074*** (0.007)	-0.078*** (0.007)
Number of Livestock	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)
Number of Poultry	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)
Landholding per worker	-0.034*** (0.012)	-0.031*** (0.012)	-0.027** (0.012)
Farm assets per worker	0.035*** (0.011)	0.030*** (0.011)	0.024** (0.011)
<i>asinh</i> distance to market (km)	-0.025 (0.031)	-0.024 (0.032)	-0.025 (0.031)
<i>asinh</i> distance to the major road (km)	-0.042*** (0.016)	-0.041*** (0.016)	-0.039** (0.016)
<i>asinh</i> distance to the populated center (km)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
<i>asinh</i> average temperature (wettest quarter) (km)	-0.137 (0.446)	-0.122 (0.446)	-0.036 (0.446)

Cooperatives in the village (Yes=1)	-0.022 (0.019)	-0.024 (0.019)	-0.036 (0.030)
Tobit residual-Voucher eq			-0.005** (0.002)
Tobit residual-microfinance eq			-0.0012* (0.0007)
Time fixed effects	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Constant	14.422*** (1.727)	14.333*** (1.730)	14.252*** (1.726)
R-sq: within	0.241	0.238	0.243
N	5722	5722	5722
Wald Test: F (1, 2723)	3.09*	0.72	1.33
Cov(residual, IV1)	0.012		
Cov(residual, IV2)	0.032		
Cov(residual, IV3)	0.093		

NB:(1) Bootstrapped standard errors in parentheses (with 200 repetitions)

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

(c) The effects of AIS and microfinance on other measures of poverty

The discussion thus far has shown that microfinance and AIS reduce poverty when poverty is proxied by household total consumption. In this section, I extend the analysis by estimating the effects on two other measures of poverty, namely, food consumption and household income. The estimated results are presented in Table 8. Table 8 shows that *ceteris paribus*, a 1% increase in the amount of microfinance would increase food consumption and income per adult equivalent by 1.1% and 3.6%, respectively. For AIS, Table 8 shows that *ceteris paribus*, a 1% increase in the value of input vouchers would increase food consumption and income per adult equivalent by 1.0% and 2.1%, respectively. These effects are statistically significant at the highest statistical significance level, suggesting that AIS and microfinance are effective in enhancing food consumption and household income. Equally important, in both food consumption and income, the Wald test shows that microfinance and input vouchers have comparable effects. As in Table 7, this suggests that microfinance and AIS have similar poverty reduction effects among these farmers.

Looking at the results in Tables 7 and 8 together, there are two key observations that deserve highlighting. First, the effects of both programmes on food consumption (Tables 8) and total consumption (Tables 7) are comparable. This suggests that the effects of the two programmes on food consumption are equally reflected in total consumption. This could be related to the fact that among farmers, who tend to be poor (National Bureau of Statistics [Tanzania], 2019), food consumption represents the largest proportion of total expenditure in the household and, therefore, significant change in household food consumption would likely be significantly reflected in household total consumption. The second observation is that the

effects of both programmes on income seem to be larger than the effects on food and total consumption. Possible explanations for this can be derived from the permanent income hypothesis popularized by Campbell & Deaton (1989). Campbell & Deaton (1989) observed that consumption tends to be smooth and stable over time. This is because the key determinant of consumption is permanent income rather than temporal (seasonal) income fluctuations. This means that not all changes on income are passed on to household consumption.

Table 8: Determinants of household real food consumption and Income

Estimation model	(2) CF-FE	(3) CF-FE
Dependent variable	<i>asinh</i> Real food consumption per adult equivalent	<i>asinh</i> Real income per adult equivalent
<i>asinh</i> Real value of microfinance	0.011*** (0.004)	0.036*** (0.010)
<i>asinh</i> Real value of input vouchers	0.010** (0.003)	0.021** (0.009)
Female household head (Yes=1)	-0.078* (0.043)	-0.130 (0.114)
Age of the head (years)	0.001 (0.001)	-0.009*** (0.004)
Education of the head (Years)	0.000 (0.004)	0.014 (0.010)
Adult equivalent	-0.088*** (0.007)	-0.088*** (0.019)
Number of Livestock	0.004*** (0.001)	0.008*** (0.002)
Number of Poultry	0.003*** (0.001)	0.005** (0.002)
Landholding per worker	-0.020 (0.013)	0.060* (0.033)
Farm assets per worker	0.026** (0.012)	0.000 (0.031)
<i>asinh</i> distance to market (km)	0.001 (0.033)	-0.138 (0.086)
<i>asinh</i> distance to the major road (km)	-0.038** (0.016)	-0.054 (0.043)
<i>asinh</i> distance to the populated center (km)	0.001 (0.001)	0.003 (0.002)
<i>asinh</i> average temperature (wettest quarter)	-0.260 (0.464)	0.237 (1.215)
Cooperatives in the village (Yes=1)	-0.036 (0.031)	-0.043 (0.054)
Tobit residual-Voucher eq	-0.003 (0.002)	-0.009 (0.006)
Tobit residual-microfinance eq	-0.002** (0.001)	-0.003* (0.002)
Time fixed effects	Yes	Yes
Region fixed effects	Yes	Yes
Constant	14.920*** (1.792)	15.163*** (4.700)
R-sq: within	0.236	0.172
N	5722	5722
Wald Test F(1, 2723)	0.73	1.42

NB:(1) Bootstrapped standard errors in parentheses (with 200 repetitions)

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

(d) Heterogeneity Across Income Groups

In this section, I examine whether the two programmes affected differently rich and poor households. I use three quantiles: low-income, middle-income, and high-income, which are classified based on total consumption. The results are presented in three columns in Table 9. Column (1) presents results for low-income households, column (2) presents results for middle-income households, and column (3) presents results for high-income households.

Table 9 shows that the effects of both programmes are not statistically significant on the consumption of low-income households. This suggests that both programmes are not effective in reducing poverty among very poor farmers. In middle-income households, the effects of both programmes are positive and statistically significant, suggesting that among middle-income households, microfinance and AIS are effective in increasing household consumption. Among high-income households, both programmes have positive effects. However, only the effect of microfinance is statistically significant. This suggests that among rich farmers, microfinance is effective in reducing poverty whereas AIS is not effective. Another key observation from Table 9 is that across all three quantiles, Wald tests are the not significant, which means that the effect of microfinance is comparable to that of input vouchers. This suggests that across all quantiles, both programmes have comparable poverty reduction effects.

Table 9: Determinants of household consumption, FE-CF Regression in Three Quantiles

Quantiles	(1) Lower income	(2) Middle Income	(3) Higher Income
Dependent variable	<i>asinh</i> Real consumption per adult equivalent		
<i>asinh</i> Real value of microfinance	0.011 (0.009)	0.006* (0.003)	0.010** (0.004)
<i>asinh</i> Real value of input vouchers	0.002 (0.006)	0.005* (0.003)	0.002 (0.005)
Female household head (Yes=1)	-0.088 (0.082)	-0.021 (0.040)	-0.093 (0.079)
Age of the head (years)	0.003 (0.002)	0.001 (0.001)	0.005* (0.003)
Education of the head (Years)	0.005 (0.007)	0.001 (0.004)	-0.001 (0.006)
Adult equivalent	-0.018 (0.015)	-0.012 (0.009)	-0.034** (0.013)
Number of Livestock	0.000 (0.002)	0.000 (0.001)	-0.001 (0.001)
Number of Poultry	0.004** (0.002)	0.000 (0.001)	0.002* (0.001)
Landholding per worker	-0.040* (0.024)	-0.017 (0.013)	-0.041* (0.024)
Farm assets per worker	0.046** (0.019)	-0.003 (0.011)	0.037** (0.018)
<i>asinh</i> distance to market (km)	-0.053	0.020	0.013

	(0.061)	(0.030)	(0.068)
<i>asinh</i> distance to the major road (km)	-0.007	-0.020	-0.044
	(0.024)	(0.017)	(0.031)
<i>asinh</i> distance to the populated center (km)	0.000	-0.000	-0.001
	(0.001)	(0.001)	(0.003)
<i>asinh</i> average temperature (wettest quarter) (km)	-0.454	1.014*	0.829
	(0.837)	(0.562)	(0.856)
Cooperatives in the village (Yes=1)	-0.023	-0.036**	0.064*
	(0.032)	(0.018)	(0.034)
Tobit residual-Voucher eq	0.004	-0.001	0.004
	(0.004)	(0.002)	(0.003)
Tobit residual-microfinance eq	-0.000	-0.001	0.000
	(0.001)	(0.001)	(0.001)
Time fixed effects	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Constant	14.706***	9.822***	10.529***
	(3.252)	(2.147)	(3.302)
R-sq: within	0.087	0.088	0.246
N	1908	1907	1906
Wald Test: F (1, 2723)	0.69	0.14	1.14

NB:(1) Bootstrapped standard errors in parentheses (with 200 repetitions)

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from Tanzania's National Panel Survey (2008/9, 2010/11, and 2012/13)

3.6. Robustness Tests

In the robustness test, I applied the Heckman selection model. To estimate the Heckman model, I use *stata* algorithm, *heckman*. The results of the Heckman model are presented in two columns in Table 10. Column (1) presents the results of the Heckman model with microfinance as the only endogenous variable and column (2) present the results of the Heckman model with input vouchers as the only endogenous model. Results in columns (2) and (3) show that *ceteris paribus*, a 1% increase in the amount of microfinance and input vouchers would increase household consumption per adult equivalent by 17.6% and 4.8%, respectively. This means that both programs are effective in raising household consumption and, therefore, they are effective in reducing poverty. One of the key observations of the results in Table 10 is that the estimated effects are considerably larger than the main results in Table 7. One of the weaknesses of the Heckman model is that it does not account for the problem associated with a few recipients of input vouchers and microfinance. Therefore, estimated results in Table 10 should be interpreted cautiously.

Table 10: Determinants of Household Consumption, Heckman Selection Model Estimation

	(1)	(2)
Dependent Variable	<i>asinh</i> Real consumption per adult equivalent	
<i>asinh</i> Real value of microfinance	0.176***	
	(0.025)	
<i>asinh</i> Real value of input vouchers		0.048**
		(0.020)
Female household head (Yes=1)	-0.187***	-0.008
	(0.070)	(0.070)
Age of the head (years)	0.003	-0.000

	(0.003)	(0.002)
Education of the head (Years)	0.024***	0.014
	(0.009)	(0.009)
Adult equivalent	-0.088***	-0.078***
	(0.017)	(0.015)
Number of Livestock	0.007***	0.008**
	(0.002)	(0.003)
Number of Poultry	0.004***	0.005**
	(0.001)	(0.002)
Landholding per worker	-0.066	-0.001
	(0.042)	(0.034)
Farm assets per worker	0.056*	0.001
	(0.031)	(0.028)
<i>asinh</i> distance to market (km)	-0.041	-0.041
	(0.033)	(0.034)
<i>asinh</i> distance to the major road (km)	-0.067**	-0.096***
	(0.027)	(0.020)
<i>asinh</i> distance to the populated center (km)	-0.001	0.001
	(0.001)	(0.001)
<i>asinh</i> average temperature (wettest quarter) (km)	-0.477	-0.182
	(0.457)	(0.331)
Cooperatives in the village (Yes=1)	-0.112*	-0.005
	(0.062)	(0.055)
Constant	1.980	0.348
	(2.518)	(1.599)
N	5722	5722

NB:(1) Bootstrapped standard errors in parentheses (with 200 repetitions)

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

3.7. Conclusions and Policy Implications

This chapter estimated the effects of microfinance and Agricultural input Subsidy (AIS) on poverty reduction among farmers involved in maize and rice production. The chapter also examined whether the two programmes have significantly different sizes of poverty reduction effects. This was motivated by the growing desire to identify options for AISs from the non-state sector that are equally pro-poor and effective among farmers (Cameron et al., 2017; Morris et al., 2007). Microfinance and AISs are potentially pro-poor but have marked differences regarding the source of finance. AISs are directly funded and managed by governments whereas microfinance is mainly operated by private actors such as NGOs and members. The comparative analysis of the poverty reduction effects of the two programmes is necessary to inform policymakers of the need to balance poverty reduction through public and private funding.

The chapter presented four main findings. First, estimates show that microfinance was effective in reducing poverty among farmers involved in maize and rice production. These findings provide rare estimates in Tanzania but are consistent with estimates in other countries showing that microfinance reduces poverty (Imai et al., 2010; Khandker, 2005; Mosley, 2001).

It is important to note that the findings in this chapter are not consistent with findings in other studies showing that microfinance lacks significant effects on poverty reduction (Roodman & Morduch, 2014; Duvendack & Palmer-Jones, 2012). However, it is also important to note that estimates in this chapter differ from these studies in one important way. Whereas borrowers in most countries (such as Bangladesh) get the microfinance loans from major microfinance institutions, borrowers studied in this chapter are aggregated from different several microfinance lenders including self-help groups, Saving and Credit Cooperatives Societies (SACCOS), Village Community Banks (VICOBA), and Microfinance Institutions. Most of these groups (self-help groups, SACCOS, and VICOBA) charge no or very small interest, which makes the loan affordable. Affordable loans are arguably easy to borrow and repay and, therefore, have higher returns. Therefore, reasonable caution must be considered when comparing these findings with those in other studies.

Second, estimates show that AIS significantly increases household consumption, thus significantly reducing poverty among these farmers. This is consistent with similar findings in other studies in SSA showing that AISs reduce rural poverty (Wossen et al., 2017; Bezu et al., 2014; Awotide et al., 2013). Third, estimates also show that the effect of microfinance on household consumption is statistically comparable to that of AIS, which suggests that microfinance is as effective as AIS in reducing poverty among farmers in Tanzania. Fourth, across the three income quantiles, estimates show that both microfinance and AIS are not effective in raising the consumption of low-income households. This shows that both programmes do not help the poorest farmers in the country. Equally important, these estimates do not support the proposition that among poor farmers, AIS would be more effective than microfinance in reducing poverty. Among middle-income farmers, both programmes are significantly effective and have comparable effects on household consumption. Among high-income farmers, however, microfinance is effective while AIS is not effective. This means that while microfinance is effective among middle-income and rich farmers, AIS is only effective among middle-income farmers.

Based on these findings, it is evident that microfinance and AIS are equally effective in reducing overall poverty and not effective among poor farmers. Moreover, the two programmes are also equally effective in reducing poverty in middle-income farmers, but microfinance is more statistically relevant among high-income farmers. This supports arguments in favour of microfinance complementing AISs, and possibly replacing AISs among well-off farmers. However, because current practices in the microfinance sector tend to exclude the poorest,

development policymakers have reasonable concerns to avoid over-relying on microfinance. To address this, I propose a blended strategy that includes both programmes. This strategy centres on microfinance as the lead strategy, especially among well-off farmers. This would, however, require enhancing the social objectives of microfinance by focusing on poor farmers. This can be enhanced by encouraging social-oriented lenders such as NGO-based microfinance institutions, rotating saving and credit associations, and self-help groups. Social lending has the potential of reaching to poor farmers who are often used to justify universal AISs (Ricker-Gilbert, Jayne and Shively, 2013). To complement the effects of microfinance, AISs should only be implemented to help very poor farmers. This will ultimately save public funds used in implementing large-scale or universal AISs.

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Appendices

Table A1: Percentage Distribution of Key uses of Loans

Uses	Consumption smoothing	Agricultural Production	Medical cost	School fees	Business finance	Asset accumulation	Others
Percentage (%)	25.8	24.1	8.3	12.0	14.3	8.0	7.5

Source: Author’s computation from NPS (Wave1, Wave2, and Wave3)

Table A2: Attrition tests: Attrition Probit and Pooling Tests

Estimation model	(1) Probit	(2) OLS
Dependent variable	Attrition (yes=1)	<i>asinh</i> Real consumption per adult equivalent
Female household head (Yes=1)	0.265*** (0.095)	-0.072** (0.035)
Age of the head (years)	0.008*** (0.003)	0.002** (0.001)
Education of the head (Years)	0.039*** (0.015)	0.020*** (0.006)
Adult equivalent	0.051** (0.020)	-0.090*** (0.008)
Number of Livestock	-0.007* (0.003)	0.006*** (0.001)

Number of Poultry	-0.000 (0.003)	0.008*** (0.001)
Landholding per worker	-0.098* (0.053)	-0.038*** (0.014)
Farm assets per worker	-0.026 (0.046)	0.059*** (0.017)
<i>asinh</i> distance to market (km)	-0.077 (0.050)	-0.023 (0.019)
<i>asinh</i> distance to the major road (km)	-0.043 (0.030)	0.009 (0.011)
<i>asinh</i> distance to the populated center (km)	0.002 (0.001)	-0.106*** (0.019)
<i>asinh</i> average temperature (wettest quarter) (km)	-0.192 (0.446)	-0.125 (0.143)
Cooperatives in the village (Yes=1)	0.140* (0.085)	-0.094*** (0.030)
Reported crop diseases (Yes=1)	-0.167* (0.092)	0.065** (0.032)
Reported preharvest loss (Yes=1)	0.012 (0.084)	0.019 (0.030)
Attrition from the original sample (Yes=1)		-0.059 (1.563)
Attrition*female household head		-0.075 (0.093)
I Attrition*age of the head		0.003 (0.003)
Attrition*education of the head		0.026* (0.015)
Attrition*adult equivalent		0.005 (0.021)
Attrition*livestock		0.002 (0.005)
Attrition*poultry		-0.001 (0.003)
Attrition*landholding per worker		-0.058 (0.050)
Attrition*farm assets per worker		0.000 (0.047)
Attrition* <i>asinh</i> distance to market (km)		-0.070 (0.045)
Attrition* distance to the major road (km)		-0.069** (0.028)
Attrition* <i>asinh</i> distance populated center (km)		0.057 (0.044)
Attrition* average temperature (wettest quarter)		0.059 (0.407)
Attrition*cooperative		0.053 (0.081)
Attrition*crop diseases		-0.100 (0.091)
Attrition*preharvest loss		0.042 (0.083)
Constant		14.615*** (0.552)
Pseudo R ² /R ²	0.076	0.205
N	1600	1600
Wald Test F(16, 1568)		1.40

NB:(1) Standard errors in parentheses

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11 and 2012/13)

Table A3: Determinants of household real consumption (excluding 40 households with both AIS and microfinance)

Dependent variable	<i>asinh</i> Real consumption per adult equivalent
<i>asinh</i> Real value of input vouchers	0.010** (0.003)
<i>asinh</i> Real value of microfinance	0.014*** (0.004)
Female household head (Yes=1)	-0.130*** (0.042)
Age of the head (years)	0.000 (0.001)
Education of the head (Years)	-0.000 (0.004)
Adult equivalent	-0.078*** (0.007)
Number of Livestock	0.003*** (0.001)
Number of Poultry	0.003*** (0.001)
Landholding per worker	-0.028** (0.012)
Farm assets per worker	0.025** (0.012)
<i>asinh</i> distance to market (km)	-0.026 (0.032)
<i>asinh</i> distance to the major road (km)	-0.039** (0.016)
<i>asinh</i> distance to the populated center (km)	0.001 (0.001)
<i>asinh</i> average temperature (wettest quarter) (km)	-0.030 (0.451)
Cooperatives in the village (Yes=1)	-0.038* (0.020)
Tobit residual-Voucher eq	-0.005** (0.002)
Tobit residual-microfinance eq	-0.001 (0.001)
Time fixed effects	Yes
Region fixed effects	Yes
Constant	14.238*** (1.745)
R-sq: within	0.241
N	5682

NB:(1) Bootstrapped standard errors in parentheses (with 200 repetitions)

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11 and 2012/13)

Table A4: Determinants of household real consumption, xtivreg2 estimation

Dependent variable	<i>asinh</i> Real consumption per adult equivalent
<i>asinh</i> Real value of input vouchers	0.021*** (0.008)
<i>asinh</i> Real value of microfinance	0.038*** (0.013)
Female household head (Yes=1)	-0.142*** (0.042)
Age of the head (years)	0.000 (0.001)
Education of the head (Years)	0.000 (0.004)

Adult equivalent	-0.075*** (0.007)
Number of Livestock	0.003*** (0.001)
Number of Poultry	0.002*** (0.001)
Landholding per worker	-0.032*** (0.012)
Farm assets per worker	0.033*** (0.011)
<i>asinh</i> distance to market (km)	-0.036 (0.032)
<i>asinh</i> distance to the major road (km)	-0.044*** (0.016)
<i>asinh</i> distance to the populated center (km)	0.001 (0.001)
<i>asinh</i> average temperature (wettest quarter) (km)	-0.147 (0.449)
Cooperatives in the village (Yes=1)	-0.027 (0.019)
R ²	0.220
N	5722
Wald Test F(1, 2723)	1.33
Underidentification test (Anderson canon. corr. LM statistic): Chi-sq(1)	209.791***
Weak identification test (Cragg-Donald Wald F statistic)	74.641
Sargan statistic (overidentification test of all instruments): Chi-sq (1)	0.702

NB:(1) Standard errors in parentheses

(2) * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11 and 2012/13)

Table A5: Summary Statistics for Three Income Quantiles

	Low-income (N=1908)	Middle-income (N=1907)	High-income (N=1907)
Variable	Mean	Mean	Mean
Consumption per adult equivalent	314138.93	555381.29	1184732.7
<i>asinh</i> Consumption per adult equivalent	12.612	13.209	13.898
Food consumption per adult equivalent	197373.52	350302.94	703950.55
<i>asinh</i> Food consumption per adult equivalent	12.38	12.95	13.539
Income per adult equivalent	468465.16	741197.69	2680503.1
<i>asinh</i> income per adult equivalent	12.72	13.038	13.718
Used input vouchers (%)	.047	.074	.08
Value of vouchers (TZS)	2416.70	5325.81	5544.61
<i>asinh</i> value of vouchers	.544	.886	.948
Microfinance Borrowing (%)	.023	.05	.096
Amount of microfinance (TZS)	4390.94	16353.62	64595.46
<i>asinh</i> amount of microfinance	.274	.617	1.257
Female household head (%)	.244	.23	.231
Age of the household head	48.11	49.056	48.676
Education of the head (Years)	.908	1.199	1.872
Adult equivalent	5.03	4.544	3.942
Landholding per workforce	.977	.972	.955
Farm assets per workforce	1.311	1.411	1.464
Livestock	5.003	5.453	6.837
Number of poultry	6.837	7.749	8.955
Distance to nearest major road (km)	24.972	22.618	18.719
Distance to agricultural market (km)	91.199	89.321	77.894
Distance to nearest populated centre (km)	56.62	50.999	46.199

Average Temperature °C in wettest quarter	23.39	23.51	23.50
Farm cooperatives in the village (%)	.473	.461	.388
IV1: Farm input retailer in the village (%)	.392	.408	.434
IV2: Proportion of smallholders in the village	.411	.603	.641
IV3: Number of borrowers in the village	5.661	6.006	6.33

Source: Author's estimation from NPS (2008/9, 2010/11 and 2012/13)

Table A6: Descriptive Statistics (Within Variations)

Variable	Used input Vouchers			Microfinance Borrowing		
	No (N= 5339)	Yes (N= 383)	Difference	No (N=5401)	Yes (N= 321)	Difference
Consumption per adult equivalent	-1277.72	16510.91	-17788.63	-3266.45	54959.85	-58226.3***
<i>asinh</i> Consumption per adult equivalent	0.00	0.02	-0.02	0.00	0.07	-0.07***
Food consumption per adult equivalent	-752.58	9725.05	-10477.64	-1644.88	27676.07	-29320.96***
<i>asinh</i> Food consumption per adult equivalent	0.00	0.01	-0.01	0.00	0.06	-0.06***
Income per adult equivalent	13473.78	-174110.2	187584	-7813.50	131466.3	-139279.8
<i>asinh</i> income per adult equivalent	0.00	0.00	0.00	0.00	0.11	-0.11**
Value of vouchers (TZS)	-1869.24	24154.61	-26023.85***	0.00	2050.16	-2050.16
<i>asinh</i> value of vouchers	-0.34	4.38	-4.72***	0.00	0.17	-0.17
Amount of microfinance (TZS)	-399.08	5157.06	-5556.15	-5123.28	86202.06	-91325.34***
<i>asinh</i> amount of microfinance	-0.01	0.16	-0.17**	-0.22	3.55	-3.77***
Age of the household head	-0.04	0.54	-0.58**	0.01	-0.25	0.26
Female household head (1/0)	0.00	0.00	0.00	0.00	0.00	0.00
Education of the head (Years)	0.01	-0.12	0.13*	-0.01	0.20	-0.21**
Adult equivalent	-0.01	0.08	0.09*	-0.01	-0.10	-0.11*
Livestock	-0.03	0.45	-0.48	-0.03	0.43	-0.46
Number of poultry	-0.02	0.19	-0.21	-0.07	1.13	-1.20**
Landholding per workforce	0.00	-0.04	0.04	0.00	0.00	0.00
Farm assets per workforce	0.00	0.00	0.00	0.01	0.01	0.00
Distance to agricultural market (km)	-0.06	0.81	-0.87	0.01	-0.18	0.19
Distance to nearest major road (km)	-0.02	0.24	-0.26	0.00	-0.16	0.16
Distance to nearest populated centre (km)	0.00	0.01	-0.01	0.06	0.10	0.04
Average Temperature °C in wettest quarter	0.01	-0.13	0.14	0.01	-0.01	0.02
Farm cooperatives in the village (1/0)	0.00	0.02	-0.02	0.00	0.01	-0.01
IV1: Farm input retailer in the village (%)	0.00	0.04	-0.04**	0.00	0.01	-0.01
IV2: Number of smallholders in the village	0.00	0.03	-0.03*	-0.01	0.20	-0.21***
IV3: Number of borrowers in the village	0.00	-0.02	0.02	0.00	0.01	-0.01

NB: * = significant at 10%; ** = significant at 5% and *** = significant at 1%

Source: Author's estimation from NPS (2008/9, 2010/11 and 2012/13)

CHAPTER 4

PUBLIC INVESTMENT IN PREVENTIVE AND CURATIVE HEALTH INTERVENTIONS AND CHILD MORTALITY NEXUS: A CASE OF TANZANIA

4.1. Introduction

Child mortality is one of the biggest development challenges in sub-Saharan Africa (SSA). In 2020, SSA accounted for 53% of global mortality for children under the age of five (United Nations, 2020). As a matter of global urgency, The United Nations put the reduction of child mortality as one of the sustainable development goals (United Nations, 2015). This means that to achieve sustainable development, SSA countries must win the fight against child mortality. To this end, many SSA countries have been implementing various investments in health interventions. The moral aspects of these interventions are easily justified as they are designed to save lives. However, most of these interventions are rarely effective (Ansah *et al.*, 2009), or in most cases, they have not been subjected to rigorous economic evaluations. In this chapter, I examine the impacts of two major health interventions designed to reduce child mortality in Tanzania: subsidized insecticide-treated nets (ITNs) and free medicare.

Public investment in delivering free medical services (free medicare) and preventive interventions can play a key role in reducing child mortality. Free medicare allows children to access medical services, which in turn, provides timely medical treatment, resulting in low child mortality (Rutherford, Mulholland and Hill, 2010; Mubyazi, 2004). Owing to this, in the mid-1990s, Tanzania waived medical fees for children under the age of five (under-fives) (Mujinja and Kida, 2014). Unfortunately, despite offering free medicare, the country continued to experience high child mortality (Ministry of Health [Tanzania], 2016). Eventually, in the late 1990s, it became clear that in SSA, where malaria accounts for over one-third of child mortality, preventive measures were important to achieve sustained child mortality reduction. To this end, in 1998, the World Health Organization (WHO) launched Roll Back Malaria: a donor-funded programme aimed at helping poor countries provide subsidized ITNs to vulnerable groups (Goodman, Coleman and Mills, 1999). Tanzania started distributing subsidized ITNs in 2014 through the National Net Voucher Scheme (TNVS) (Kramer *et al.*, 2017). TNVS and free medicare are among the largest public health interventions in the country and, therefore, have attracted enormous interest from donors and policymakers around the world (Kramer *et al.*, 2017; Mulligan, Yukich and Hanson, 2008).

Despite the large-scale nature and the growing interest from health and development stakeholders, the evidence on the effectiveness of subsidized ITNs and free medicare on child mortality in Tanzania and across SSA remains limited. This makes it difficult to practice evidence-informed policymaking, and nearly impossible for policymakers to weigh between available interventional alternatives. In this chapter, I first fill this gap by estimating the impacts of subsidized ITNs and free medicare on child mortality in Tanzania. I then provide comparative tests to examine whether the two programmes equally affect child mortality. From the health policy perspective, estimating the effects of both interventions allows policymakers to compare the impacts of these preventive and curative interventions, thus providing one of the bases for policymakers to design health intervention priorities. This chapter, therefore, provides much needed but very rare empirical evidence on the effects of large-scale and long-term ITN subsidies and free medicare on child mortality, thus providing a sizable contribution to the literature and policymaking in the health sector.

Because the two interventions are not randomly delivered, assessing the impact of these investments is very problematic as genuine endogeneity concerns arise when establishing causal effects. For instance, to significantly reduce child mortality, governments tend to allocate more subsidized ITNs in malaria hotspots, which tend to have high child mortality. Similarly, government health facilities, which provide free medicare to the under-fives, are not randomly allocated as governments construct more health facilities in urban, well-developed, or politically influential locations, which tend to have low child mortality rates. Equally important, parents' decision to use free medicare and subsidized ITNs may vary depending on endogenous characteristics such as education, income, and aspirations of parents. To address these endogeneity concerns, I use the two-stage residual inclusion in a semi-parametric proportional hazards model popularized by Terza, Basu and Rathouz (2008).

This chapter contributes to two major streams of empirical studies. The first consists of studies on the effect of subsidized ITNs on child mortality. Studies in this stream remain scarce. In this stream, this chapter closely relates to two studies in SSA. The first is D'Alessandro *et al.*, (1995), which observed a reduction of 8% in infant mortality for every 10% increase in usage of subsidized ITNs in The Gambia. In the subsequent years, however, D'Alessandro *et al.*, (1995) observed a decline in ITN usage when the free distribution ended, which was subsequently followed by an increase in child mortality signifying the correlation between subsidized ITNs and child mortality. The second study was conducted in Tanzania by Schellenberg *et al.*, (2001) to estimate the effect of subsidized ITNs between May 1997 and

August 2000 in two rural districts (Kilombero and Ulanga) in the country. Their findings show that subsidized ITNs increased the survival time of infants by 27%. This chapter differs from these papers, particularly Schellenberg *et al.*, (2001), in two major ways. First, I use three waves of panel data covering five years that were collected across all districts in the country and, therefore, I produce countrywide estimates. Second, I control for the endogeneity of subsidized ITNs using the two-stage residual inclusion, thus providing more robust estimates.

The second stream focuses on the effect of free medicare on child mortality. In this stream, this chapter closely relates to the work of Ansah *et al.*, (2009) in Ghana, which examined child mortality differences between households that used free medicare against households that used out-of-pocket payment in Dangme District in Ghana. Ansah *et al.*, (2009) found that children in households using free healthcare did not have significantly lower child mortality compared to households that relied on cash payments. Because, earlier studies had indicated that cessation of medical fees resulted in high rates of medical services utilization in countries such as Kenya (Mbugua, Bloom and Segall, 1995), South Africa (Wilkinson *et al.*, 2001), and Uganda (Xu *et al.*, 2006), lack of significant effect on child mortality reported in (Ansah *et al.*, 2009) suggests that higher utilization of medical care due to free medicare may not necessarily translate into lower child mortality. This chapter differs from Ansah *et al.*, (2009) in that it uses countrywide panel data in Tanzania, thus producing countrywide estimates in a much longer period.

In this chapter, I merge these streams of empirical studies and estimate the effect of subsidized ITNs and free medicare on child mortality. I found that access to subsidized ITNs significantly reduced child mortality associated with malaria. Free medicare also had a negative effect on malaria-caused child mortality, albeit not statistically significant at the conventional significance levels. Moreover, the comparative analysis shows that the levels of the effect of the two interventions are statistically comparable against malaria-caused child mortality. When deaths from all diseases are considered, however, subsidized ITNs and free medicare are effective in reducing overall child mortality. Moreover, in reducing overall child mortality, the use of subsidized ITNs is more effective than free medicare.

The remaining parts of the paper proceed as follows. Section 4.2 presents the policy context of the two interventions. Section 4.3 discusses the data sets, variables construction, and descriptive statistics. Section 4.4 presents the methodology used in estimating the results.

Section 4.5 presents and discusses the empirical results and Section 4.6 presents the sensitivity analysis. Section 4.7 presents the conclusions and policy implications.

4.2. Policy Context

Malaria is the leading cause of hospitalization and child mortality in Tanzania. For instance, in 2014, malaria accounted for 37% of hospital admissions and 41 % of mortality among the under-fives in the country (Ministry of Health [Tanzania], 2016). Due to its significance in child mortality and the economic burden attached to malaria hospitalization, the government in Tanzania has prioritized the fight against malaria (Ministry of Health [Tanzania], 2016). There are two major groups of strategies used in fighting malaria in Tanzania: preventive and curative strategies (Ministry of Health [Tanzania], 2014). Preventive strategies are meant to prevent people from catching the disease and include measures such as the use of mosquito nets and residual spraying (Goodman, Coleman and Mills, 1999). In Tanzania, the use of mosquito nets, particularly ITNs, is the leading preventive measure (Ministry of Health [Tanzania], 2016). Sleeping under ITNs prevents people from mosquito bites, which in turn, prevents them from catching malaria. On the other hand, curative strategies encompass the use of various medical treatments to cure malaria. The type and the cost of medication depend on malaria episodes, which range from uncomplicated malaria (one that does not require hospital admission), moderate episodes (malaria that requires basic hospitalization), and complicated episodes (one which requires complicated medical treatments such as cerebral malaria with neurological sequelae) (Sicuri et al., 2013).

It is important to note that preventive and curative are complementary strategies and, therefore, are implemented together (Wilkinson *et al.*, 2001; Ministry of Health [Tanzania], 2007). Development and health policy makers, therefore, seek to implement preventive interventions such as subsidized ITNs together with curative interventions such as medical fee waivers so that they can achieve optimal morbidity and mortality reduction.

(a) Subsidized ITNs in Tanzania

In Tanzania, state interventions in the distribution of subsidized bed nets started in the 1990s in trials that were not scaled-up (Magesa *et al.*, 1991). However, in the 2000s, various donor-funded interventions have been implemented more widely. In 2004, the government implemented the Tanzania Net Voucher Scheme (TNVS) which distributed subsidized ITNs to pregnant women and the under-fives during their antenatal and immunization clinic visits

(Kramer *et al.*, 2017; Bonner *et al.*, 2011). Between 2004 and 2008, TNVS distributed ITNs, and since 2009, long-lasting insecticidal nets (LLINs).

TNVS succeeded in distributing ITNs/LLINs to pregnant women and the under-fives (Njau *et al.*, 2009). However, not all eligible people were accessing health facilities to benefit from the programme, and not all people redeemed their vouchers (Lalji *et al.*, 2016). Because of this, the distribution of ITNs/LLINs through TNVS did not achieve the 80% universal coverage set by the roll-back malaria initiative (Mboma *et al.*, 2018). To this end, two mass campaigns were launched: (1) the children under-fives catch-up campaign in 2009 and (2) the universal coverage campaign in 2011, which focused on the population other than under-fives (Lalji *et al.*, 2016). Across the country, the under-fives received ITNs/LLINs through the vouchers under TNVS or through the Under-Five Catch-up campaign (Mboma *et al.*, 2018). Moreover, there have been other public-funded initiatives with the aim of achieving 80% universal coverage. For instance, the keep-up strategy in schools was tried in the northern zone in 2013, but up to date, it has not been scaled up to other regions. A second mass universal replacement campaign was conducted between 2015 and 2017 focusing on age groups other than the under-fives in the country (Mboma *et al.*, 2018). Because the analysis in this chapter focuses on the under-fives, I focus on the TNVS and the complementary catch-up campaign, which were entirely devoted to the under-fives.

Generally, for the under-fives, there were two main distribution systems. The main mechanism was through child clinic attendance. During the first clinic, the mother was given a net voucher, which could be redeemed by paying the top-up amount, which was approximately TSH 500 (USD 0.30) (Kramer *et al.*, 2017). Other than paying the top-up amount, there were no other participation criteria. Because all new babies are required to attend several clinics for compulsory immunization, it was thought that most infants will be able to get their net vouchers through this mechanism. In later years, however, it became clear that not all parents were redeeming their net vouchers, and not all new babies attended the clinic. Therefore, a new distribution mechanism was launched, namely, the children under-fives catch-up campaign in 2009-2010 (Kramer *et al.*, 2017). This was a public net distribution campaign that targeted under-fives who had not received an ITN. During this campaign, under-fives were issued with free ITNs.

(b) Free Medicare in Tanzania

The provision of free medicare is a long-standing policy in Tanzania. After its independence in 1961, the country's development policymaking was aligned with African socialism, and, therefore, health services were offered free of charge in government-run health facilities (Ndulu and Mutalemwa, 2001). Following the structural adjustments in the 1980s, however, the health sector was liberalized, and user fees were introduced in 1993 (Mujinja and Kida, 2014). To ensure equal access to health services, the government waived user fees for vulnerable groups, including the under-fives, pregnant women, and elderly citizens (Ministry of Health [Tanzania], 2007).

Because of limited funding, free medicare is only provided in government health facilities (Mujinja and Kida, 2014). To enhance access to government facilities, which are the sole providers of free medicare, the government focuses on ensuring that each village has at least a government-run health facility (Ministry of Health [Tanzania], 2016). By the end of 2014, there were 5,913 village-based hospitals (dispensaries) serving 15,802 villages across the country (Ministry of Health [Tanzania], 2016). This means, approximately one dispensary was serving about 3 villages. Out of these dispensaries, 4,502 were owned by the government. Because only government health facilities provide free medicare to the under-fives, it is evident that access to free medicare services, particularly in rural areas, is very limited. Among targeted vulnerable groups, free medicare covers all medical cases and admission costs as long as treatment was done in government health facilities (Mujinja and Kida, 2014).

4.3. Source of Data, Variable Measurement, and Descriptive Statistics

(a) Source of Data and Variable Measurement

(i) Source of Data

The data used in this chapter comes from Tanzania's National Panel Survey (NPS) conducted by the National Bureau of Statistics (Tanzania) in collaboration with the World Bank. The data is freely available on the website of the National Bureau of Statistics and the World Bank. By design, NPS follows stratified, multi-stage cluster-based sampling. The principal strata are Tanzania Mainland and Zanzibar (National Bureau of Statistics [Tanzania], 2009). Within each stratum, designated clusters were chosen randomly, with the probability of selection proportional to their population size. The baseline sample was designed in 2008/9 to be sufficient to produce nationally representative estimates. The first wave in 2008/9 was followed by Wave 2 (2010/11), Wave 3 (2012/13), Wave 4 (2014/15), and Wave 5 (2019/20). Unfortunately, the sampling framework was changed during Wave 4, leaving only about 800

households from previous waves linked to waves 4 and 5. Therefore, I use only the first three waves, which are completely linked.

The sample used in this chapter is extracted from the household/individual questionnaire for the under-fives. The sample contains a total of 5,969 under-fives during the first three waves of the survey. Among these, 978 and 1,140 turned over five years of age after the first wave and second wave, respectively. Of the remaining children, 560 children, representing 9.38% of the sample, were only surveyed once in the three waves, hence their mortality status could not be established during the three waves. All these observations are included as censored observations during the regression estimation process.

(ii) Measurement of Variables

Child mortality

The outcome variable of interest is child mortality. The individual and household data contain key information on various aspects of household health, including hospitalization, types of diseases treated, and if any member of the household died, causes of death were identified. I construct two categories of deaths, namely, malaria-caused deaths and total deaths caused by all diseases. Death is a binary variable taking the value of 1 if the child died before the age of five and 0 otherwise. Moreover, because I use the Cox model, which requires duration data, the age of the child is also needed. The age is measured in years.

One of the concerns on the reliability of mortality data comes from the fact that most deaths in developing countries, such as Tanzania, are not registered in the official civil registration system as most patients are not hospitalized (National Bureau of Statistics [Tanzania], 2015; Rao, Bradshaw and Mathers, 2004). This presents two challenges. First, without the official death certificate, it is very difficult to accurately understand the actual cause of death. Death certificates are the most accurate source of causes of death as they specify causes of hospitalization and death (Blencowe *et al.*, 2016). Eventually, poor civil registration systems may result in underestimating the true mortality rate as most deaths are not registered (Alarcon and Robles, 2007).

Second, because death certificates specify the timing of death, without a death certificate, therefore, it is difficult to accurately establish that the deceased was under the age of five. This is particularly an issue for children whose age is a couple of months before/past five. Inaccurate reporting of the age of the child can understate child mortality for under-fives as children who are a few months before the age of five may be reported as being five-year-

olds. Errors in the reported age of children who died may distort results (Alarcon and Robles, 2007).

In the absence of a complete civil registration system, household surveys are the key source of health status data (Alarcon and Robles, 2007). One of the challenges in these surveys, however, is that health status information is self-reported and, therefore, the credibility of the subsequent information depends on the ability of the informant to recall accurately both the cause and time of death. One of the concerns against self-reported information is that respondents might not be able to recall accurate details relating to causes of death, which in turn, may lead to biased estimates. This problem can be exacerbated by the illiteracy of parents and poor access to health facilities, especially in rural areas. Eventually, due to self-reported health status, the true causes of death may be misidentified (Blencowe *et al.*, 2016).

The final concern relates to misreporting of causes of death. One of the reasons behind this is due to erroneous reporting caused by human factors such as forgetting. For instance, information relating to causes of death may not be remembered correctly and, therefore, the informant may unknowingly provide inaccurate information. Several factors can exacerbate this kind of misreporting. For instance, compared to rich households, poor households are more likely to misreport the causes of death (Alarcon and Robles, 2007). This could be related to the fact that poor parents are most likely to be uneducated and less equipped to keep key records about their children. Misreporting also is prevalent among culturally, economically, and socially marginalized communities (Haws *et al.*, 2010; Alarcon and Robles, 2007). Equally important, because the death of a child is always a traumatic event; cultural values, the age of women and family history may influence the responses (Alarcon and Robles, 2007).

The second cause of misreporting is intentional misreporting, which occurs when the informant chooses not to tell the true cause of death. For instance, people tend to hide causes of death they consider shameful and immoral or those relating to negligence (Blencowe *et al.*, 2016). Because of the stigma associated with these deaths, parents would hide the true cause and report causes that seem familiar and common. This is likely to result in overstating deaths from common diseases such as malaria and fever. Unfortunately, whether intentional or unintentional, misreporting can result in the misclassification of deaths (Blencowe *et al.*, 2016).

It is important to note that accurate classification of the cause of death is very important in designing policies necessary in reducing the number of preventable deaths (Numaguchi *et al.*, 2022). Because of this need, and to avoid potential biases due to self-reported health status,

key steps are often taken by the data collecting institutions. First, during the NPS data collection in Tanzania, informants were asked to provide death certificates whenever possible (National Bureau of Statistics [Tanzania], 2011). Because medicare for the under-fives in Tanzania is free, most deaths in areas with access to government health facilities were registered and death certificates issued. Nonetheless, this only applies to registered deaths. Second, to address the challenge posed by unregistered deaths and ensure that parents can generate reasonably accurate recalls, NPS collects data in regular and reasonably short intervals (one year during the first four waves). Because informants tend to forget the details relating to death as time passes (Alarcon and Robles, 2007), collecting data after a short interval makes it likely to generate accurate recalls on key issues such as hospitalization and the age of the deceased. Because the data used was collected after every year, the data provided is likely to have a reasonably high level of accuracy. Nonetheless, this does not eliminate the possibility that some deaths may be misreported. To address concerns relating to misreporting, in addition to specifically accounting for malaria-caused deaths, I also provide additional estimates accounting for all causes of deaths. Using total deaths avoids the need to understand the causes of death as the focus is only on whether the child died, of which no subjective recalls are involved.

Explanatory variables

The explanatory variables of interest are subsidized ITNs and free medicare. The use of subsidized ITNs is a binary variable taking the value of 1 if the child has been sleeping under a subsidized ITN and 0 otherwise. Free medicare is a binary variable taking the value of 1 if the child has been treated using free medicare service and zero otherwise. These variables are constructed from the health section in the individual/household questionnaire.

There is various key control variable. The first group consists of the characteristics of the child, namely, sex and parenting options. The sex of the child is constructed as a binary variable taking the value of 1 for girls and 0 otherwise. The second variable relates to the parenting of the child. This also is a binary variable taking the value of 1 if the child lives in the child lives in a household headed by a person other than their parents and 0 otherwise. These also are constructed from the individual/household questionnaire. The second group reflects household public goods such as access to clean drinking water, use of water-flushed toilets, and type of house proxied by whether the house was built using modern roofing materials. Clean water is a binary variable taking the value of 1 if the household has access to clean (tap) water and 0 otherwise. The variable for the type of the house is also a binary variable

taking the value of 1 if the house was constructed using modern roofing materials and 0 otherwise. The variable for the type of toilets is also a binary variable taking the value of 1 if the household uses water-flushed toilets and 0 otherwise. These variables are also constructed from the individual/household questionnaire.

The third group consists of community-level variables intended to reflect the accessibility and availability of social services in the local areas. Variables in this group include distance to the nearest market (km), distance to the nearest populated centre, and the proportion of people attending health facilities. These variables are constructed from the community questionnaire. The last group of control variables consists of the characteristics of the household. Variables in this group include age, sex, and education of the household head, number of adults, number of under-fives, a dummy variable for rural residence, and household assets. These are constructed from the individual/household questionnaire.

(b) Descriptive Statistics

Table 1 presents the trends of selected key variables. This table shows that during the three waves of the survey, the malaria-caused child mortality in the sample increased from 1.6% in Wave 1 to 1.9% in Wave 2 and 2.1% in Wave 3. This trend is also reflected in the trend of overall mortality, albeit at higher rates. Table 1 further shows that throughout the three waves, malaria accounted for over 33% of child mortality. Furthermore, the percentage of children receiving ITNs subsidized by TNVS declined from 15.8% in Wave 1 to respectively 9.0 and 15.6% in Wave 2 and Wave 3. However, although the use of subsidized ITNs in the sample is low, the overall use of bed nets in the sample is high, rising from 64.1% in Wave 1 to respectively 86.2% and 85.4% in Wave 2 and Wave 3. This highlights the significance of other sources of bed nets, such as commercially purchased nets.

Table 2 presents comparative statistics based on mortality, usage of subsidized ITNs, and the use of free medicare statuses. Summary statistics of the full sample are also provided in column (1). The mortality rate in the full sample is 1.9%. This mortality rate relates to deaths caused by malaria alone; hence, it is smaller than the overall mortality of about 6.5% estimated in other reports (National Bureau of Statistics [Tanzania], 2015; Ministry of Health [Tanzania], 2016). Looking at the groups in Table 2, I observe a significantly lower mortality rate among net voucher beneficiaries compared to non-beneficiaries. However, the mortality rate among free medicare beneficiaries is comparable to that of the non-beneficiaries. Moreover, I found that the under-fives who died were younger than those who were alive. This reinforces the fact

that most deaths occur during infancy (National Bureau of Statistics [Tanzania], 2015). The age of the child is comparable between subsidized ITNs and free medicare beneficiaries.

Regarding the other two characteristics of the child, I do not find significant differences between girls when the sample is divided based on death and use of subsidized ITNs. However, compared to non-beneficiaries, free medicare users had significantly fewer girls. Similarly, I do not find any significant grandparenting difference between the under-fives who died and those who were alive. However, compared to beneficiaries, non-beneficiaries of subsidized ITNs and free medicare on average had a higher grandparenting percentage.

Table 2 shows low participation rates in both programmes. The use of subsidized ITNs and free medicare in the full sample is 13.8% and 1.4%, respectively. Considering the difference between the groups, I found that the group of under-fives who died used fewer subsidized ITNs than under-fives who did not die. However, I do not find a significant voucher usage difference between free medicare beneficiaries and non-beneficiaries. Similarly, I do not find significant differences in the free medicare usage based on child death status and voucher receipt.

There are also variables for the characteristics of the households. I observe a comparable percentage of women-headed households across the three groups. Similarly, I do not find any significant difference in the age of the household based on child death and free medicare statuses. However, household heads in the group that used vouchers were younger than non-beneficiaries. The number of adults in the group of children who died was smaller than amongst living children. Similarly, free medicare beneficiaries had fewer adults compared to non-beneficiaries. However, I did not find a significant number of adults difference between net voucher beneficiaries and non-beneficiaries. Regarding the number of under-fives in the household, I do not find any significant difference between children who died and those alive. However, compared to non-recipients, users of subsidized ITNs had more under-fives. On the contrary, the group of free medicare beneficiaries had fewer under-fives than non-beneficiaries.

There are also control variables for household public goods. In this group, Table 2 shows that compared to living children, children who died had a significantly low rate of living in a house with a modern wall. Equally, non-beneficiary children in each programme had a significantly low rate of living in houses with modern walls. I do not find a significant difference between children who died and living children regarding the use of water-flushed toilets. However, in each programme, compared to beneficiary children, non-beneficiary children had higher rates of using water-flushed toilets. Living children also have a significantly higher rate of clear water usage than children who died. A similar pattern can also

be observed in free medicare usage where non-beneficiary children have a higher clean water usage rate than free medicare beneficiaries. However, I do not observe any significant clean water usage difference between the net voucher beneficiaries and non-beneficiaries.

I also control for the rurality and location of households. 73.7% of the sample resided in rural areas, suggesting that the under-fives predominantly resided in rural areas. Regarding the differences between the groups, I do not find significant differences in the rurality when the sample is divided between the groups in the three classifications. Similarly, the distance to the market, main road, and district headquarters are comparable when the sample is grouped based on mortality status as well as between free medicare beneficiaries and non-beneficiaries. However, voucher beneficiaries are significantly closer to the market, main road, and district headquarters than non-beneficiaries. On the contrary, there is no difference between children who died and those who did not and between free medicare beneficiaries and non-beneficiaries regarding the distance from the household to the market, main road, and district headquarters.

Finally, at the end of Table 2, I present the descriptive statistics of the instruments. First, I do not find significant differences in the years of stay when the sample is grouped based on death status, use of subsidized ITNs, and use of free medicare. Second, I found that compared to children who died, households with living children have higher rates of attending village assemblies. Similarly, voucher beneficiaries had a higher rate of attending village assemblies than non-beneficiaries. Third, I do not find a significant difference in village political party leadership when the sample is grouped based on child death status, use of subsidized ITNs, and free medicare usage.

Table 1: Trends in Child Mortality, Use of Subsidized ITNs, and Free Medicare

	Wave 1	Wave 2	Wave 3
Malaria-Caused Mortality (%)	1.6	1.9	2.1
Overall Mortality (%)	4.1	5.7	5.2
Malaria deaths/total deaths (%)	39.4	33.7	40.6
Used Subsidized ITNs (%)	15.8	9.0	15.6
The use of bed nets	64.1	86.2	85.4
The use of ITNs	39.5	28.3	26.2
Overall free medicare use-all diseases (%)	22.9	31.8	23.8
Free medicare use for malaria (%)	2.3	0.8	0.7

Sources: Author's computation from NPS (Wave 1, Wave 2, and Wave 3)

Table 2: Descriptive Statistics

	(1) Full sample (N=5,969)		(2) Child Death			(3) Used subsidized ITNs			(4) Used free medicare		
Variable	Mean	Std	No N=5,860	Yes N=109	Difference	No N= 5,145	Yes N=824	Difference	No N=5,888	Yes N=81	Difference
Death (%)	1.90	0.14	0.00	100	100	2.10	0.60	1.40***	1.90	1.20	0.70
Girls (%)	50.40	0.5	50.40	49.10	1.30	50.20	51.20	1.00	50.50	38.30	12.20**
Age of the child (Years)	2.78	1.44	2.81	1.31	1.50***	2.78	2.79	0.01	2.77	3.20	0.42
Grandparenting (%)	30.50	0.46	30.60	27.30	3.30	31.00	27.50	3.50**	30.70	17.30	13.40***
Use of subsidized ITNs (%)	13.80	0.34	14.00	4.50	9.50***	0.00	100	100	13.80	16.00	2.30
Free medicare (%)	1.40	0.12	1.40	0.90	0.50	1.30	1.60	0.30	0.00	100	100
Woman household head (%)	17.80	0.38	17.70	19.10	1.40	17.90	16.60	1.30	17.80	16.00	1.80
Age of the head (years)	42.65	14.4	42.66	41.96	0.70	42.80	41.69	1.11**	42.68	40.27	2.41
Number of adults	7.30	4.73	7.36	5.83	1.53***	7.33	7.32	0.01	7.35	5.83	1.52***
Number of under-fives in the family	1.94	0.02	1.95	1.94	0.01	1.93	2.04	0.11**	1.95	1.67	0.28*
House has modern walls (%)	39.5	0.00	39.7	30.3	9.4*	40.1	36.4	3.7**	39.6	31.1	8.5*
House has water-flushed toilets (%)	14.9	0.04	14.9	11.8	3.1	15.0	6.7	8.3**	15.4	11.7	3.7**
Access to clean water (%)	24.0	0.5	24.1	14.5	9.6*	23.8	25.0	1.2	24.1	15.6	8.5*
Asset index	0.00	0.02	0.01	-0.37	0.38**	-0.01	0.06	-0.07	0.03	-0.08	0.11**
Residing in rural areas (%)	73.70	0.44	73.60	77.30	3.70	73.70	73.70	0.00	73.60	75.30	1.70
Distance to market (km)	73.78	55.4	73.64	81.01	7.37	74.59	68.70	5.88***	73.63	84.48	10.85
<i>asinh</i> distance to market	3.82	1.21	3.81	3.93	0.12	3.83	3.71	0.12****	3.81	4.00	0.19
Distance to the main road (km)	18.47	22.3	18.49	17.15	1.34	18.86	16.07	2.79***	18.46	19.07	0.60
<i>asinh</i> distance to the main road	2.67	1.59	2.67	2.62	0.05	2.68	2.58	0.10*	2.67	2.63	0.04
Distance to populated centre (km)	46.51	41.4	46.48	48.31	1.83	46.33	47.62	1.29	46.43	52.28	5.85
<i>asinh</i> distance to the populated centre	3.96	1.27	3.96	4.03	0.07	3.95	3.95	0.00	3.96	4.03	0.07
Distance to the district (km)	30.45	34.6	30.32	37.30	7.00	30.87	27.88	2.99**	30.35	37.68	7.33
<i>asinh</i> distance to the district	3.11	1.76	3.10	3.39	0.29	3.10	3.13	0.03	3.11	3.14	0.03
IV1: Years of stay in the village	29.23	0.25	29.24	28.83	0.41	29.42	28.03	1.39	29.20	31.63	2.43
IV2: Attending village assemblies (%)	43.10	0.49	43.30	34.50	8.70*	42.70	46.00	3.30*	43.10	44.40	1.30
IV3: Village leader from the ruling party (%)	74.60	0.43	74.60	70.90	3.70	74.40	75.80	1.50	74.50	79.00	0.045

NB: (1) $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Source: Author's Computation from NPS (Wave1, Wave2, Wave3)

4.4. Conceptual Framework and Identification Strategy

(a) Conceptual Framework

This section presents the mechanisms through which public investments in subsidized ITNs and free medicare reduce child mortality. I adapt the theoretical model that analogous the child health production function discussed in Rosenzweig and Schultz (1983) and Mwabu (2009). The model assumes that households seek to maximize the following utility function.

$$U = U(W, Y, H) \quad (1)$$

Where; W is a health neutral good, i.e., a commodity that affects the utility but has no direct effect on child health (e.g., parent's clothing), Y is a health-related good that simultaneously affects the utility and child health outcome (e.g., mother's nutrition-related consumptions, alcohol consumption, and smoking), and H represents the child health outcome.

The production of child health can be expressed by the following production function.

$$H = H(Y, Z, \mu) \quad (2)$$

Where; Z is a market input that affects child health directly. Here, Z includes subsidized ITNs and free medicare for the under-fives. Z can be purchased at the market price or be subsidized by the government. The focus in equation (2) is whether subsidizing Z enhances child health outcome, H . μ is the component of child health due to genetic or environmental conditions that are not controlled by the household.

In the economics literature, equation (2) is described as a child health production function (Rosenzweig & Schultz, 1983). One of the characteristics of this production function is that it is embedded in the household utility function presented in equation (1).

Assume further that the household maximizes (1) given (2) and is subject to the following household budget constraints.

$$I = WP_w + YP_y + ZP_z \quad (3)$$

Where; I is an exogenous household income and P_w , P_y and P_z are respectively the exogenous prices of the health-neutral good W , household health-related good Y , and child health good Z . Moreover, the child health good, Z , is assumed to be purchased only to improve child health and, therefore, it enters the household utility function only through H .

Now, using equations (1-3), one can derive and learn the mechanisms of investing in child health goods. Because subsidizing ITNs and free medicare aimed at increasing their consumption through reduced prices (Mboma et al., 2018; Rutherford et al., 2010), therefore, I argue that reducing the prices of these child health inputs would constitute the main mechanism. To understand how the change in the prices of inputs affects the demand for the inputs, equations (1-3) can be manipulated. Following Mwabu (2009), such manipulation can give the following functions.

$$W = D_w(P_w, P_y, P_z, I, \mu) \quad (4.1)$$

$$Y = D_y(P_w, P_y, P_z, I, \mu) \quad (4.2)$$

$$Z = D_z(P_w, P_y, P_z, I, \mu) \quad (4.3)$$

Equations (4.1-4.3) can alternatively be referred to as demand functions for the respective inputs (Rosenzweig and Schultz, 1983).

Generally, among other things, equations (4.1-4.3) suggest that the quantity of inputs, including child health input, Z , is determined by the price of the respective input. Because the decision is based on the household budget, it is important to note that the demand for the inputs will also be affected by household income and the prices of other goods demanded by the households. To be specific, for instance, equation 4.3 suggests that the demand for child health inputs, Z , is determined by the price of Z , household income, and the prices of other inputs (P_w and P_y) needed by the household. Owing to this relationship, subsidizing Z through interventions such as medical fee waiver and subsidized ITNs, will reduce the price of the subsidized input, thus boosting the use of Z among the beneficiaries.

The subsequent increase in the consumption of Z will have a direct effect on child health outcome, H . Following Mwabu (2009), change in child health can be derived from equation (2) as follows:

$$dH = F_y dY + F_z dZ + F_\mu d\mu \quad (5)$$

Where; F_y , F_z , and F_μ are respectively the marginal product of inputs, Y , Z , and μ . Equation (5) shows that the change in child health outcome is affected by the change in the consumed quantity of household health inputs, Y , and child health input, Z . The size and direction of the effect depend on the marginal product of the inputs and the magnitude of demand for the inputs following a change in input prices (Mwabu, 2009). For instance, if the policy intervention such

as subsidizing ITNs and provision of free medicare would lead to a huge demand of Z , one would expect to see a positive change, and hence, an improvement in child health outcome, H .

(b) Empirical Approach

(i) Model Specification

The empirical strategy applies an extension of the model presented in equation (5). Here, the child health input, Z , consists of two child health inputs: subsidized ITNs from TNVS and free medicare. Therefore, I replace the vector Z with these two programmes. I examine whether subsidized ITNs and free medicare reduce child mortality among the under-fives by estimating the following equation.

$$H = h(V, FM, Y, X, C, \mu) \quad (6)$$

Where: H is the health outcome of the child, proxied by child mortality. V represents the use of subsidized ITNs taking the value of 1 if the child slept under an ITN subsidized by TNVS and 0 otherwise. FM represents the use of free medicare taking the value of 1 if the child was treated for malaria under the free medicare programme and 0 otherwise. As a preventive intervention, TNVS targeted the reduction of deaths caused by malaria by cutting down malaria infections, which in turn, would have a negative effect on child mortality (Kramer et al., 2017; Schellenberg et al., 2001). Free medicare is intended to make medical services accessible to all under-fives, thus ensuring timely medical treatment. Therefore, FM is also expected to have a negative effect on child mortality (Abel-smith & Rawal, 1992; Rutherford et al., 2010). Y is a vector for the mother's consumption of health-related goods that affects the health outcome of the child. Because specific data on these consumptions is unavailable, I control for consumption of health goods in the household by asset index. The asset index is a proxy of household income as income leads to asset accumulation (Ragasa & Mazunda, 2018). Therefore, it must be correlated with the mother's nutrition consumption. Unlike income, however, asset index is arguably not endogenous (Zhang et al., 2021). Because of data limitations, I do not control for the mother's consumption of harmful items such as alcohol and smoking as they were not directly recorded.

I also assume that child mortality is affected by some child and household characteristics, X . Because of data limitation, the available characteristics of the child only consist of the sex and parenting of the child. The sex of the child is a binary variable taking the value of 1 for girls and 0 otherwise. Reports in Tanzania indicate that amongst the under-fives, more boys die than girls (National Bureau of Statistics 2015), and, therefore, the sex of the

child, in this case, is expected to have a negative effect on child mortality. Parenting of the child is also a binary variable taking the value of 1 if the child lives in households headed by a person other than the parents (mostly grandparents), and 0 otherwise. The literature on the role of parenting suggests that parenting offered by a person other than the biological parents has negative effects on a child's wellbeing (Zhang et al. 2021; Del Boca, Piazzalunga and Pronzato, 2018). Therefore, grandparenting is expected to have a positive effect on child mortality.

The characteristics of the household include the age, sex, and education of the household head, the workforce, and the number of under-fives in the household. The age of the household head is associated with a lower ability to work and lower income (National Bureau of Statistics [Tanzania], 2019) and, therefore, it is expected to have a positive effect on child mortality, implying that the likelihood of child death increases as the household head gets older. Similarly, because women in Tanzania have restricted access to productive assets, have low education, and tend to be poorer than men (National Bureau of Statistics [Tanzania], 2019), households headed by women, therefore, are expected to have higher child mortality. High education is associated with high income (National Bureau of Statistics [Tanzania], 2019), and, therefore, the education of the head is expected to have a negative effect on child mortality. The workforce size represents the ability of the household to generate higher income and the availability of people who can be actively engaged in childcare and, therefore, it is expected to have a negative effect on child mortality. More under-fives represent additional commitment and demand for childcare and, therefore, it is expected to have positive effects on child mortality. There are also controls for public goods in the household, which include a dummy variable for houses constructed using modern walls, use of water-flushed toilets, access to clean water, and use of hygiene-enhancing equipment (such as brooms, moppers, refrigerators, and ironing devices). These variables are expected to have negative effects on child mortality.

C is a vector of community characteristics that affect child health outcomes. These characteristics include the distance from the household to the nearest populated centre and market. These variables represent the rurality of the village of residence and the lack of good transport infrastructure and medical services (Stock, 1983) and, therefore, they are expected to increase child mortality. There is also a control for the availability of health services in the village proxied by the proportion of people that attended any health facility in the village. This is expected to have a negative effect on child mortality as convenient access to health facilities reduces child mortality (Lohela et al., 2012; Stitzenberg et al., 2007; Stock, 1983).

There are also unobserved determinants of child mortality, μ , which include factors such as family-specific health endowments, such as genetic traits, and environmental factors, which were not measured in the survey.

(ii) Identification Strategy

The identification strategy used in estimating equation (6) depends first on how child mortality is measured and how equation (6) is modelled. One way to model equation (6) is when H is measured as a binary variable in which nonlinear models such as probit models can be used. One weakness of nonlinear modelling is that they do not account for any difference relating to the ages of the children. Thus, the death of an infant is treated equally as the death of a four-year-old. To model the time between birth and death, researchers use survival models (Cox, 1972; Zhang et al., 2021). In survival models, the child health outcome H is measured as the time taken until the occurrence of child death (survival time). This strategy is more appropriate for estimating factors affecting the survival time of the child. This makes it possible to account for age differences for different children among the under-fives. Therefore, in this chapter, I examine how the use of ITNs and free medicare affects the survival time of the under-fives.

In cases like this, where the survival time is necessary for modelling child mortality, estimating (6) using standard nonlinear models is not appropriate because it ignores the time element which is important in modelling the survival time (Zhang et al., 2021). The appropriate strategy to model equation (6) is using survival analysis commonly used for modelling duration data including the time and factors associated with child mortality (Kadobera et al., 2012). In this chapter, therefore, I use survival analysis to examine the effects of subsidized ITNs from the TNVS and free medicare on child survival time.

Survival analysis focuses on the distribution of survival times with a particular focus on survival and the predictors. Following Cox (1972), I apply the proportional hazards (PH) function. According to the PH, the hazard associated with child mortality, at the time 't' for an individual, 'i' with covariates, ' ω ' is expressed as follows.

$$h(t_i) = h_0(t_i) \exp\{\omega_i \varphi\} \quad (7)$$

Where; t is the survival time of child i measured in years. $h_0(t_i)$ is a baseline hazard function. ω is a vector of survival predictors and φ is a vector of parameters of the respective predictors. The PH function does not impose a distribution of baseline hazards, $h_0(t_i)$. Therefore, the baseline hazard, $h_0(t_i)$, remains unspecified. Equation (7) is often referred to as the Cox model.

The logarithmic transformation of the hazard function (7) gives the following linear function.

$$\log h(t_i) = \beta_0(t) + \varphi\omega_i \quad (8)$$

Therefore, the log-linear PH function analogous to equation (6) takes the following form.

$$\log h_i(t) = \beta_0(t) + \beta_1 V_i + \beta_2 FM_i + \beta_3 Y_i + \beta_4 X_i + \beta_5 C_i + \mu \quad (9)$$

The constant $\beta_0(t) = \log h_0(t_i)$, represents the baseline log hazard. $\beta_1, \beta_2, \beta_3, \beta_4$, and β_5 are parameters to be estimated for the respective covariates.

Therefore, in this chapter, I focus on estimating equation (9) using the Cox model. However, estimating (9) using the conventional Cox model is likely to result in biased estimators due to the potential endogeneity of subsidized ITNs and free medicare. Endogeneity, in this case, is likely to come from several sources. First, net vouchers are rarely distributed randomly. For instance, to be effective in mortality reduction, the government may distribute net vouchers targeting primarily areas with higher malaria infections, which tend to have higher pre-existing mortality rates. Similarly, access to subsidized ITNs is likely to be related to some characteristics of the parents such as willingness to follow medical advice, motivation, and civility, which are unknown to the researcher. This means that participation in the net subsidy programme is likely to be correlated to unobserved heterogeneity. Therefore, estimation of the effect of subsidized ITNs in (9) using the conventional Cox model is likely to result in biased effects of subsidized ITNs.

The use of free medicare is also potentially endogenous. For instance, the government is likely to supply more medical facilities in communities that are well developed and likely to economically afford to use medical services, which in turn, are likely to have lower mortality rates. Finally, like net voucher distribution, the use of free medicare is likely to correlate to unmeasured factors such as parenting commitments, education of the mother, and household income. This means that the use of free medicare is potentially correlated to unobserved heterogeneity, and thus estimating the effect of free medicare in (9) using the conventional Cox model is also likely to result in a biased effect of free medicare.

To address the potential endogeneity of the subsidized ITNs and free medicare, I use an instrumental variable approach. Following Terza et al. (2008), I use a two-stage residual inclusion method (2SRI). The 2SRI method is analogous to the control function approach in that it uses residuals from the first-stage regression in estimating the outcome equation in the second stage (Zhang et al., 2021).

Because I have two endogenous variables, I estimate two first-stage regressions. The respective first-stage regressions for subsidized ITNs and free medicare take the following forms.

$$Pr(V = 1|X, Z) = Pr(\alpha_1\gamma + Z\alpha_2 + \varepsilon_v > 0) \quad (10.1)$$

$$Pr(FM = 1|X, Z) = Pr(\rho_1\gamma + Z\rho_2 + \varepsilon_m > 0) \quad (10.2)$$

Where; X and Z are vectors of the covariates and instruments, respectively. X includes all exogenous covariates in equation (9).

After including the residuals from the first-stage regressions, equation (9) takes the following form.

$$\log h_i(t) = \beta_0(t) + \beta_1 V_i + \beta_2 FM_i + \beta_3 X_i + \beta_4 C_i + \beta_5 \hat{\varepsilon}_v + \beta_6 \hat{\varepsilon}_m + \mu \quad (11)$$

Where; ε_v stands for residual from the subsidized ITNs function (10.1) and ε_m is the residual from the free medicare function (10.2).

One of the advantages of using 2SRI is that it allows testing for the endogeneity of the endogenous variable. In the spirit of Wooldridge (2015), if the residuals, $\hat{\varepsilon}_v$ and $\hat{\varepsilon}_m$, are statistically significant, then subsidized ITNs and free medicare are endogenous and thus the use of 2SRI is justified. To produce more accurate estimates of standard errors, I perform all the estimations based on 100 bootstrap samples.

The use of 2SRI requires exogenous instruments. Fortunately, exogeneity of instruments can be tested statistically. I use the covariance between the residual from the naïve estimation of the main function and the instruments to test the exogeneity of the instruments. Following Wooldridge, (2013), an instrument is exogenous if it meets the following zero covariance condition.

$$cov(z, \mu) = 0 \quad (12)$$

Where cov refers to the covariance between the instrument, z , and the residual, μ , from naïve estimation of the outcome equation (9).

I use three instruments to address the endogeneity of subsidized ITNs and free medicare. Because these are free public-funded programmes, I argue that the usage of these services is influenced by the availability of relevant health service providers in the local area and parents' access to relevant information. Unfortunately, the actual availability of relevant health facilities in the local area is equally endogenous, which means it cannot be used as an

instrument. Therefore, to address the potential endogeneity, I construct three instruments that increase access to information about subsidized ITNs and free medicare while carrying no direct effects on child mortality. The first instrument is the number of years the household head has stayed in the village (IV1). I maintain that IV1 increases familiarity and social capital in the village, which in turn, increases access to relevant information. Access to information regarding public programmes such as free medicare and subsidized ITNs increases the household's likelihood of using these services but does not directly affect child mortality.

Second, I use a dummy variable for attending village assemblies, taking a value of 1 if a member of the household attended village assemblies during the year and 0 otherwise (IV2). Village assemblies can be used to disseminate information in the village. During village assemblies, village leaders, including government officials in the village, would have opportunities to educate people on the availability and use of public services such as subsidized ITNs and free medicare. Attending village meetings, therefore, would increase the likelihood of households using subsidized ITNs and free medicare. However, I maintain that attending village assemblies does not directly affect child mortality in the respective households in any way other than through access to information.

The third instrument is a dummy variable taking the value of 1 if the village's chairperson comes from the ruling party and 0 otherwise. The political party from which the chairperson comes can influence the location of public-funded programmes. In Malawi and Zambia, for instance, areas under the ruling party received more agricultural input subsidies than areas under the opposition parties (Banful, 2010; Mason and Ricker-Gilbert, 2013). I maintain that net subsidies would similarly follow a similar politically motivated distribution and, therefore, villages under the control of the ruling party would potentially receive more net vouchers, which in turn, increases the likelihood of the under-fives in that village using subsidized ITNs.

To ensure that only strong instruments are used, I impose the cut-off criterion of not more than 0.05 p-value popularized in Bound et al., (1995).

4.5. Empirical Results

(a) Determinants of Using Subsidized ITNs and the Free Medicare

The first-stage regression is presented in Table 3, which presents the determinants of subsidized ITNs and free medicare. Note that when the transformation of variables was applied, I used inverse hyperbolic sine (asinh), which, unlike logarithmic transformation, retains zero-valued

observations (Bellemare and Wichman, 2020). The focus in Table 3 is on the relevance and economic intuition of the instruments. One of the conditions for a relevant and valid instrument is that it must be strongly correlated with at least one of the endogenous variables. Following Bound, Jaeger and Baker (1995), I imposed the cut-off condition of a significance level of $p < 0.05$. Table 3 shows that all instruments meet this condition, which suggests that each instrument is strongly correlated with at least one of the endogenous variables.

Table 3 shows that years of stay by the household head in the village (IV1) has a positive effect on the use of free medicare. This suggests that the under-fives in households headed by heads who have stayed in the village for a long time tended to have significantly higher usage of free medicare. This could be related to the fact that a long stay in the local community results in familiarity and social capital, which is necessary to ensure access to information on available public programmes (Wossen *et al.*, 2017). IV1 has no significant effect on the use of subsidized ITNs.

Furthermore, attending village meetings (IV2) and village leaders coming from the ruling party (IV3) significantly increased the likelihood of using subsidized ITNs. The significance of village meetings on subsidized ITNs implies that village meetings might have been used in information dissemination regarding the availability of subsidized ITNs. The statistical significance of the ruling party's control in village leadership suggests that the distribution of net vouchers might have been politically biased. This follows a familiar pattern in SSA where the allocation of public goods and services such as agricultural inputs subsidies have been reported to favour areas controlled by the ruling party (Banful, 2010; Mason and Ricker-Gilbert, 2013). For free medicare, IV2 and IV3 are not statistically significant at the conventional significance levels.

In addition to these instruments, Table 3 also contains significant control variables that deserve highlighting. For subsidized ITNs, column (1) shows that grandparenting has a negative effect on subsidized ITNs, implying that living in households headed by grandparents or other relatives reduced the likelihood for the under-fives to use subsidized ITNs. This is consistent with findings in other studies showing that grandparenting resulted in less investment in childcare and delayed child development (Zhang *et al.*, 2021; Del Boca *et al.*, 2018). The number of under-fives in the household has a significant positive effect, suggesting that children in households with many under-fives had higher ITN usage rates. This is intuitive as TNVS targeted to provide one subsidized ITN to each under-five (Kramer *et al.*, 2017;

Mulligan, Yukich and Hanson, 2008). Finally, all proxies of public goods in the household have positive effects. This suggests that living in a household that has a modern roof, water-flushed toilet, tap water, and access to hygiene-enhancing equipment, increased the likelihood of using subsidized ITN. This could be related to the fact these household public goods imply a good living environment in the household, which is essential for safe child development.

For free medicare, column (2) shows that compared to boys, girls were less likely to use free medicare. Column (2) also shows that grandparenting reduced the likelihood of children using free medicare. This highlights the reluctance of grandparents and other non-parent guardians to seek childcare (Zhang *et al.*, 2021; Del Boca *et al.*, 2018). Finally, column (2) shows that the proportion of people attending medical facilities has positive effects on free medicare. This shows that children in areas with a high proportion of medical services users had a higher likelihood of using free medicare. This could be related to the fact that villages with higher medical services usage tend to have convenient access to medical facilities, which in turn, increases the availability of free medicare services in the village.

Table 3: Probit Estimation of the Determinants of Using Subsidized ITNs and Free Medicare

Dependent variable	(1) Used subsidized ITNs (yes=1)	(2) Used free medicare against malaria (yes=1)
IV1: Years of stay of the household head in the village	0.000 (0.001)	0.007** (0.004)
IV2: Attending village meeting (Yes=1)	0.084*** (0.005)	-0.026 (0.102)
IV3: Village led by the ruling party (Yes=1)	0.109** (0.050)	0.063 (0.117)
Sex of the child (Girl=1, Boy=0)	0.019 (0.042)	-0.222** (0.094)
Grandparenting (Yes=1)	-0.116* (0.063)	-0.258* (0.155)
Female household head (Yes=1)	-0.013 (0.060)	-0.050 (0.136)
<i>asinh</i> age of the household head	-0.160 (0.101)	-0.035 (0.239)
Education of the head (Years)	-0.005 (0.007)	-0.010 (0.015)
Number of adults in the household	-0.019 (0.015)	-0.027 (0.027)
Number of under-fives in the household	0.070*** (0.026)	0.021 (0.072)
Asset index	0.028 (0.022)	0.124 (0.168)
House with modern wall (yes=1)	0.144*** (0.053)	0.003 (0.114)
The house has flush toilet (yes=1)	0.224*** (0.078)	0.221 (0.182)
House has tap water (yes=1)	0.181*** (0.056)	0.060 (0.129)
House has hygiene-enhancing equipment (yes=1)	0.034***	0.008

	(0.010)	(0.026)
Rural residence (Yes=1)	-0.049	-0.009
	(0.070)	(0.149)
Proportion of medical services users in the village	0.167	1.707***
	(0.195)	(0.403)
<i>asinh</i> distance to the market	0.006	0.087
	(0.022)	(0.071)
<i>asinh</i> distance to the populated centre	-0.023	-0.005
	(0.016)	(0.033)
Time dummies (Wave 2&3)	Yes	Yes
Full regional dummies	Yes	Yes
Pseudo R2	0.0542	0.1050
Constant	-0.529	-6.679
	(0.445)	(105.329)
Observations	5,969	5,969

NB (1) *** p<0.01, ** p<0.05, * p<0.1

(2) Bootstrapped standard errors in parentheses

Source: Author's Estimation from NPS (Wave 1, Wave 2, and Wave 3)

(b) The Effects of TNVS and Free Medicare on Child Survival Time

Estimates of the determinants of child survival time are presented in Table 4. These results are estimated using the survival model discussed in Section 4. Table 4 presents estimates in both coefficients (columns 1-3) and hazard ratios (columns 4-6). For robustness purposes, the model is presented parsimoniously. Columns (1) and (4) exclude the control variables, thus presenting the pure but naïve effects of the subsidized ITNs and free medicare. Columns (2) and (5) include all standard controls but do not control for the endogeneity, thus presenting the full naïve estimation of the survival model, and columns (3) and (6) present the results based on the 2SRI.

Across all columns in Table 4, subsidized ITNs and free medicare consistently have negative coefficients and negative hazard ratios. These effects are comparable and stable across these columns. However, because of the endogeneity of both programmes, I rely on the 2SRI, which controls for the endogeneity of subsidized ITNs and free medicare. One of the advantages of using the 2SRI is that it offers the researcher the mechanism to test for the endogeneity of the endogenous variables through the statistical significance of residuals in the second-stage regression (Wooldridge, 2015). Estimates in columns (3) and (6) show that the residuals presented at the end are statistically significant. This suggests that subsidized ITNs and free medicare are indeed endogenous and, therefore, the control of endogeneity was necessary to ensure unbiased estimators.

Equally important, because I am using instrumental variables, it is important to test and establish the validity of the instruments used. In addition to the condition of statistical relevance presented in section 5.1, valid instruments must also be exogenous. Here, I present two tests to

verify the exogeneity of instruments. First, Table A1, which is appended at the end of this chapter, shows that the instruments have no significant effects at the conventional significance levels. This implies that none of the three instruments significantly affects child survival time. Second, I test for instrument exogeneity as imposed in equation (12). Following Wooldridge (2010), the condition of instrument exogeneity is achieved if the covariance between the residual from naïve estimation and the instruments is close to zero. The covariances presented at the end of naïve models in columns (2) and (5) are equivalent to zero, which suggests that the instruments used are exogenous. Furthermore, in Section 6, I provide sensitivity tests to illustrate that the estimated results are not sensitive to any of the instruments.

Having established the validity of instruments, I now focus on the effects of subsidized ITNs and free medicare. Because of significant endogeneity, I rely on 2SRI models in columns (3) and (6). For subsidized ITNs, columns (3) and (6) show that the use of subsidized ITNs has negative effects. These effects are statistically significant at the highest statistical significance level. Equally important, the estimated effects are comparable across the parsimonious models. In the subsequent discussions, I rely on hazard ratios in column (6), which are easier to interpret. Column (6) shows that the hazard ratio of subsidized ITNs is -0.710 (0.290-1.000). This means that *ceteris paribus*, at any time, the expected hazard rate associated with child mortality caused by malaria is 71.0% lower in children that used subsidized ITNs compared to children that did not use subsidized ITNs.

These estimates confirm that TNVS was effective in reducing malaria-caused child mortality among the under-fives. These findings are consistent with the findings of another subsidy programme tried between 1996 and 1997 in two districts in Tanzania. Schellenberg *et al.*, (2001) observed that this programme resulted in a 27% increase in survival time for children aged between 1 month to 4 years and an 18% overall increase in survival time for under-fives. Similarly, in The Gambia, D'Alessandro *et al.*, (1995) estimated an 8% reduction in infant mortality for every 10% increase in usage of subsidized ITNs. One of the differences between estimates in this chapter and those in Schellenberg *et al.*, (2001) and D'Alessandro *et al.*, (1995) is that estimates presented here account only for malaria-caused deaths whereas Schellenberg *et al.*, (2001) and D'Alessandro *et al.*, (1995) accounted for the overall child mortality.

For free medicare, column (6) shows a hazard ratio of -0.550 (0.450-1). This suggests that *ceteris paribus*, at any time, the expected hazard rate associated with malaria-caused child

mortality is 55% lower in the under-fives that used free medicare compared to the under-fives who did not receive free medicare. However, this hazard ratio is not statistically significant at the conventional significance levels suggesting that the use of free medicare in malaria treatment is not effective in reducing the hazards associated with malaria-caused child mortality. This is contrary to established expectations that access to medical services effectively reduces child mortality (Rutherford, Mulholland and Hill, 2010; Rutstein, 2000). Nonetheless, these findings are consistent with other studies in SSA such as Ansah *et al.*, (2009) in Ghana, which also observed insignificant effects of free medicare on child mortality.

In Tanzania, such insignificant effects of free medicare could be related to various factors. The first relates to poor access to health facilities in the country, especially in rural areas (Ministry of Health [Tanzania], 2016). Poor access to medical facilities imposes travel burdens, which has been associated with high child mortality in the country (Manongi *et al.*, 2014; Kadobera *et al.*, 2012) as well as in other countries in SSA (Okwaraji *et al.*, 2012; Rutherford, Mulholland and Hill, 2010). This can be further exacerbated by poor transport infrastructure in rural areas in the country (Kadobera *et al.*, 2012). Second, even in areas where health facilities are easily accessible, poor quality of health services and a lack of medicine in most health facilities would still make free medicare less effective (Ministry of Health [Tanzania], 2016).

Another consistent observation in Table 4 is that the hazard ratio of subsidized ITNs is larger than that of free medicare. This implies that using subsidized ITNs has a larger effect on reducing child mortality. I run Wald tests on the equality of the two estimated parameters. The null hypothesis is that the two parameters are statistically equal. The Chi-square of the test presented at the end of column (6) is not statistically significant. This means that I fail to reject the null hypothesis and conclude that the two hazard ratios are statistically equal. Therefore, despite the effect of free malaria medicare being not statistically significant, the level of its effect, nonetheless, is statistically comparable to that of subsidized ITNs.

There are also significant control variables in column (6) that deserve highlighting. The number of adults in the household has a negative effect suggesting that households with more adults tended to have low child mortality. This could intuitively suggest that more adults imply more ability in the household to provide household-level childcare, particularly those aspects of childcare that require supervision from adults. On the other hand, the number of under-fives in the household has a positive effect, suggesting that households with more under-five children

tended to have higher child mortality. This is also intuitive as households with many children in Tanzania tend to be large and poor (National Bureau of Statistics (Tanzania), 2019), which means that the resources needed to provide childcare are constrained. Lastly, the variable for households with modern walls has a negative effect, which suggests that children in households with modern-walled houses tended to have low child mortality. This implies that well-off households had low child mortality.

Table 4: Cox Model Estimation of the Determinants of Child Survival Time

	(1) Naïve	(2) Naïve	(3)2SRI	(4) Naïve	(5) Naïve	(6) 2SRI
Type of estimated parameters	Coefficients			Hazard ratios		
Used subsidized ITN (yes=1)	-1.294*** (0.459)	-1.314*** (0.461)	-1.273*** (0.461)	0.274*** (0.126)	0.269*** (0.124)	0.280*** (0.129)
Used free medicare against malaria (yes=1)	-0.608 (1.007)	-0.837 (1.012)	-0.874 (1.013)	0.544 (0.548)	0.433 (0.438)	0.417 (0.423)
Sex of the child (Girl=1, Boy=0)		-0.028 (0.191)	0.089 (0.209)		0.972 (0.186)	1.093 (0.228)
Grandparenting (Yes=1)		-0.115 (0.300)	-0.285 (0.335)		0.892 (0.267)	0.752 (0.252)
Female household head (Yes=1)		-0.082 (0.270)	-0.110 (0.271)		0.921 (0.249)	0.896 (0.243)
<i>asinh</i> age of the household head		0.782* (0.410)	0.396 (0.452)		2.186* (0.896)	1.486 (0.672)
Education of the head (Years)		0.013 (0.030)	-0.014 (0.034)		1.013 (0.030)	0.986 (0.034)
Number of adults in the household		-0.376*** (0.061)	-0.410*** (0.064)		0.687*** (0.042)	0.664*** (0.043)
Number of under-fives in the household		0.580*** (0.131)	0.722*** (0.154)		1.786*** (0.234)	2.059*** (0.317)
Asset index		-0.051 (0.125)	-0.066 (0.126)		0.950 (0.119)	0.936 (0.118)
House with modern wall (yes=1)		-0.192 (0.241)	-0.494* (0.296)		0.825 (0.199)	0.610* (0.181)
The house has flush toilet (yes=1)		-0.285 (0.394)	-0.655 (0.460)		0.752 (0.296)	0.519 (0.239)
House has tap water (yes=1)		-0.461 (0.317)	-0.063 (0.389)		0.630 (0.200)	0.939 (0.365)
Hygiene-enhancing equipment (yes=1)		0.062 (0.053)	0.131 (0.166)		1.064 (0.057)	1.140 (0.175)
Rural residence (Yes=1)		-0.292 (0.319)	-0.385 (0.324)		0.747 (0.238)	0.680 (0.220)
Proportion of medical services users in the village		-0.046 (0.907)	-0.648 (1.207)		0.955 (0.866)	0.523 (0.632)
<i>asinh</i> distance to the market		0.088 (0.107)	0.071 (0.110)		1.092 (0.117)	1.073 (0.118)
<i>asinh</i> distance to the populated centre		0.043 (0.076)	0.001 (0.080)		1.044 (0.079)	1.001 (0.081)
Tobit residual-Vouchers equation			-9.627* (5.222)			0.000* (0.000)
Tobit residual-Free medicare equation			1.665** (0.670)			5.287** (3.545)
Time dummies (Wave 2&3)	Yes	Yes	Yes	Yes	Yes	Yes
Full regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,969	5,969	5,969	5,969	5,969	5,969
Cov(residual, IV1)		0.001			0.001	

Cov(residual, IV2)	0.000	0.000
Cov(residual, IV3)	-0.000	-0.000

NB (1) Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's Estimation from NPS (Wave 1, Wave 2, and Wave 3)

(c) The Effects of Subsidized ITNs and Free Medicare on Child Survival Time, Accounting for all Deaths)

The results thus far have shown that while the use of subsidized ITNs is effective in reducing hazards relating to malaria-caused child mortality, the use of free treatment for malaria is not effective. One of the limitations of the results presented in Table 4 is that only deaths due to malaria are considered. In practice, however, the free medicare policy in Tanzania covers all diseases and, therefore, estimating the effects only on malaria-caused deaths does not reflect the full picture. In this section, I re-estimate the effects of the two programmes by including deaths from all diseases. These results are presented in Table 5.

Results in Table 5 show that both subsidized ITNs and free medicare have significant negative effects on child mortality. I rely on the estimated hazard ratios presented in column (2). For subsidized ITNs, the estimated hazard ratio in column (2) indicates that *ceteris paribus*, the use of subsidized ITNs reduced the hazards associated with child mortality by 62.2% (0.378-1.000). This suggests that despite targeting specifically to reduce malaria morbidity and mortality, the use of subsidized ITNs is also effective in reducing overall child mortality. This could be related to the fact that malaria accounts for over 30% of child mortality among the under-fives (Ministry of Health [Tanzania], 2016) and, therefore, significantly reducing malaria-related deaths will result in a significant decline in overall child mortality. For free medicare, results in column (2) show that *ceteris paribus*, the use of free medicare reduces the hazards associated with child mortality by 29.6% (1.000-0.704). Unlike estimates in Table 4, free medicare in Table 5 is statistically significant at a 5% level of significance, suggesting that it is effective in reducing overall child mortality.

Looking at the results in Tables 4 and 5, there are two key observations. First, the estimated effects are comparable in terms of the direction of the effects as the two interventions reduce the hazards associated with child mortality. Moreover, for subsidized ITNs, the level of statistical significance is also comparable. However, unlike in Table 4, the effect of free medicare in Table 5 is statistically significant. This implies that while the use of free medicare is not effective in reducing malaria-caused child mortality, it is, however, effective in reducing overall child mortality. Intuitively, this could be related to the fact that free medicare is an intervention that covers all diseases, and therefore, accounting for all deaths provide a full

picture of the policy.

The last observation between Table 5 and Table 4 is that Wald tests in Table 5 are statistically significant. This shows that the effect of subsidized ITNs is significantly bigger than the effect of free medicare. This suggests that among the under-fives, subsidized ITNs are more effective in reducing overall mortality. This highlights the significance of preventive interventions, compared to curative interventions alone. However, it is important to note that ITNs specifically target reducing malaria-caused deaths. Therefore, the fact that the use of subsidized ITNs has a significantly larger effect than free medicare, reinforces the significance of preventive measures against major diseases, such as malaria.

It is important also to note that the comparison between the effect of subsidized ITNs and free medicare in Table 5 has some limitations. One of these limitations is that free medicare covers all diseases while subsidized ITNs are for malaria only. Essentially, the Wald test in Table 5 compares an intervention that focuses on one disease against an intervention that focuses on unlimited types of diseases. Therefore, the comparative analysis must be cautiously interpreted. One way of dealing with this is to focus on only one major disease such as malaria as presented in Table 4. Unfortunately, scaling down the unlimited use of free medicare to only one disease is not without criticism. So, perhaps the best idea is to take estimates from both tables (4 and 5) and interpret them together. That is why it was important to present these two tables of results.

Table 5: Cox Model Estimation of the Determinants of Child Survival Time (all diseases/deaths)

	(1) Coefficients	(2) Hazard Ratios
Use of Net voucher (Yes=1)	-0.973*** (0.252)	0.378*** (0.095)
Use of Free medicare (Yes=1)	-0.351** (0.155)	0.704** (0.109)
Sex of the child (Girl=1, Boy=0)	0.101 (0.129)	1.107 (0.143)
Grandparenting (Yes=1)	-0.384* (0.203)	0.681* (0.139)
Female household head (Yes=1)	-0.064 (0.167)	0.938 (0.157)
<i>asinh</i> age of the household head	0.651** (0.280)	1.917** (0.536)
Education of the head (Years)	-0.027 (0.020)	0.973 (0.020)
Number of adults	-0.389*** (0.038)	0.678*** (0.026)
Number of under-fives	0.795*** (0.093)	2.214*** (0.205)
Asset index	-0.088 (0.082)	0.916 (0.075)

House with modern wall (yes=1)	-0.392** (0.174)	0.676** (0.118)
Use of flush toilet (yes=1)	-0.427* (0.256)	0.653* (0.167)
House has tap water (yes=1)	0.291 (0.211)	1.338 (0.283)
Hygiene-enhancing equipment (yes=1)	0.102*** (0.038)	1.108*** (0.042)
Rural residence (Yes=1)	-0.492*** (0.189)	0.612*** (0.116)
Proportion of medical services users in the village	-0.577 (0.744)	0.561 (0.418)
<i>asinh</i> distance to the market	-0.009 (0.064)	0.991 (0.064)
<i>asinh</i> distance to the populated centre	-0.022 (0.049)	0.978 (0.048)
Probit residual-Net Voucher function	-9.002*** (3.005)	0.000*** (0.000)
Probit residual-free medicare function	6.467 (5.504)	643.491 (692.041)
Time dummies	Yes	Yes
Regional dummies	Yes	Yes
Wald Test: chi2 (1)	4.36**	4.36**
Log likelihood	-2355.91	-2355.91
Observations	6,150	6,150

NB (1) Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's Estimation from NPS (Wave 1, Wave 2, and Wave 3)

4.6. Sensitivity Analysis

In this section, I consider the possibility that estimated results are sensitive to the three instruments, namely, the years of stay of the household head in the village (IV1), the dummy variable for attending village assemblies during the year (IV2), and the dummy variable for village chairperson coming from the ruling party (IV3). Here, I re-estimate the main results presented in Table 4. Comparable re-estimated results for Table 5 are appended in Table A2 (appended). Because I have three instruments for two endogenous variables, I include two instruments each time the model is re-estimated. If all the instruments are exogenous and partially correlated with the endogenous variables, the estimated coefficients of subsidized ITNs and free medicare should be consistent across all specifications (Wooldridge, 2014). Therefore, this analysis serves as the validity test for the instruments.

The results of the sensitivity analysis are estimated using 2SRI and are presented in Table 6. Column (1) uses IV1 and IV2. In Column (2), I use IV1 and IV3 and in Column (3), I use IV2 and IV3. Results in Table 6 show that both subsidized ITNs and free medicare have negative hazard ratios, suggesting that the two programmes reduced the hazards associated with malaria-caused child mortality. However, as in Table 4, the effects of free medicare are not statistically significant across all columns. The estimated results are stable and comparable

across the three columns. Importantly, the hazard ratios for subsidized ITNs and free medicare in Table 6 are comparable to the main results presented in Table 4. This suggests that my estimates are not specifically sensitive to any of the three instruments. This further confirms the validity of the instruments.

Table 6: Sensitivity Test of the Instruments

	(1) IV1 and IV2	(2) IV1 and IV3	(3) IV2 and IV3
	Haz ratio	Haz ratio	Haz ratio
Use of net voucher (1/0)	0.282*** (0.131)	0.277*** (0.127)	0.277*** (0.127)
Free malaria medicare (1/0)	0.416 (0.422)	0.423 (0.224)	0.415 (0.421)
Control Variables and residuals	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
N	5,969	5,969	5,969
Log likelihood	-871.416	-870.616	-870.691

NB (1) Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's Estimation from NPS (Wave 1, Wave 2, and Wave 3)

4.7. Conclusions and Policy Implications

Child mortality reduction is one of the main development targets in Tanzania (Ministry of Health [Tanzania], 2014). To fight against the high and stagnant child mortality, between 2004 and 2014, the country subsidized ITNs/LLINs for children under the age of five (under-fives) to protect them against malaria, a disease that accounts for up to 30% of mortality among the under-fives in the country (National Bureau of Statistics [Tanzania], 2015). With similar motives, the government provides free medicare to the under-fives. Other governments across SSA have also been implementing similar interventions. Despite these interventions attracting a lot of public funds, no empirical evaluations have been made to estimate their effects on child mortality, thus blurring much-needed knowledge on their effectiveness. In this chapter, I used data from NPS collected in five years across all districts and regions in the country. I used the survival model to estimate the effect of using subsidized ITNs from the TNVS and the use of free medicare on child survival time.

This chapter presents three key findings. First, estimates show that the use of subsidized ITNs reduced 71.0% of the hazards associated with malaria-caused mortality among the under-fives. This suggests that TNVS was very effective in reducing malaria-caused child mortality in the country. This is consistent with findings in other net subsidy schemes in Tanzania (Schellenberg *et al.*, 2001) and The Gambia (D'Alessandro *et al.*, 1995). Second, estimates show that although free medicare reduced hazards associated with malaria-caused deaths, its effect, however, is not statistically significant and, therefore, it is not effective in reducing

malaria-caused child mortality. However, when deaths from all diseases are considered, estimates show that the use of free medicare significantly reduced the hazards associated with child mortality by 29.6%. Generally, this implies that while free medicare may not be specifically effective against malaria, it is, however, effective against overall child mortality. The use of subsidized ITNs is also effective in reducing overall child mortality.

The significant effects of free medicare are consistent with the established consensus that access to medical services reduces child mortality (Rutherford, Mulholland and Hill, 2010). Nonetheless, the lack of significant effects against malaria, which is the leading cause of child mortality in the country, raises concerns. This could be related to poor access to government health facilities which are the main provider of free medicare. This can also be related to poor services in government health facilities in the country (Khamis and Njau, 2014). To ensure that the effect of free medicare is widely experienced against major diseases such as malaria, it is paramount to improve both the access and quality of health services. Access to health services can be improved by increasing the number of health facilities in local areas and improvement of transport infrastructures. This will reduce the travel burden (distance, time, or cost) that has been associated with high child mortality (Manongi *et al.*, 2014; Kadobera *et al.*, 2012). Improvements in service quality would require ensuring the availability of qualified doctors and proven medicines (Ministry of Health [Tanzania], 2016; Lohela, Campbell and Gabrysch, 2012). This entails further investments in new health facilities, roads, and qualified personnel, particularly in rural areas.

Third, despite differing levels of statistical relevance, the effects of the two interventions on malaria-caused mortality are statistically comparable. In the overall child mortality, however, the use of subsidized ITNs has statistically larger effect than free medicare. This suggests that subsidized ITNs are more effective than free medicare in reducing overall child mortality among the under-fives. This reinforces the importance of preventive interventions against major diseases in reducing child mortality. However, it is important to note that these interventions are complementary, with TNVS being a preventive intervention and free medicare a curative intervention. Therefore, because of this complementary relationship, implementing both interventions could achieve a wider child mortality reduction. However, because the effect of subsidized ITNs is more statistically relevant for malaria-caused mortality and higher than that of free medicare in reducing the overall child mortality, hence more effective, in case the implementation of both programmes is not possible, estimates in this chapter, therefore, suggest that the use of subsidized ITNs would save more lives among the under-fives than free medicare alone.

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Appendices

Table A1: Cox Model Estimation of the Determinants of Child Survival Time

IV1: Years of stay of the household head in the village	0.995 (0.006)
IV2: Attending village meeting (Yes=1)	0.713 (0.152)
IV3: Village led by the ruling party (Yes=1)	0.769 (0.171)
Sex of the child (Girl=1, Boy=0)	0.989 (0.190)
Grandparenting (Yes=1)	0.922 (0.277)
Female household head (Yes=1)	0.926 (0.249)
<i>asinh</i> age of the household head	2.671** (1.210)
Education of the head (Years)	1.014 (0.030)
Number of adults in the household	0.694*** (0.041)
Number of under-fives in the household	1.775*** (0.234)
Asset index	1.187* (0.110)
House with modern wall (yes=1)	0.837 (0.202)
The house has flush toilet (yes=1)	0.749 (0.292)
House has tap water (yes=1)	0.637 (0.201)
Hygiene-enhancing equipment (yes=1)	1.042 (0.052)
Rural residence (Yes=1)	0.831 (0.264)
Proportion of medical services users in the village	0.686 (0.628)
<i>asinh</i> distance to the market	1.085 (0.115)
<i>asinh</i> distance to the populated centre	1.056 (0.081)
Full time dummies	Yes
Full region dummies	Yes
Observations	5,969

NB (1) Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Author’s Estimation from NPS (Wave 1, Wave 2, and Wave 3)

Table A2: Sensitivity Test for the Instruments (Accounting for deaths from all diseases)

	(1) IV1 and IV2	(2) IV1 and IV3	(3) IV2 and IV3
	Haz ratio	Haz ratio	Haz ratio
Use of subsidized ITNs (1/0)	0.378*** (0.095)	0.373*** (0.093)	0.375*** (0.094)
Free malaria medicare (1/0)	0.705** (0.109)	0.701** (0.108)	0.713** (0.110)
Control Variables and residuals	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
N	6,150	6,150	6,150
Log likelihood	-2355.98	-2357.92	-2357.42

NB (1) Bootstrapped standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's Estimation from NPS (Wave 1, Wave 2, and Wave 3)

CHAPTER 5

OVERALL CONCLUSIONS AND POLICY IMPLICATIONS

5.1. Key Findings

This thesis focused on three key aspects of household welfare: farm labour productivity, poverty, and child mortality. In three separate essays (papers), I examined how public investments improve these aspects of household welfare and examined whether microfinance from the non-state sector can potentially complement the effects of public interventions in reducing poverty. The first paper presented in Chapter 2 examined the effects of agricultural inputs subsidy (AIS) and agricultural extension services (AES) on farm labour productivity while the second paper presented in Chapter 3 estimated and compared the effects of microfinance and that of AIS on poverty reduction among farmers involved in maize and rice production. The final paper which is presented in Chapter 4 estimated the effects of public investments in preventive and curative interventions on child mortality.

This thesis presents ten key findings discussed in the three essays. The first three findings relate to the effects of AIS and AES on farm labour productivity presented in Chapter 2. First, estimates show that a 1% increase in the value of input vouchers from NAIVS increases labour productivity in maize-planted plots by 4.1% and crop yields (land productivity) by 4.3%. This suggests that NAIVS was effective in increasing farm labour productivity and land productivity. These estimates support and broaden findings in other studies in SSA showing that AISs increase wages in farming activities (Ricker-Gilbert, 2014; Dorward & Chirwa, 2011) and crop yields (Ricker-Gilbert & Jayne, 2017; Wossen et al., 2017). Second, Chapter 2 also shows that receipt of AES increased labour productivity in maize plots by 12.0% and land productivity by 13.4%. The effect of AES on farm productivity is consistent with findings in other studies showing that AES effectively increases farm productivity in other SSA countries (Danso-Abbeam, Ehiakpor and Aidoo, 2018). Even in studies where the overall effect is less consistent, receiving useful agricultural advice has strong and consistent positive effects (Ragasa & Mazunda, 2018). Third, further estimates show that each programme has comparable effects on land and labour productivity. This suggests that the effect of each programme on crop yields was equally reflected in farm labour productivity. Because growth in farm labour productivity in SSA has been slower than growth in crop yields (Collier and Dercon, 2014), these estimates, therefore, are encouraging as they suggest that crop yields and labour productivity in maize plots are equally impacted by AIS and AES. Equally important,

this suggests that public investment in these interventions can be used to enhance both crop yields and farm labour productivity.

Chapter 3 presents four key findings regarding the effects of AISs and microfinance on rural poverty reduction. First, estimates in this chapter show that input vouchers have positive and statistically significant effects on household consumption among households involved in maize and rice production and, therefore, AISs effectively reduce poverty among these farmers. This is consistent with other studies in SSA showing that AISs reduce rural poverty (Wossen et al., 2017; Bezu et al., 2014; Awotide et al., 2013). Second, estimates show that microfinance is effective in increasing household consumption, thus reducing poverty among these farmers. These findings are consistent with estimates in other countries (Imai et al., 2010; Khandker, 2005; Mosley, 2001). However, it is important to note that some studies have observed a lack of significant poverty reduction effects of microfinance (Roodman & Morduch, 2014; Duvendack & Palmer-Jones, 2012; Morduch, 1998). However, it is important to note that estimates in Chapter 3 differ from these studies in one important way. Unlike borrowers in countries like Bangladesh who relied on major microfinance institutions, borrowers studied in this chapter are aggregated from different microfinance sources, namely, self-help groups, Saving and Credit Cooperatives Societies (SACCOS), Village Community Banks (VICOBA), and Microfinance Institutions. Some of these groups (self-help groups, SACCOS, and VICOBA) charge no or very small interest, which makes the loan affordable. Affordable loans are arguably easy to borrow and repay and would have higher returns. Therefore, reasonable caution must be considered when comparing these findings with those in other studies.

Third, comparing the effects of the two programmes, estimates in Chapter 3 show that the effect of microfinance on household consumption is statistically comparable to that of input vouchers. These results, therefore, do not support the hypothesis that compared to AIS, microfinance is more effective in reducing poverty among farmers in the country. Fourth, considering the effects of the two programmes across income groups, estimates show that both microfinance and AIS are not effective among low-income farmers. Among middle-income farmers, however, both programmes are significantly effective in reducing poverty. However, among high-income farmers, microfinance is significantly effective while AIS is not effective. Furthermore, the comparative analysis across the three income quantiles shows that both programmes have statistically comparable effects on household consumption. This suggests that among farmers involved in maize and rice production, microfinance is as effective as AIS in reducing poverty among these farmers. On one hand, these comparable effects, therefore, support the growing sentiments that microfinance has the potential to serve as a non-state

complement, or alternative to AIS (Cameron et al., 2017; Morris et al., 2007). On the other hand, these estimates do not support the proposition that among poor farmers, AIS would be more effective than microfinance in reducing poverty.

In Chapter 4, I observe three key findings on the effects of subsidized insecticide-treated nets (ITNs) and free medicare on child mortality. First, estimates show that the use of subsidized ITNs reduced 71.0% of the hazards associated with malaria-caused mortality among the under-fives. This suggests that the net voucher scheme (TNVS) was effective in reducing malaria-caused child mortality in the country. This is consistent with findings in other net subsidy schemes in Tanzania (Schellenberg *et al.*, 2001) and The Gambia (D'Alessandro *et al.*, 1995). Second, estimates show that although free medicare reduced hazards associated with malaria-caused deaths, its effect, however, is not statistically significant and, therefore, it is not effective in reducing malaria-caused child mortality. However, if deaths from all diseases are accounted for, free medicare has strong statistical significance, reducing the hazards associated with child mortality by 29.6%. This implies that while free medicare may not be specifically effective against malaria-caused child mortality, it is, however, effective against overall child mortality. The significant effect of free medicare is consistent with the established consensus that access to medical services reduces child mortality (Rutherford, Mulholland and Hill, 2010). Nonetheless, the lack of significant effects against malaria, which is the leading cause of child mortality in the country, raises concerns. This could be related to poor access to government health facilities, which are the main provider of free medicare. This can also be related to poor services in government health facilities in the country (Khamis and Njau, 2014). To ensure that the effect of free medicare is widely experienced against major diseases such as malaria, it is paramount to improve both the access and quality of health services. This can be done by increasing the number of health facilities in local areas and improving transport infrastructures. This will reduce the travel burden (distance, time, or cost) that has been associated with high child mortality (Manongi et al., 2014; Kadobera et al., 2012). Improvements in service quality would require ensuring the availability of qualified doctors and proven medicines (Ministry of Health [Tanzania], 2016; Lohela, Campbell and Gabrysch, 2012).

Third, the effects of the two interventions on malaria-caused mortality are statistically comparable. In the overall mortality, however, the use of subsidized ITNs has statistically larger effects than free medicare, suggesting that subsidized ITNs are more effective than free medicare. However, it is important to note that these interventions are implemented as complementary (with TNVS as a preventive intervention and free medicare as a curative

intervention) and, therefore, implementing both interventions could achieve a wider reduction in child mortality.

5.2. Benefit-Cost Analysis and Policy Recommendations

(a) Benefit-Cost Analysis

The key findings highlighted in section 5.1 above show that the evaluated programmes were significantly effective. The next question, which is important for policy recommendation, is whether these programmes should be sustained. This question cannot be answered based on effectiveness alone. For economic policies to earn continued support, they must also be cost-effective. In this section, I discuss whether the programmes were cost-effective. The subsequent policy recommendations rely on the benefit-cost estimations.

(i) Benefit-Cost Analysis of NAIVS on Farm-Level Productivity

Estimates in Chapter 2 show that both AIS and AES were effective in raising farm labour productivity in maize-planted plots. The question addressed in this section is whether these programmes were also cost-effective. I only focus on AIS because the data does not have the cost of AES.

Following Wossen et al., (2017) and Dorward & Chirwa (2011), the benefit-cost analysis in this section is based on the production-based approach, which focuses only on direct benefits. This approach, however, ignores the indirect benefits of AIS such as low food prices due to increased maize production (Dorward *et al.*, 2008), and opportunity costs such as disruptions in the private input markets (Mason and Jayne, 2013). To guide this analysis, I compute the benefit/cost ratio (BCR). Following Wossen *et al.* (2017), BCR is computed as the ratio between crop income gain and the total cost of the subsidy scheme. Here, crop income gain is the difference between crop income in subsidized plots during subsidized years (Wave2 and Wave3) and crop income of the same plots before subsidization (Wave1). Crop income is given by crop output (kg) multiplied by regional maize prices⁷.

The programme cost reflects only the cost of the National Agricultural Input Subsidy Scheme (NAIVS). NAIVS was a partial subsidy scheme that covered only 50% of the price of subsidized fertilizers. Operationally, the government procured the fertilizer, paying 100% of the cost of fertilizers to producers, and then sent the fertilizers to beneficiaries who were selected by the village's voucher committee. However, before receiving the subsidized fertilizers, beneficiaries had to refund to the government 50% of the cost of fertilizers (through

⁷ Regional maize prices were collected from the Ministry of Trade in Tanzania

voucher redemption). This means that the cost of subsidizing fertilizers equals the cost of fertilizers minus the farmer's share (50%). To arrive at the cost of NAIVS, therefore, I deduct the top-up amount paid by the beneficiary plus administrative costs. This is consistent with similar computations in other comparable evaluations (World Bank, 2014); (Dorward & Chirwa, 2011).

Following the production approach, computations in this section, therefore, rely on the direct cost and administrative costs of NAIVS. The direct cost includes the government's share of the cost of input vouchers, which is generated from the data. The data provides the farmer's top-up amount paid to redeem the vouchers (50%), which equals the value of subsidies paid by the government. Unfortunately, the data does not contain the administrative costs incurred to implement NAIVS. The administrative costs presented in Table 1 were extracted from World Bank (2014), which collected all the costs of NAIVS. These administrative costs include indirect costs (which include the costs of managing the implementation of the programme) and complementary investments (which include the costs of strengthening agro-dealers' networks).

To factor out the effect of inflation, both crop income and costs were deflated to reflect real income and cost based on 2008's (Wave1) prices. To compute real income and cost, I use spatial inflation rates provided in the data for each stratum. The computed BCR is presented in Table 1. Table 1 shows that the overall BCR in the two waves was 1.56. This means that every TZS (\$) spent by the government on input subsidy led to TZS (\$) 1.56 of additional crop income in maize-planted plots. This is comparable to 1.30 estimated in Tanzania (World Bank, 2014), 1.11 in Nigeria (Wossen *et al.*, 2017), and 1.06 (Chirwa and Dorward, 2013) and 1.62 ((Arndt *et al.*, 2016) in Malawi. However, as mentioned earlier, this BCR does not account for opportunity costs such as the negative effects of the subsidy scheme in farm input markets (Mason and Jayne, 2013). Equally, this BCR does not include indirect benefits such as continued fertilizer usage by beneficiaries in unsubsidized years (Carter, Laajaj and Yang, 2021).

One of the limitations of this benefit/cost ratio computation is that the method assumes that apart from AIS and inflation, other factors that affect crop income remained constant between Wave 1 and the subsequent waves (Wave 2 and Wave 3). Therefore, during this time, NAIVS was the main factor affecting real income differences between Wave 1 and the subsequent waves. However, this cannot be established with certainty as other relevant factors

might have also changed between Wave 1 and the subsequent waves. Therefore, the interpretation of the BCR presented here should be cautiously done.

Table 1: Computation of the Benefit-Cost Ratio

(1) Average crop income gain in wave 2 (Wave2-Wave1)	25,747.1	
(2) Average crop income gain in wave 3 (Wave3-Wave1)	75,059.3	
(3) Average crop income gain [(1) +(2)]/2		50,403
(5) Average cost of input vouchers (net farmer's top-up)	25,860	
(6) Indirect Cost	4,550	
(7) Complementary investments	1,833	
(8) Total Administrative Costs (6) + (7)	6,383	
(9) Total NAIVS cost (5) +(8)		32,243
(10) Benefit-Cost Ratio (3)/(9)		1.56

NB: (1) Both income and cost are computed per hectare.

(2) Income and Costs are constant at 2008 prices.

(3) Administrative costs extracted from World Bank (2014).

Source: Crop income and the cost of vouchers are author's estimation from NPS (Wave1, Wave2, and Wave3).

(ii) Benefit-Cost Analysis of AIS on Household Income

The estimated effects in Chapter 3 show that both microfinance and AIS are effective in increasing household consumption and thus reducing poverty among farmers. However, from the public policy perspective, one question needs to be equally addressed: are these programmes cost-effective? Because microfinance does not attract public funding and relies on commercial sustainability, I only focus on the benefit-cost analysis of NAIVS which was partly funded by the government.

The approach used in this benefit-cost analysis resembles what was used in (i) above. Thus, I rely on the production-based approach, which focuses on direct benefits and costs and, therefore, ignores indirect benefits and costs of the programme (Wossen *et al.*, 2017; Dorward & Chirwa, 2011). Following Wossen *et al.*, (2017), the benefit/cost ratio (BCR) is computed as the ratio between crop income gain and the total cost of the subsidy scheme. Crop income gain is the difference between crop income in subsidized households during subsidized years (Wave2 and Wave3) and crop income of the same households before subsidization (Wave1). Crop income is given by crop output(kg) multiplied by regional prices⁸. I compute the total income from maize and rice.

Based on the production approach highlighted in part (a) above, my computations rely on the direct cost and administrative costs of NAIVS. The direct cost includes the government's share of the cost of input vouchers. This is generated from the data. The cost of input vouchers was evenly shared between the government and the beneficiaries. The data provide the farmer's top-up amount paid to redeem the vouchers (50%), which equals the value of subsidies paid by

⁸ Regional maize prices were collected from the Ministry of Trade in Tanzania

the government. Unfortunately, the data does not contain the administrative of NAIVS. The administrative costs presented in Table 2 were extracted from World Bank (2014), which collected all the costs of NAIVS. These administrative costs include indirect costs incurred to manage the implementation of NAIVS and complementary investments, which include the costs of strengthening agro-dealers networks.

Estimates of the BCR are presented in Table 2. Table 2 shows that compared to the average real crop income in Wave 1 (before subsidy), there was an average TZS 85063.8 of crop income gain during the two subsequent waves. Dividing this income gain with the average programme cost (TZS 61328.2) gives a BCR of 1.39. This means that every TZS (\$) spent on input vouchers led to TZS (\$) 1.39 crop income gain per beneficiary household. It is important to note that the BCR reported in Table 2 does not account for unmeasured costs such as the crowding-out effects of AISs in the input market (Mason and Jayne, 2013). Similarly, estimates in Table 2 also do not account for indirect benefits such as the continued usage of fertilizers by beneficiaries in unsubsidized years and the nutritional benefits due to food security (Carter et al., 2021); (Harou, 2018).

Table 2: Estimation of Benefit-Cost Ratio

Cost Items	Costs
(1) Average crop income gain per household compared to Wave 1 levels (TZS)	95063.8
(2) Average cost of vouchers per household (TZS)	56038.4
(3) Administrative cost per household (TZS)	5289.8
(4) Total Cost of Input Vouchers (TZS) (2) + (3)	61328.2
(5) Benefit-cost Ratio in Wave 2 [(1)/((4))]	1.55

Source: Author's estimation from NPS (2008/9, 2010/11, and 2012/13)

iii). Benefit-Cost Analysis of Subsidized ITNs and Free medicare

The last benefit-cost estimation relates to the cost-effectiveness of subsidized ITNs and free medicare in reducing child mortality. I present separately the benefit analysis of each of these programmes.

First, I examine if the TNVS was cost-effective in reducing child mortality. The analysis is guided by estimated disability-adjusted-life-years lost (DALY) and the corresponding cost per DALY averted, which is commonly applied in most health policy evaluations (Binka, Mensah and Mills, 1997; Goodman, Coleman and Mills, 1999; Fox-Rushby and Hanson, 2001). DALY is calculated as the present discounted value of future years of healthy life lost due to morbidity/disability and premature mortality (Larson, 2013). Because of the failure to record the time spend with malaria infections, it was not possible to estimate years lost due to disability (YLD) and, therefore, the estimated DALY includes only years of

life lost due to premature death (YLL). This is consistent with previous studies in SSA that have shown that YLL is the main determinant of DALY in malaria controls (Hanson *et al.*, 2003; Goodman, Coleman and Mills, 2000).

Unfortunately, the data does not contain information on the direct and indirect costs of subsidized ITNs during TNVS. However, previous evaluation studies, particularly, Mulligan, Yukich and Hanson (2008), collected and analysed the costs of implementing TNVS and estimated that the total cost per ITN was \$7.54. After deducting the user top-up (\$0.83), the subsidy amount paid by the government is \$6.74 (7.57-0.83), which I use in this analysis.

The number of deaths averted due to the usage of subsidized ITNs is presented in Table 3. Table 3 shows that there were 824 subsidized ITN beneficiaries in the sample. I assume that every beneficiary received one ITN and, therefore, during the three waves, 824 subsidized ITNs were received in the sample. Using \$6.74 as the cost for each subsidized ITN leads to \$5,554 total cost paid by the government. The difference between the mortality rates for non-beneficiaries and beneficiaries is 1.49% (2.1-0.61), which leads to 12 deaths averted due to subsidized ITNs, resulting in \$463 per death averted.

To estimate the DALYs averted, I use the life expectancy at birth as 62 years reported in Tanzania during the period covered (Ministry of Health (Tanzania), 2016; National Bureau of Statistics (Tanzania), 2015). After accounting for the average of 1.3 years at death, the life expectancy at death is thus 60.7 years. Following Goodman, Coleman and Mills, (1999), health effects are discounted at 3%. For simplicity, I do not use age and disability weights. Furthermore, I assume that protection for 12 months was provided by each subsidized ITN. Table 3 shows that YLL is 27.9, which in turn, equals the DALY as I do not have YLD. The Cost per DALY averted is thus \$16.6. Since any intervention with a cost per DALY averted of less than \$25 is considered highly attractive and attractive if it was less than \$150 (Goodman, Coleman and Mills, 1999), I thus maintain that TNVS was a highly cost-effective health intervention.

Table 3: Deaths Averted due to TNVS.

	NAIVS (Subsidized ITNs)	
	No	Yes
1. Observations	5,145	824
2. Cost per ITNs subsidized (\$)	0.0	6.74
3. Total amount of subsidies (\$) (1)x(2)	0.0	5,554
4. Malaria caused deaths	104	05
5. Mortality rate (%)	2.10	0.61
6. Mortality rate difference	n.a	1.49
7. Number of deaths averted (6)x(1)	n.a	12

8. Cost per death averted (\$) (3)/ (7)	n.a	463
9. Age at death	1.30	
10. Life expectancy at the age of death (62-1.3)	60.7	
11. Discount rate	3%	
12. Discounted Years of Life Lost (YLL=DALY) ⁹	27.9	
Cost per DALY averted (\$) 463/(12)	16.6	

Source: Author's Computation from NPS (Wave1, Wave2, Wave3)

Similarly, the data do not contain the full cost of treating malaria. I extract the cost of malaria treatment from Sicuri *et al.*, (2013), which collected and analysed the economic costs of malaria in 2009 for children in three sub-Saharan countries, including Tanzania. I extract the direct and health system cost of malaria treatments in Tanzania for different episodes of malaria as presented in Table 4. As with subsidized ITNs, I use the life expectancy at birth as 62 years. I assume that each beneficiary was treated for a single episode of malaria in the year and health effects are discounted using 3%. I do not use age and disability weights. The computed costs per DALY averted are presented in Table 5. Because the data do not provide details on the nature of malaria episodes treated, I consider four different malaria episodes presented in Table 5. Furthermore, because malaria hospitalization with severe anaemia has the highest cost, its cost per DALY averted will, therefore, be higher than that of cerebral malaria with neurological sequelae, and hence, to save time and space, I do not estimate the DALYs for malaria hospitalization with severe anaemia.

Table 5 shows that the cost per DALY averted is \$11.2 for uncomplicated malaria, and respectively \$123.7, \$247.2, and \$157.0 for moderate malaria hospitalization, cerebral malaria with neurological sequelae, and overall averages for all malaria episodes. Since every health intervention with a cost per DALY averted of less than \$150 is still considered attractive (Goodman, Coleman and Mills, 1999), these estimates, therefore, suggest that free medicare is only cost-effective for uncomplicated malaria and an episode that requires moderate hospitalization. Thus, free medicare is not effective in complicated malaria episodes (cerebral malaria, cerebral malaria with neurological sequelae, and malaria hospitalization with severe anaemia). Moreover, free malaria is not cost-effective if one considers the average that includes all episodes of malaria.

⁹ Following Larson, (2013), $YLL = \left(\frac{1}{r}\right) (1 - e^{-rt})$ where r=discount rate, e=2.72, t is the life expectancy at death.

Table 4: Malaria Treatment Costs

Malaria episode	Direct cost (\$)	Health System Cost (\$)	Total Cost (\$)
Uncomplicate malaria (MalariaUN)	0.42	1.75	2.17
Malaria hospitalization (MalariaHO)	5.46	18.56	24.02
Cerebral malaria (MalariaCE)	5.46	19.13	24.59
Cerebral malaria + neurological sequelae (MalariaCE&NS)	7.86	40.16	48.02
Malaria hospitalization + severe anemia (MalariaHO&SE)	5.46	48.21	53.67
Average Cost	4.93	25.56	30.50

Source: (Sicuri *et al.*, 2013)

Table 5: Death averted due to Free Medicare

	(1) No Free medicare	Malaria Episode			(5) Overall Mean
		(2)MalariaU N	(3)MalariaH O	(4)MalariaCE&N S	
1. Observations	5,888	81	81	81	81
2. Cost per malaria episode (\$)	0.0	2.17	24.02	48.02	30.50
3. Total amount of subsidies (\$) (1)x(2)	0.0	175.8	1945.6	3889.6	2,470.5
4. Malaria caused deaths	109	0.97	0.97	0.97	0.97
5. Mortality rate (%)	1.9	1.2	1.2	1.2	1.2
6. Mortality rate difference	n.a	0.7	0.7	0.7	0.7
7. Number of deaths averted (6)x(1)	n.a	0.57	0.57	0.57	0.57
8. Cost per death averted (\$) (3)/(7)	n.a	308.4	3413	6,823.9	4,334
9. Age at death	n.a	3.2	3.2	3.2	3.2
10. Life expectancy at death	n.a	58.8	58.8	58.8	58.8
11. Discount rate	n.a	3%	3%	3%	3%
12. Discounted Years of Life Lost (YLL=DALY)	n.a	27.6	27.6	27.6	27.6
14. Cost per DALY averted (\$) =cost per death averted/ (12)	n.a	11.2	123.7	247.2	157.0

Source: Author's Computation from NPS (Wave 1, Wave 2, Wave 3)

(b) Policy Recommendations

This section focuses on providing policy recommendations based on the estimated effects and cost-effectiveness. First, the estimated effects indicate that the use of AIS was effective in enhancing farm labour productivity. Moreover, estimates in the current chapter show that AIS was also cost-effective in maize farming. From the public policy perspective, the positive effects of AIS on farm productivity and its cost-effectiveness presented in this chapter suggest that NAIVS achieved its main objective, which was to improve farm productivity (World Bank, 2014). Because many beneficiaries failed to buy fertilizers after NAIVS ended, to enhance the farm productivity of poor farmers, AISs are cost-effective and could play a key role in enhancing crop income.

Second, estimates on the effect of microfinance and AIS on poverty show that AIS was as effective as microfinance in increasing household consumption, thus reducing rural poverty among maize and rice farmers in Tanzania. Moreover, cost-effective estimates presented in the current chapter show that AIS was cost-effective among these farmers. This means it can be sustained as a poverty reduction strategy among farmers. However, because AISs rely on public funding, based on these estimates, it is intuitive for policymakers in the country to consider microfinance as a compliment, if not the alternative to AISs as a welfare-enhancing programme among farmers. However, because current practices in the microfinance sector tend to exclude the poorest, development policymakers have reasonable grounds to avoid over-relying on microfinance. To address this, I propose a blended strategy, in which microfinance is the lead strategy. This strategy would require enhancing the social objectives of microfinance by encouraging social-oriented lending as seen in NGO-based microfinance institutions, rotating saving and credit associations, and self-help groups. Social lending can potentially reach poor farmers who are often used to justify universal AISs (Ricker-Gilbert, Jayne and Shively, 2013). To complement the effects of microfinance, AISs would only be implemented periodically to help very poor farmers. This will ultimately save public funds used in implementing large scale or universal AISs.

Lastly, estimates in Chapter 4 show that when only malaria-caused deaths are accounted for, the use of subsidized ITNs is effective in reducing malaria-caused child mortality while free medicare is not effective. However, when all deaths are accounted for, both programmes are effective. Moreover, in the overall child mortality, subsidized ITNs are more effective than free medicare. Furthermore, the benefit-cost analysis shows that while subsidized ITNs are very cost-effective in reducing child mortality, the use of free medicare is only cost-effective for uncomplicated malaria and malaria episodes that require moderate hospitalization. For complicated episodes, free medicare is not cost-effective. Because most under-fives are treated for moderate malaria episodes, these results, therefore, suggest that free medicare is largely cost-effective in fighting malaria-caused child mortality. This reinforces the need for sustaining both TNVS and free medicare. Moreover, it is important to note that these interventions were implemented as complementary, with TNVS as a preventive intervention and free medicare as a curative intervention (Ministry of Health [Tanzania], 2016). Therefore, because of this complementary relationship, implementing both interventions could achieve a wider reduction in child mortality. However, because the effect of subsidized ITNs is more statistically relevant for malaria-caused mortality and more effective than free medicare against overall child

mortality, in situations where implementation of both programmes is not possible, these findings, therefore, suggest that the use of subsidized ITNs would save more lives than free medicare alone.

5.3: Suggestions for Future Research

This thesis focused on the role of public investment in farm labour productivity, poverty reduction, and reduction of child mortality. The thesis also estimated the effect of microfinance on poverty and compared the effects of microfinance and public investment in agricultural input subsidies. Like most studies on these topics, the papers presented in this thesis are not exhaustive. For agricultural input subsidies and agricultural extension services, future studies may consider examining the role of these public interventions in mitigating climate shocks, particularly severe droughts. For free medicare, future researchers may consider looking into areas such as the effect of free medicare on other major diseases such as fever and anaemia. Future studies may also examine why the free medicare usage rate in Tanzania is low. Researchers may also examine the effect of free medicare on other target groups such as pregnant women and the elderly. For subsidized ITNs, future studies may consider examining the effects of subsidized ITNs on other beneficiary groups, such as on schooling for school-age children.

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