Feed the Future Innovation Lab for Food Security Policy

Research Paper 29 October 2016

AGRICULTURAL INPUT SUBSIDY PROGRAMS IN AFRICA: AN ASSESSMENT OF RECENT EVIDENCE

By

T.S. Jayne, Nicole M. Mason, William J. Burke, and Joshua Ariga

Food Security Policy *Research Papers*

This *Research Paper* series is designed to timely disseminate research and policy analytical outputs generated by the USAID funded Feed the Future Innovation Lab for Food Security Policy (FSP) and its Associate Awards. The FSP project is managed by the Food Security Group (FSG) of the Department of Agricultural, Food, and Resource Economics (AFRE) at Michigan State University (MSU), and implemented in partnership with the International Food Policy Research Institute (IFPRI) and the University of Pretoria (UP). Together, the MSU-IFPRI-UP consortium works with governments, researchers and private sector stakeholders in Feed the Future focus countries in Africa and Asia to increase agricultural productivity, improve dietary diversity and build greater resilience to challenges like climate change that affect livelihoods.
The papers are aimed at researchers, policy makers, donor agencies, educators, and international development practitioners. Selected papers will be translated into French, Portuguese, or other languages.

Copies of all FSP Research Papers and Policy Briefs are freely downloadable in pdf format from the following Web site: http://foodsecuritypolicy.msu.edu/

Copies of all FSP papers and briefs are also submitted to the USAID Development Experience Clearing House (DEC) at: http://dec.usaid.gov/

AUTHORS

Thom Jayne is University Foundation Professor, Michigan State University;

Nicole Mason is Assistant Professor, Michigan State University;

William Burke is Research Scholar at Stanford University's Center on Food Security and the Environment;

Joshua Ariga is Senior Economist with the International Fertilizer Development Centre (IFDC).

AUTHORS' ACKNOWLEDGMENT:

The authors gratefully acknowledge financial support from the World Bank, the Food Security III Cooperative Agreement (GDGA-00- 000021-00) between Michigan State University and the USAID Bureau for Food Security, Office of Agriculture, Research, and Technology, and from the Guiding Investments in Sustainable Agricultural Intensification in Africa (GISAIA) grant from the Bill and Melinda Gates Foundation.

We appreciate helpful comments and insights on an earlier draft of this report from Aparajita Goyal, Asfaw Lemma, Saweda Liverpool-Tasie, Athur Mabiso, David Mather, Isaac Minde, Milu Muyanga, John Nash, David Nyange, John Olwande, Karl Pauw, Shahidur Rashid, Danielle Resnick, Jake Ricker-Gilbert, Nicholas Sitko, Hiro Takeshima, and Veronique Theriault. We are also grateful for the watchful editing of Patricia Johannes.

This paper is also published as MSU International Development Working Paper 145

Published by the Department of Agricultural, Food, and Resource Economics, Michigan State University, Justin S. Morrill Hall of Agriculture, 446 West Circle Dr., Room 202, East Lansing, Michigan 48824, USA

EXECUTIVE SUMMARY

This study reviews the evidence regarding the recent wave of *smart* input subsidy programs in Africa and identifies components of a holistic and sustainable agricultural productivity growth strategy that could improve the contribution of input subsidy programs to African governments' national development objectives.

African governments' commitment after the Abuja African Fertilizer Summit (2006) to increase fertilizer use from 8 to 50 kg of nutrients per hectare by 2015 reinforces the importance of inorganic fertilizer for increasing crop productivity and attaining food security in Africa. The impacts of achieving this target, however, will depend greatly on the agronomic efficiency of applied fertilizer. Many African governments' efforts to raise agricultural productivity have focused on programs to increase fertilizer use. Relatively little effort has been made in recent decades to help African farmers raise the efficiency with which they use fertilizer.

Over the past decade, targeted input subsidy programs have constituted the main tool by which many African governments have sought to raise fertilizer use; in many countries, these programs have become the centerpiece of state agricultural development and food security strategies. While they have produced important benefits on national food production and food security, these impacts have been attenuated by generally low crop response to fertilizer use and to implementation features that depress the programs' contribution to overall fertilizer use. These limitations in turn have diminished the subsidy programs' contribution to poverty reduction and sustainable agricultural productivity growth. Low crop response to fertilizer has also impeded the growth of commercial demand for fertilizer in Africa. There is strong evidence that farmers will demand more fertilizer when they are able to obtain higher crop response to fertilizer and therefore make its use more profitable.

A more holistic strategy for raising smallholder crop productivity – focusing on sustainably raising the efficiency of fertilizer use as well as the quantity of fertilizer used – will more effectively achieve the region's agricultural, food security, and poverty reduction objectives. Such a holistic strategy may include input subsidy programs, especially if they are implemented according to *smart subsidy* criteria, which has often proven difficult. Other and probably more important components of a holistic agricultural productivity strategy will include greater public investment in coordinated systems of agricultural research, development, and extension that emphasize bi-directional learning between farmers of varying resource constraints and agro-ecologies, extension workers, researchers, and agro-dealers. The agricultural systems of Africa are undergoing rapid change with regard to population densities, land scarcity, relative factor abundance and prices, land degradation, climate variability, and new technologies. Because African farming systems are dynamic, yesterday's best agronomic and crop management practices are unlikely to be suitable for today. Existing public agricultural research, development, and extension systems are profoundly under-resourced, often demoralized, and in a *de facto* sense, sometimes defunct. Effective agricultural science and extension programs are necessary to interactively work with farmers to identify new *best practices* to maintain and increase crop productivity in the face of these dynamic changes in the economic and biophysical environments. Moreover, because of substantial micro-level variation in these environments, effective crop science and extension systems must be *localized* to properly tailor agronomic best practices to heterogeneous environments.

While African governments' efforts to raise fertilizer use are laudable, expenditures on input subsidy programs *in most cases* appear to produce substantially less impact on national development objectives than their potential. The gap between existing and realistically achievable impacts reflects both informational/knowledge barriers and political economy barriers. While the contribution of input subsidy programs (and fertilizer use in general) to sustainable growth could be much greater with strong and sustained government commitment to complementary public goods investments as well as to government redesign of certain aspects of subsidy programs, it is necessary to take a hard country-by-country assessment of the feasibility of achieving these outcomes in the foreseeable future.

ACRONYMS

AGRA	Alliance for a Green Revolution in Africa
AVCR	Average Value Cost Ratios
CGE	computable general equilibrium
DPP	Democratic Progressive Party
EIU	Economist Intelligence Unit
EFSP	Ethiopia's Food Security Program
FAO	Food and Agriculture Organization
FMSP	Federal Market Stabilization Program
GSSP	Ghana Strategy Support Program
HIPC	Highly Indebted Poor Countries
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
ISPs	input subsidy programs
NAAIAP	Kenya's National Accelerated Agricultural Inputs Access Program
Kg	kilogram
MFISP	Malawi's Farm Input Subsidy Program
MP and AP	marginal or average physical products of fertilizer
MVCR	marginal value cost ratios
MMD	Movement for Multi-Party Democracy
MSU	Michigan State University
MT	metric ton
NAVIS	National Agricultural Input Voucher Scheme
NCPB	National Cereals and Produce Board
NBER	National Bureau of Economic Research
NUE	nutrient use efficiency
OFSP	Other Food Security Program
PNSEB	National Fertilizer Subsidy Program in Burundi
R&D	Research and Development
SOM	soil organic matter
SSA	Sub-Saharan Africa
TFRA	Tanzania Fertilizer Regulatory Authority
UDF	United Democratic Front
USAID	United States Agency for International Development
VCR	value cost ratios
ZFISP	Zambia's Farmer Input Support Program

TABLE OF CONTENTS

1. INTRODUCTION

Fertilizer subsidy programs are among the most contentiously debated of development issues in Africa. Throughout the 1990s, agricultural input subsidy programs (ISPs) were largely phased out in Sub-Saharan Africa. To our knowledge, only two countries (Zambia and Malawi) continued to implement modest input subsidy programs sporadically over this period. Based on evidence from the 1980s and early 1990s, a consensus emerged that fertilizer subsidy programs were generally ineffective in promoting African government's development goals, contributing little to agricultural productivity growth, food security, or the reduction of poverty while placing major burdens on treasuries (Kherallah et al. 2002; Morris et al. 2007; World Bank 2008).

Fertilizer subsidy programs in Africa also tended to have adverse side effects, contributing to corruption and state paternalism, often hindering the development of commercial input distribution systems, and sometimes contributing to local supply gluts that put political pressure on governments to implement costly grain purchase and support price policies for farmers. For these reasons, international lenders and bilateral donors tended to discourage African governments from relying on input subsidy programs during this period of aid conditionality.

However, starting in 2005 the landscape changed quickly and profoundly. Within several years after African governments committed to raise their expenditures on agriculture under the 2003 Maputo Declaration, at least 10 countries had introduced or re-introduced fertilizer subsidy programs costing roughly $1 billion annually.[1] Large-scale input subsidy programs often became the centerpiece of governments' agricultural development programs. Skepticism based on the past performance of these programs was swept aside by arguments that a new genre of smart subsidy programs could be implemented that took account of past lessons to maximize the benefits and minimize the problems of prior programs.

How did this sea change occur so quickly? And what have we learned about this recent wave of input subsidy programs in Africa? Despite the proliferation of smart input subsidy programs, there has been limited rigorous evaluation of their impacts to date. Filling these knowledge gaps is the major motivation for this study. More specifically, the study has two main objectives. The first is to assemble the recent evidence on input subsidy programs (ISPs) in Sub-Saharan Africa[2] and to place this work in the broader literature on agricultural productivity growth. In so doing, we strive to shed light on two major questions:

(a) To what extent are ISPs evolving toward smart subsidy principles, especially with regard to targeting of beneficiaries and involvement of the private sector?

(b) What are the economic impacts of ISPs in Africa? Specifically, we address the effects of country-level ISPs on indicators such as total fertilizer use, national food production, the development of commercial input distribution systems, and the general equilibrium effects on food prices, wage rates, and poverty rates. We also assess the evidence as to whether ISPs are generating dynamic and enduring effects that kick-start broader growth processes or sustainable intensification in rural areas.

The study's second main objective is to identify ways in which ISPs could be implemented to more effectively achieve national policy objectives, given that many African governments are likely to continue them at least in the near future. This work focuses on potential changes in

---

[1] As shown in Table 3.1., the ten countries for which data is available spent $1.02 billion on agricultural input subsidy programs in 2014.

[2] Hereafter *Africa* for simplicity.

program design and implementation as well as complementary public expenditures and policies that assist farmers in raising input use efficiency.

These two objectives are addressed through comprehensive reviews of the micro-level evidence in seven countries where input subsidy programs have featured prominently (Ghana, Nigeria, Kenya, Tanzania, Malawi, Zambia, and Ethiopia).[3] We also draw from and summarize the conclusions of recent multi-country assessments of ISPs in Africa (e.g., Wanzala-Mlobela, Fuentes, and Mkumbwa 2013; Druilhe and Barreiro-Hurlé 2012; Jayne and Rashid 2013).

Given the rapid evolution of ISP design and implementation, many knowledge gaps remain. ISPs in countries such as Rwanda, Burundi, and Nigeria are undergoing design changes to incorporate lessons learned from prior assessments and overcome weaknesses, leading to continuous refinement over the past decade. Great efforts in several countries have been made to ensure that ISPs are now *smarter* and more effective than in prior years. Moreover, the evidence base on ISPs and smallholder crop response to fertilizer is expanding rapidly. The growing availability of farm panel survey data combined with soil sample data, advances in estimation methods, and innovations in survey design methods have enhanced economists' ability to identify program effects with greater precision and less bias. This study provides an updated review of evidence over the past decade; however both continued lack of evidence about program impacts in some areas and conflicting evidence in other cases pose challenges for consensus building. Nonetheless, the weight of the empirical studies does point in clear directions on some key points.

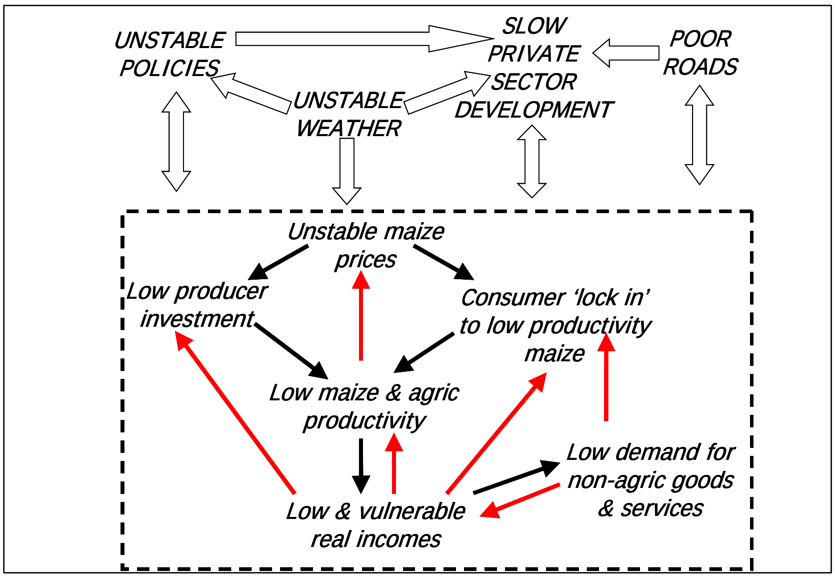
[3] The Government of Ethiopia officially states that it does not have an input subsidy program, yet fertilizer is typically made available to farmers at prices roughly 20-25% lower than the price at which commercial distributors sell fertilizer in other countries of the region. Instead of using targeted input vouchers, the Ethiopian government has been promoting fertilizer use through subsidizing the operations of farmers' organizations.

2. RATIONALE FOR FERTILIZER SUBSIDY PROGRAMS

Most rural African settings suffer from multiple market failures, providing an important entry point for subsidies to address the constraints faced by economic agents, especially poor farmers (World Bank 2008; Morris et al. 2007). Welfare economics has long recognized the potential usefulness of subsidies in situations where social benefits of individual actions exceed purely private benefits (due to market failures or externalities). This is, indeed, often the case in many countries where agriculture faces a number of market failures and constraints. Subsidies can also be justified under specific circumstances, for example when there are potential economies of scale, strong learning-by-doing effects, potential for innovations with large transformative impacts, strategic trade intervention opportunities, or environmental benefits, as well as for social equity considerations (Gautam 2015).

In primarily agrarian economies, low levels of inorganic fertilizer use are associated with low crop yields, low rural incomes, and high poverty rates. Agricultural, rural and national economic development are all constrained by a number of interacting household, local and national poverty and productivity traps illustrated in Figure 2.1. Dorward et al. (2008) present a conceptual framework that describes African rural economies as being in a low-productivity poverty "trap", out of which risk-averse farm households are unable to extricate themselves. Input use remains low in equilibrium with low-productivity, reinforcing staple crop self-sufficiency goals, stifling diversification into other agricultural and non-agricultural activities. The trap impedes rural people's ability to protect themselves from shocks, and hampers wider local and national economic development. The result is a vicious cycle of unstable food prices (a) inhibiting net producers' investment in staple production, (b) decreasing net consumers' willingness to rely on the market for staple purchases, and (c) poor consumers' limited opportunities to escape from low productivity staple cultivation. These in turn inhibit the growth of the non-farm economy.

Figure 2. 1. Vicious Circle of the Low Productivity Maize Production Trap



Source: Figure is adapted from Dorward and Chirwa (2011).
Note: Red arrows represent feedback effects.

Relieving these constraints through input subsidy programs can not only help affected farmers but also potentially unleash strong general equilibrium impacts by: boosting agricultural productivity, nutrition, and incomes; lowering food prices; raising real wages, employment, and broader economic growth through forward and backward linkages; promoting structural transformation; and strongly contributing to poverty reduction (Gautam 2015). Because staple crops account for such a large proportion of total cultivated area in most African countries, smallholder staple crop productivity growth is likely to generate dynamic growth processes that will lead to agricultural diversification and farm-nonfarm growth linkages and employment effects that contribute to economic transformation and poverty reduction.[4]

By raising crop yields dramatically for several years in a row, fertilizer subsidy programs have the potential to kick-start dynamic growth processes that allow households to break out of the "trap" and move onto a higher productivity and income growth trajectory. Eventually, recipients may generate cash savings that enable them to invest in productive farm equipment and purchase commercial fertilizer. These investments in complementary farm assets and inputs sustain farmers' upward productivity growth trajectory. If millions of small farms experience such growth, it could produce lower food prices, increased demand for agricultural wage labor, and increased circulation of money in rural areas that generate multiplier effects, all of which contribute to employment and economic growth. In these ways, fertilizer subsidy programs could be a powerful tool for transforming agrarian societies and kick-starting broader structural transformation processes.

Other motivations for fertilizer subsidy programs in Africa have focused on a learning effect. Fertilizer use may be low in some areas because farmers have no experience with it. A subsidy on fertilizer could enable farmers to gain valuable information about the benefits of using fertilizer without risking a major capital outlay (Carter, Laajaj, and Yang 2014). After learning about the benefits of using fertilizer, farmers may then continue to purchase it after the subsidy program ends. Such a learning effect would be confined to areas where fertilizer use is uncommon, but likely to be profitable.

A frequently articulated argument for input subsidy programs in Africa is that many developed countries have implemented them for decades to build up their agricultural sectors, and there is no reason why Africa should not enjoy the same benefits. This view assumes that input subsidy programs in developed countries actually contributed to those countries' development, or that they were an effective use of public resources compared to other public investments such as agricultural R&D, farmer education, infrastructural development, and irrigation. We are aware of very little empirical research to support these positions. Studies from Asia (e.g., EIU 2008; Fan, Gulati, and Thorat 2008) found that fertilizer subsidy programs were quite far down on the rankings of public expenditures with respect to cost-effective impacts on agricultural productivity growth and poverty reduction. A comprehensive review of these studies can be found in Appendix C.

While there are varied motivations for fertilizer subsidy programs, all of them are based on the assumption that existing levels of fertilizer use are *sub-optimal* or *too low*. The causes of low fertilizer use in Africa are often considered to be related to: (i) households' insufficient access to credit to purchase fertilizer in quantities even close to official recommendations, if at all; (ii) rural households' lack of information about the benefits of using fertilizer; (iii) risks of using fertilizer—even if fertilizer use is expected to raise net household income on average, the risk of

[4] See Johnston and Kilby (1975), Mellor (1976), Lipton (2006) and Christiaensen, Demery, and Kuhl (2011) for Africa and worldwide evidence.

a loss discourages use; (iv) weak development of commercial input markets; and (v) price volatility in output markets, which deter farmers from purchasing inputs to produce a marketable surplus. Fertilizer subsidy programs can arguably overcome all of these problems by reducing the costs that farmers incur to access fertilizer.

2.1. Lack of Profitable Use

Of all of the reasons for low fertilizer use in Africa, the expected profitability of using fertilizer is typically not questioned. There are several causes for this view. First, the trio of (fertilizer-responsive) modern varieties, irrigation, and fertilizer were the main ingredients of Asia's *green revolution* (Gulati and Narayanan 2003). Second, there are many areas of Africa where fertilizer is highly valued by farmers and where studies demonstrate high financial returns to most farmers.

However, we believe there is a selection bias in the literature on farmer returns to fertilizer use in Africa. Studies of fertilizer use tend to be concentrated in areas where fertilizer use is common and relatively high. It is possible that fertilizer use provides higher returns to farmers in such areas compared to other areas where use is low. Moreover, prior to 2005 or so, analysts' main source of fertilizer response estimates for African smallholder farmers came from experiment stations or on-farm trials. However, on-farm trials tend to be heavily managed by scientists in terms of seed type, planting date, row spacing, seed spacing, weeding, and even choice of farmer to participate. Very few nationally representative smallholder farm panel data sets were available to understand staple crop response to fertilizer on fields that were managed by smallholder farmers and accounting for the various resource constraints that they faced. While on-farm trials are generally considered to provide accurate estimates of the crop response rates to fertilizer that farmers *may get* under favorable conditions on well-managed plots, they are often not representative of the response rates that smallholder farmers *do get* when they follow the management practices they often must employ, given the various resource constraints they face (Snapp et al. 2014). Farm trials often involve farmers on a non-random basis. They tend to be disproportionately "master farmers" who possess better management practices and fewer constraints. Cases of crop damage from drought, flooding, pests, or disease are often dropped from trials, even though these are real possibilities for farmers purchasing inputs in the real world. Trial plots tend to be carefully chosen for suitability and are generally smaller than most farmer-managed plots, providing greater sunlight "edge effects" that likely raise crop response to fertilizer.

For these reasons it is likely that prior estimates of crop response rates (or nutrient use efficiency, hereafter NUE) from researcher-managed farm trials in Africa provide potentially misleading estimates of fertilizer use profitability and that our understanding of the economics of fertilizer use needs to be updated based on observations from farmer-managed fields.

Since roughly 2005 a growing number of studies have begun estimating crop response rates to fertilizer based on increasingly available panel surveys of smallholder farmers. Farm panel surveys are arguably the most accurate source of obtaining estimates of the NUE that farmers actual obtain in their fields for many reasons: (1) many are nationally-representative, and are thus more representative of the population than trials, many of which are undertaken in high-potential areas; (2) they take into account farmers' actual behavior and resource constraints (we call these farmer managed plots as opposed to researcher-managed plots that are owned by farmers, but are managed carrying out specific instructed protocols); (3) panel survey data are better able to control for the effects of time-constant unobserved factors correlated with fertilizer use which might otherwise bias researchers' estimates of NUE in cross-sectional data; and (4) from an *ex ante* framework of the farmer deciding whether to purchase and apply fertilizer to a particular field, survey data that retain cases of crop damage, floods, striga, personal problems leading to inadequate labor being utilized, etc., represent valid cases that should be included in estimations of on-farm averages for NUE.[5]

The evidence on *researcher-managed* farm trials in east/southern Africa produced NUE estimates ranging from 18-40 kgs maize per kg nitrogen (Whitbread, Sennhenn, and Grotelüschen 2013; Vanlauwe et al. 2011). Until recently, this was the range of NUE that was commonly believed to hold for smallholders' own fields using their own management practices. Given prevailing fertilizer and farm-gate maize prices in the region, nitrogen use efficiency estimates in the range of 18-40 kgs maize per kg nitrogen usually show highly profitable returns to farmers. By contrast, Table 2.1. shows our inventory of recent survey-based estimates of NUE from studies based on farmer-managed fields.

The estimates shown in Table 2.1. consistently find response rates in the range of 8 to at most 24 kgs maize per kg nitrogen applied, with a concentration at the lower end around 8-15. These studies suggest that smallholder households obtain levels of crop response that are generally substantially lower than those estimated from researcher-managed on-farm trials.

Given prevailing commercial retail input and output price ratios, we (or the studies' authors) calculate either the expected marginal or average physical products of fertilizer (MP and AP) and, subsequently, the expected marginal and average value cost ratios (MVCR and AVCR) of the following forms:

$$E(MVCR_{fijt}) = \frac{E(p_{yijt}) * E(MP_{xijt})}{w_{fijt}} \quad (1)$$

$$E(AVCR_{fijt}) = \frac{E(p_{yijt}) * E(AP_{xijt})}{w_{fijt}} \quad (2)$$

where w_f is the price of fertilizer, p_y is the producer price of the crop in question, i indexes individual farms, j indexes their fields and t indexes time. An expected AVCR of greater than one means that a farmer expects to increase its income as a result of fertilizer use (the average gain per unit); an expected MVCR of greater than one indicates income would be expected to increase with an increase in the rate of fertilizer application. However, African smallholder farmers tend to be risk averse, and the inclusion of a risk premium will often better measure the relationship between the VCRs and farmer adoption behavior (e.g., Anderson, Dillon, and Hardaker 1977). Moreover, farmers incur other costs associated with fertilizer use that are unaccounted for in VCR measures, for example increased weeding labor is needed on fertilized plots because the fertilizer contributes to weed growth that competes with plants for the nutrients. Farmers may also incur transaction costs of obtaining inputs and selling crops that are not accounted for in w_f and p_y. For these reasons, an AVCR of two has been typically used in the literature as the benchmark for reliably profitable adoption (e.g., Xu et al. 2009b; Sauer and Tchale 2009; Bationo et al. 1992) dating back to work by the FAO (1975) in order to better accommodate risk and uncertainty, adjust for the many unobserved costs associated with fertilizer use, and serve as an approximation for the rate at which fertilizer is profitable *enough* for smallholder farmers to want to use it (see Kelly 2005).[6]

---

5 In many cases, the objectives of on-farm research trials are not to estimate the response rates that farmers are actually getting their own fields, but to demonstrate the differences in yield or NUE that could be achieved if specific management practices or soil-augmenting investments were made (Snapp et al. 2014). For these reasons, we believe that NUE estimates derived from researcher-managed trials are generally inappropriate for use in studies estimating the impacts of nation-wide input subsidy programs.

6 In most recent data it becomes possible to account for some farm-specific costs (e.g., transportation) in which case the VCR's considered profitable would be lower than 2. By how much, unfortunately, is still dependent on unobservable factors, so

Table 1.1. Recent Estimates of Fertilizer Application and Response Rates in Sub-Saharan Africa

African study areas (Sources)	Geographic focus	% maize fields receiving commercial fertilizer use	Application rate for users	Estimated nitrogen use efficiency (kgs output per kg N)	Estimated value-cost ratio (VCR)
Sheahan, Black and Jayne (2013)	20 districts of Kenya where maize is commonly grown, 5 years of data from 1997 to 2010.	Ranges from 64% (1997) to 83% (2007)	26 kg N/ha (1997) to 40 kg N/ha (2010)	AP=21 kg maize/kg N MP=17 kg maize/kg N	AVCR=Ranging from 1.3 (high-potential maize zone) to 3.7 (eastern lowlands)
Marenya and Barrett (2009)	Kenya (Vihiga and S. Nandi districts); relatively high-potential areas	88% (maize and maize/bean intercrop)	5.2 kg N/ha	MP=17.6 kg maize/kg N	MVCR=1.76 (but fertilizer was <1.0 on 30% of plots).
Matsumoto and Yamano (2011)	100 locations in Western and Central Kenya (2004, 2007)	74%	94.7 kgs fertilizer product/ha maize	MP=14.1 to 19.8 kg hybrid maize/kg N	MVCR=ranging from 1.05 to 1.24 for hybrid maize
Snapp et al. (2014)	Malawi – nationally representative LSMS survey data	27% (maize plots)	62.9 kgs/ha maize	5.33 for monocrop; 8.84 for intercropped maize	MVCR= ranging from 1.04 to 1.38 AVCR= ranging from 1.25 to 1.71
Morris et al. (2007)	W/E/S Africa			E/S Africa: 14 kgs maize/kg N (median) W. Africa: 10 kg maize/kg N (median)	E/S Africa: 2.8 W. Africa: 2.8
Minten, Koru, and Stifel (2013)	Northwestern Ethiopia	69.1% of maize plots fertilized	65.3 kg N/ha	MP=12 kg maize/kg N on-time planting; 11 kg maize/kg N for late planting	1.4 to 1.0 (varying by degree of remoteness)
Pan and Christiaensen (2012)	Kilimanjaro District, Tanzania			11.7 kg maize/kg N	
Xu et al. (2009b)	AEZ IIa in Zambia (relatively good quality soils/rainfall suitable for maize production)	56.4% on maize	61.4 kgs N/ha (among users)	AP=18.1 (range from 8.5 to 25.5) MP=16.2 (range from 6.9 to 23.4)	Accessible areas=1.88 Remote areas=1.65
Burke (2012)	Zambia (nationally representative), 2001, 2004, 2008	36-38% of maize fields; 45-50% of maize area	35.2 N/ha maize	9.6 kg maize/kg N	0.3 to 1.2 depending on soil pH level for 98% of sample
Ricker-Gilbert and Jayne (2012)	Malawi, national panel data	59% of maize fields	47.1 N/ha maize	8.1 kg maize/kg N	0.6 to 1.6
Chibwana, Fisher, and Shively (2012)	Malawi – farmer-managed field data in Kasungu and Machinga Districts			9.6 to 12.0 kg maize per kg N	MVCR 1.4 to 1.8
Chirwa & Dorward (2013)	Malawi – national LSMS survey data			Negative to 9.0	Below 2.0
Liverpool-Tasie et al. (2015)	Nigeria – national LSMS survey data			8.0 kg maize/kg N 8.8 kg rice/kg N	Below 2.0 Below 2.0
Mather et al. (2015)	Tanzania – national LSMS-ISA survey data	15.9% (2009) 20.6% (2011) 17.9% (2013)	55.6 N/ha maize	7.8 kg maize/kg N (highlands) 5.7 kg maize	MVCR 0.94 to 1.23 (varies by year) MVCR 0.71 to 1.08

Source: Authors.

---

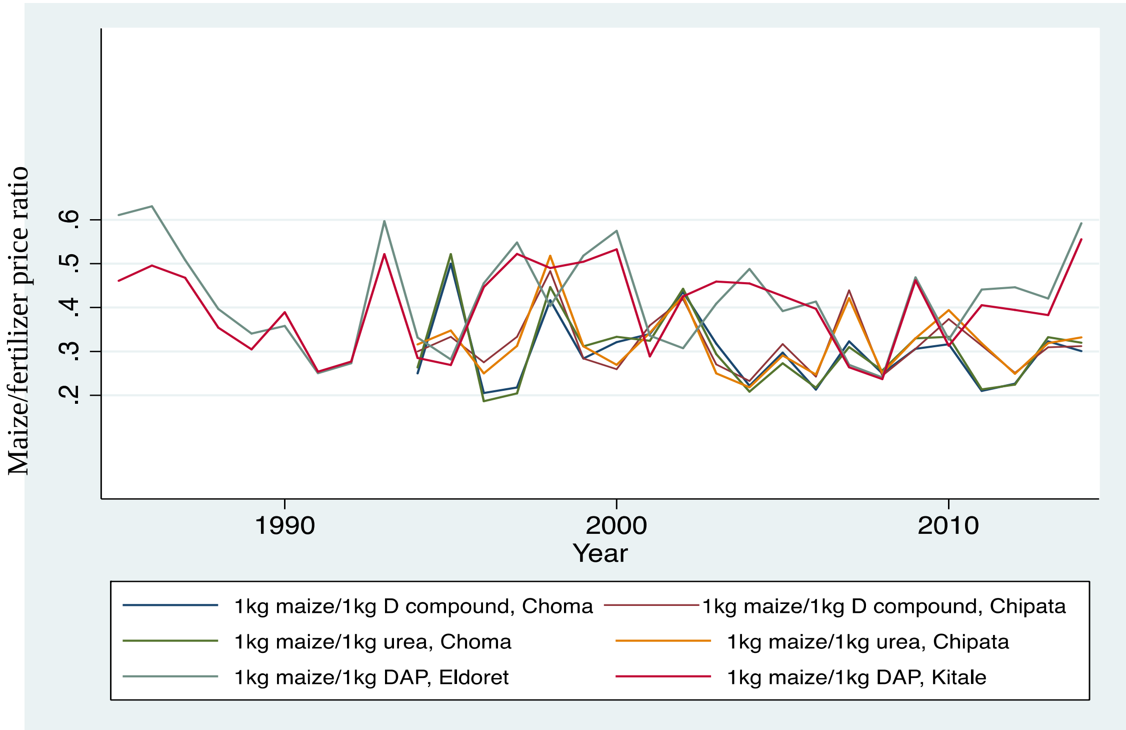
there is no rule of thumb for estimates accounting for farm-gate pricing. Until one is agreed upon in the literature we simply accept that *2* is an increasingly pessimistic choice. As a matter of reporting results in individual case studies, we would encourage authors to discuss the *distribution* of VCR estimates so that readers can make their own assessments as well.

unobserved costs associated with fertilizer use, and serve as an approximation for the rate at which fertilizer is profitable *enough* for smallholder farmers to want to use it (see Kelly 2005).[7]

The VCR estimates in the far right column of Table 2.1. show very few cases over 2.0. Most of the estimates fall between 1.0 and 2.0, signifying marginal or moderate levels of profitability when risk and other unmeasured costs are not taken into account. If the growing evidence that low fertilizer use is at least partially driven by low response rates on many African soils is correct, it is worth noting the consistency between this conclusion and that of Nobel Laureate T.W. Schultz: farmers can be poor but efficient. That is, low fertilizer use may be part of the problem, but if response rates were not high enough to provide incentives to use it, a rational farmer's efficient choice would be non-adoption.

Another important point to be made here is regarding the makeup of the VCR calculations in equations 1 and 2: input prices, output prices and input productivity. Despite the efforts of subsidy programs, the fact of the matter remains that, while volatile, the ratio of these prices has been fairly constant on trend. Figure 2.2. shows various maize to fertilizer price ratios for locations throughout Zambia and Kenya.

Figure 2.2. Various Maize/Fertilizer Price Ratios for Zambia and Kenya over Time



Sources: Zambia, Central Statistical Office, Government of Zambia. Kenya, Ministry of Agriculture for Nakuru fertilizer prices, Market Information Bureau for maize prices.

[7] In most recent data it becomes possible to account for some farm-specific costs (e.g., transportation) in which case the VCR's considered profitable would be lower than 2. By how much, unfortunately, is still dependent on unobservable factors, so there is no rule of thumb for estimates accounting for farm-gate pricing. Until one is agreed upon in the literature we simply accept that *2* is an increasingly pessimistic choice. As a matter of reporting results in individual case studies, we would encourage authors to discuss the *distribution* of VCR estimates so that readers can make their own assessments as well.

The majority of trends in these ratios (not shown) are essentially flat and *no ratio trend is statistically positive* (or negative) over time. If the ratio of grain to fertilizer prices continues with a zero trend for the foreseeable future, this would indicate that shifts over time in fertilizer profitability must be driven by changes in response rates.

The upshot of this section is that there are many reasons for low fertilizer use, and ISPs can help address them in ways that, at least in principle, can contribute to agricultural productivity growth and other important development objectives. However, if the cause of low fertilizer use is low profitability, this implies that the net value of output produced from incremental fertilizer use may not exceed the social cost of the additional fertilizer. Under such conditions, then it is not clear that increased fertilizer use will enhance economic efficiency or productivity goals until crop response rates to fertilizer use are increased.

2.2. Factors Affecting Crop Response to Fertilizer

It is important to stress that both the mean and variance of crop response rates vary greatly between irrigated and rainfed conditions. Water control is a fundamental "game-changer" for the economics of fertilizer use. Roughly 45% of South Asia's grain crops are under irrigation, which typically affords two-three cropping seasons per year and relatively stable yield response to fertilizer. Consequently, fertilizer application rates on cereal crops are substantially higher on irrigated fields than on rainfed plots).[8] By contrast, 96% of sub-Saharan Africa's cultivated land is rainfed, much of it in semi-arid areas experiencing frequent water stress and with one crop season per year. Fertilizer application rates on rainfed fields in India are quite low and not very different from application rates in much of rainfed Africa (Rashid 2010). In contrast, fertilizer application rates on rainfed maize fields in Thailand are significantly higher than in most of Africa, but Thai farmers benefit from higher levels of rainfall, better access to other forms of water control in the event of moisture stress, generally superior soils, and lower import parity prices of fertilizer than in most areas of Africa (Ekasingh et al. 2004). Water control may be an increasingly important determinant of fertilizer use rates in the future with more variable climate conditions.

For these reasons, the economics of fertilizer use in Africa are generally less favorable compared to other regions of the world where water control is more commonly available. The water constraint on fertilizer use can be relieved, albeit to a limited extent and only over a significant period. You et al. (2012) estimate that the share of cultivated area that is potentially irrigable in Sub-Saharan Africa could rise to just 11% over the next 50 years (p. 781), which would remain substantially lower than in Asia and Latin America.

Soil quality is a massive challenge that African farmers face in raising crop response to fertilizer. The availability of seventeen essential nutrients (or elements) ultimately determines a plant's growth and the yield potential of food crops (Jones et al. 2013).[9] The efficiency of fertilizer use depends on the level of pre-existing *available* nutrients stocked in the soil as well as the *availability* of nutrients applied as fertilizer. Part of what determines nutrient availability is the soil characteristics that represent the physical, biological, and chemical properties of soils. There are numerous ways to measure each of these, but common metrics include pH (soil chemistry), soil organic matter (SOM),[10] (soil biology), and texture (soil physics). Research in the fields of agronomy, soil science, and farming systems ecology are pointing the way to how sustainable

[8] Irrigated cereal fields in Pakistan, Bangladesh and India received 43%, 84%, and 186% more fertilizer nutrient per hectare than corresponding non-irrigated fields (see Rashid et al. (2013).

[9] Much of the information on soils in this report is prevalent throughout agronomic literature. Unless otherwise specified, the discussion summarized here and further details can be found in Jones et al. 2013. Also see Burke et al. forthcoming.

[10] Related measurements are organic carbon content or soil carbon content. These measures are highly correlated, and can effectively be thought of as rebased measures of each other.

intensification will need to occur in rainfed SSA and the role of fertilizer in these systems (e.g., Snapp 2010; Vanlauwe et al. 2011; Powlson et al. 2011). A huge body of evidence documents how rising rural population density in much of Africa is leading to rising land pressures, reduced fallows, more continuous cultivation, soil degradation, and weaker response to fertilizer application over time (Drechsel et al. 2001; Stoorvogel and Smaling 1990; Tittonell and Giller 2013). Declining soil fertility appears to be a leading cause of stagnant or declining trends in maize-fertilizer response rates observed over time, even while hybrid seed adoption is on the rise. Giller et al. (2006) and Tittonell et al. (2007) conclude that smallholder farmers are largely unable to benefit from the current yield gains offered by plant genetic improvement due to their farming on depleted soils that are non-responsive to fertilizer application. The efficiency with which fertilizer nutrients affect crop yield is strongly reduced by soil degradation (e.g., nutrient loss, too high or too low pH, or lower SOM). The process of soil nutrient depletion may partially explain why Yanggen et al.'s (1998) review reports crop response rates from the 1980s and early 1990s that are generally higher than those recorded recently even in spite of an increased proportion of cereal area under improved varieties. Tittonell and Giller (2013) recommend thinking about sustainable intensification efforts in terms of three categories of fields: (i) those responsive to fertilizer use; (ii) non-responsive but still productive; and (iii) non-responsive and degraded. Rising population pressures and more continuous cropping are shifting the relative proportion of cropped area in much of Africa from categories (i) and (ii) to category (iii), where productivity and crop response to fertilizer is poor.

A major soil characteristic that determines crop responsiveness to fertilizer is SOM or carbon content. Higher SOM levels suggest higher levels of nutrient stocks (especially nitrogen) and a soil's capacity to hold water, another source of nutrients. Higher SOM is also an indicator of relatively high microbial activity, and thus higher concentrations of the enzymes needed to free up nutrients in the soil so that they may be taken up by plants. High SOM conditions facilitate root growth and the ability to *forage* for nutrients (Marenya and Barrett 2009). In short, for many reasons higher SOM is associated with higher yields and yield response to fertilizer. In this vein, Marenya and Barrett (2009) conclude that "farmers cultivating more degraded soils may find it unprofitable to invest in soil nutrient inputs, not necessarily because the fertilizer/crop-price ratio is too high or due to credit, information or risk constraints, nor because of supply-side impediments that limit fertilizer's physical availability, but because marginal yield response to nitrogen application is low on carbon-deficient soils…. Poverty reduction efforts founded on a belief that fertilizer promotion can help lift poor smallholders out of poverty thus seem likely to fail among the large subpopulation who cultivate degraded soils." The critical relationship between soil conditions and fertilizer response has been largely overlooked to date in the development economics literature on fertilizer promotion policy in SSA.

Another body of literature stresses the role of multi-crop systems involving legumes in restoring soil organic carbon, fixing nitrogen, and hence raising response rates and the profitability of fertilizer (Giller and Candisch 1995; Snapp et al. 2010). Minimum-tillage and cover crop practices are also widely believed to restore soil organic matter (Lal 2011). A related literature points to the broader challenges of sequestering carbon in soils to not only raise the productivity of fertilizer and other inputs but to reduce global greenhouse gas emissions (Powlson et al. 2011). This literature suggests that improved farm agronomic and management practices may be at the intersection of efforts to both raise farm productivity and climate change mitigation and adaptation. African farmers face many constraints in adopting these practices. Adaptive research to identify ways of overcoming these constraints appears to be a crucial part of a holistic strategy for raising fertilizer use.

Another branch of research documents the degree to which soil acidity limits crop response to fertilizer application. The pH scale ranges from 0 to 14, with 7 being neutral and lower (higher) values indicating more acidic (alkaline) soils. As the balance of cations leans towards aluminum and hydrogen (non-essential elements for plant growth) and away from calcium and magnesium, pH goes down. This, in turn, limits the soil solution's capacity to hold essential nutrients and/or makes it more likely that essential nutrients will form the type of bond that is not easily broken by enzymes coming from roots and microbial activity. In the case of phosphorus, for example, nutrient particles are more likely to form iron or aluminum phosphates on acidic soil (which are less available for plants) as opposed to the mono- or di-calcium phosphates (which are more available for plants) that are more common on semi-neutral to neutral soils. High levels of aluminum in acidic soils also increase the vulnerability to toxicity that decreases root growth, and thus plant capacity to take up nutrients. In short, acidic soil conditions can be expected to negatively impact yield both directly and through lowered yield response to fertilizers.

While the Brazilian *Cerrado* region is heralded as a modern agricultural success story, its naturally highly acidic soils required liming for many years (to raise soil pH) before farmers could productively utilize these lands and achieve a profitable response to fertilizer application (World Bank 2009; Rada 2013). Using nationwide panel survey data from Zambia, Burke (2012) shows that maize response to basal fertilizer application is strongly inversely related to soil pH. Highly acidic soils where prevailing pH <4.3 (on which 51% of Zambian farms are located for that study) achieved an average of 2.1 kgs maize/kg basal fertilizer, rising to 3.7 kg/kg on fields where pH is between 4.4 and 5.4 (47% of farms), and 7.8 kg/kg on fields where pH is 5.5 or greater (2% of farms).

For these reasons, facile comparisons of average fertilizer application rates between Africa and other regions of the world are highly misleading. Policy discussions of low fertilizer use in Africa have tended to emphasize failures in input and credit markets and underemphasize the role of declining soil fertility associated with rising land pressures and continuous cultivation, poor soil management practices, and rainfed farming conditions in limiting African farmers' ability to use fertilizer profitably. This has led to the widespread but overly simplified view that low fertilizer use in Africa primarily reflects market access problems that can be overcome through input subsidy programs. The evidence from agronomic and soil science disciplines indicates that increasingly continuous cultivation, associated soil degradation, low soil organic matter, and soil acidity problems will lock a growing proportion of African farmers into low crop response rates to fertilizer use, thus constraining the effective demand for fertilizer and progressively reducing the payoffs to input subsidy programs, unless they are complemented by sustained public investments to address fundamental soil fertility constraints.

A potential consequence of this discussion is that official fertilizer use recommendations are often based on unrealistic assumptions about smallholders' soil conditions and response rates (often derived from trials and experiments). In some African countries, official fertilizer use recommendations of the national extension systems are uniform throughout the country. For example, Zambia's Ministry of Agriculture advises the *4 by 4* strategy of four 50 kg bags of Compound D and four 50 kg bags of urea per hectare of maize, for a total application rate of 400 kgs per hectare. Perhaps not surprisingly, less than 3% of Zambian smallholder farmers use fertilizer this intensively on their maize. Similarly, three studies investigating the profitability of fertilizer use in Kenya all found that official recommended use rates to be far in excess of the economically optimal level for most farmers (Duflo, Kremer, and Robinson 2008; Marenya and Barrett 2009; Sheahan, Black, and Jayne 2013).

The policy challenge of sustainably raising crop response to fertilizer is somewhat like turning a battleship: it is imminently feasible but will take considerable time. The profitability and effective demand for fertilizer in African agriculture in 2030 will depend on the extent to which African governments invest *today* in soil testing, efforts to educate farmers about agronomic practices to rebuild soil organic matter, obtain favorable soil pH levels, and take advantage of crop rotations and intercrops capable of restoring soil responsiveness to fertilizer application. Unfortunately, public sector funding to crop science, agronomic management, and extension systems built on appropriate recommendations has remained chronically under-provisioned in many African countries, being much smaller than in any other region of the world (IFPRI 2011). Public agricultural extension systems in many African countries are virtually defunct. In Zambia and Malawi, these expenditures currently account for less than 15% of total annual expenditures to agriculture. By contrast, Zambia's input subsidy and associated maize price support programs have accounted for 70-90% of public agricultural expenditures in recent years, while Malawi's input subsidy program alone has accounted for 40-70%. Clearly, the foundation for increased fertilizer use in SSA will depend on a more holistic approach to sustainable agricultural intensification.

3. THE EVOLUTION OF FERTILIZER SUBSIDY PROGRAMS IN AFRICA, 2000-2015

Throughout the 1990s and until 2005, agricultural input subsidy programs had been largely phased out in Sub-Saharan Africa. The discontinuation of fertilizer subsidy programs occurred during this period of structural adjustment, aid-conditionality, and strong international lender influence over agricultural policies.[11]

Starting in 2005 the landscape changed quickly and profoundly. Within several years after African governments committed to raise their expenditures on agriculture under the 2003 Maputo Declaration, at least 10 countries had introduced or re-introduced fertilizer subsidy programs costing over $1 billion annually (Table 3.1.). Large-scale input subsidy programs became the centerpiece of many African governments' agricultural development programs. We identify five main factors driving this rapid sea change.

First, many African governments never accepted the tenets of structural adjustment and cut ISPs only under duress. Leaders had many incentives for attempting to retain input subsidy programs. They were politically popular and often were part of the post-independence *social contracts* between leaders and their constituents to rectify colonial policies that discriminated against smallholder farmers. Bates (1981), van de Walle (2001) and many others contended that politically influential rural elites benefitted from input subsidy programs and lobbied forcefully for their re-emergence when the environment for their re-introduction was more favorable. Hence, the seeds of strong local support for ISPs has most likely been in the policy soil throughout the past several decades but were largely dormant during the structural adjustment period.

Starting around 2000, many African governments experienced a relaxation of the constraints on public budgets associated with the Highly Indebted Poor Countries (HIPC) debt forgiveness programs and a shift in international donor support from aid conditionality to budget support. With the autonomy afforded governments by the relaxation of public budget constraints, the latent resentment over structural adjustment and desire to re-institute politically popular but expensive programs such as ISPs was revived.

A third factor encouraging the return to ISPs was the emergence of multi-party political systems in Africa starting in the early 2000s. Political parties often sought to outdo one another in terms of the support promised to constituents (Levy 2005), and ISPs were one of the promises that leaders often made (e.g., in Malawi, Nigeria, and Zambia) to garner the rural vote.

The watershed event heralding the re-emergence of ISPs in Africa was the *Malawi miracle*. After reaching office in 2005, the new and politically embattled President Bingu wa Mutharika immediately gained local support after announcing a large-scale Agricultural Inputs Subsidy Program in opposition to the World Bank, arguing that the country would no longer allow itself to be dependent on food aid. Initial but somewhat superficial assessments of that program (e.g., Dugger 2007; AGRA 2009) reported how Malawi's program had turned the country from a food basket case into a grain exporter and dramatically reduced rural poverty rates.[12] Besides being a compelling *David and Goliath* story, the Malawi ISP received immediate public relations boosts

[11] See Appendix A for a summary of ISP implementation modalities in selected African countries.

[12] The AGRA (2009) report asserted that Malawi was "a model of success showing the rest of the African governments the way towards a sustainable version of the African green revolution".

from prominent advocates such as Jeffrey Sachs and Pedro Sanchez of the Millennium Village Projects and Akin Adesina of AGRA.

Table 3.1. ISP and Broader Agricultural Sector Spending 2011-2014

Country	Year	ISP Cost (Million US$) Official Source	ISP Cost (Million US$) Computed using secondary data	MT of Program fertilizer Distributed	'rogram cost per MT of program fertilizer distributed (US$/MT) [B/C]	Public Expenditure on Agriculture (Million US$)	ISP Cost as % share of public agricultural spending [=(B/E)*100]
			(B)**	(C)	(D)	(E)	(F)
Universal subsidy							
Mali	2011	na	39	173	890	213	18.1
	2012	na	15	65	918	195	7.7
	2013	na	18	75	947	204	8.7
	2014	na	16	84	780	199	8.3
Burkina Faso	2011	na	22	25	867	291	7.5
	2012	na	31	36	841	310	9.9
	2013	na	42	51	819	351	12.0
	2014	na	44	51	850	358	12.2
Ghana	2011	122	112	176	634	419	26.6
	2012	123	114	176	646	364	31.2
	2013	na	143	262	545	391	36.5
	2014	na	166	268	619	378	43.9
Senegal	2011	na	42	54	785	182	23.3
	2012	na	33	41	785	374	8.7
	2013	na	27	36	764	368	7.4
	2014	na	32	43	736	390	8.2
Nigeria	2011	na	190	264	719	817	23.3
	2012	na	177	249	711	788	22.4
	2013	na	187	264	708	802	23.3
	2014	na	167	256	653	795	21.0
Targeted subsidy programs							
Kenya	2011	15	61	57	1072	356	17.2
	2012	na	61	68	894	386	15.7
	2013	na	72	81	896	444	16.3
	2014	na	89	112	796	479	18.6
Malawi	2011	127	179	149	1200	345	52.0
	2012	151	116	177	654	355	32.7
	2013	207	185	213	868	350	52.9
	2014	168	183	208	879	352	51.9
Tanzania	2011	94	134	110	1223	349	38.4
	2012	76	104	126	828	326	32.0
	2013	na	104	105	989	338	30.9
	2014	na	92	112	829	332	27.9
Zambia	2011	184	239	182	1010	613	30.1
	2012	166	164	184	902	325	50.6
	2013	113	173	188	601	376	45.9
	2014	na	180	208	865	407	44.2
Ethiopia's program (officially not a "subsidy")							
	2011	na	55	551	100	530	10.4
	2012	na	54	633	86	771	7.0
	2013	na	38	449	84	850	4.5
	2014	na	43	597	73	937	4.6

Source: Official data are from government sources (Ghana: ministry of food and agriculture http://mofa.gov.gh; Malawi: Wanzala, Fuentes, and S. Mkumbwa 2013; Tanzania: World Bank's (2009) appraisal of the Accelerated Food Security Program (AFSP). Notes: The authors thank Shaidur Rashid and Asfaw Lemma for their support in preparing parts of this table. Computed costs are weighted average of commercial and fertilizer prices by amount of subsidized fertilizer in each country, and do not include administrative and other programmatic costs (e.g., import commissions. Prices for all countries except Ethiopia are obtained from the IFDC. Quantities of subsidized fertilizer are obtained from NEPAD for all countries except Ethiopia, Mali, Malawi, and Zambia. Other estimates are from Jayne and Rashid 2013 (Malawi); Fuentes et al. 2012 (Mali); Ricker-Gilbert et al. 2013 Malawi and Zambia); Liverpool-Tasie and Takashima 2013 (Nigeria). [b] Public Expenditure data are from the IFPRI's (SPEED) database.

IFDC prices available at
http://213.193.193.214/IFDC_ReportServer/Pages/ReportViewer.aspx?/IFDC_Reports/Monthly+National+Prices&rs:Command=Render). Wanzala-Mlobela, M., P. Fuentes, and S. Mkumbwa 2013; SPEED data available at:
(http://www.ifpri.org/book-39/ourwork/programs/priorities-public-investment/speed-database).

President Mutharika was awarded several prizes. While more recent analyses have shown the Malawi program's successes to be debatable in some respects and factually incorrect in others,[13] the Malawi case had an important *primacy effect* on policy discourse on the continent, convincing numerous governments to undertake similar targeted input subsidy programs.[14] By 2010, at least nine other countries accounting for over 60% of sub-Saharan Africa's population[15] had re-instituted input subsidy programs.

The term smart subsidy allowed politicians and supporters to argue that even though the prior track record of ISPs in Africa was quite dismal, it was possible to redesign the programs in ways that overcame prior political interference, implementation problems, and learn from experience so as to increase the benefits of ISPs going forward. Morris et al. (2007) and the World Bank (2008) identified specific criteria for smart subsidy programs to guide African governments. The most important of these criteria were that they: (i) promote the development of the private sector; (ii) target farmers who were not using fertilizer but who could find it profitable to do so; (iii) are one part of a wider strategy that includes complementary inputs and strengthening of markets; (iv) promote competition and cost reductions by reducing barriers to entry; and (v) have a clear exit strategy. While these are clearly useful criteria to guide the design of subsidy programs, in hindsight few questions were raised as to how these criteria could be implemented in practice and whether sufficient change had been instituted on the ground to justify expectations that well known past implementation problems could now be overcome.

The final major factor contributing to the re-emergence of ISPs in Africa was the global food price crisis in 2007 and 2008. During this time, panic over the availability of food supplies on world markets convinced many analysts and African leaders to support ISPs to promote national food self-sufficiency. Finally, in response to these concerns, the World Bank quickly shifted its position on ISPs, and started to support and even finance several countries' ISPs, including Ethiopia, Tanzania, Zambia, and Malawi, either directly or through the budget support that it provided to Ministries of Finance. Informal interviews with Bank representatives indicated that the Bank needed to deflect criticism that it was insensitive to the food security needs of poor countries caught in the wave of global food and fertilizer market gyrations, and moreover felt that it would have greater influence over the design and implementation of ISP programs if it contributed to their financing.

In summary, the main factors explaining the rapid re-emergence of ISPs in Africa were: (1) residual support for ISPs among African leaders during the earlier structural adjustment period; (2) debt reduction and the shift in international and bilateral development support from aid conditionality to budget support; (3) the Malawi miracle and associated public relations effectiveness in branding it as a major success; (4) the uncertainties about food supplies during the 2007/2008 food and fertilizer price crisis: and (5) the World Bank's decision to financially support a number of African countries' fertilizer subsidy programs.

[13] For evidence of this, see Lunduka, Ricker-Gilbert, and Fisher (2013).

[14] For example, President Meles Zenawi of Ethiopia invited President Mutharika to Ethiopia to learn from and replicate the Malawi miracle.

[14] This figure excludes South Africa because of its fundamentally different agricultural system.

In more recent years since 2010, other factors contributing to the staying power of ISPs have emerged. A recent study (Shimeles, Gurara, and Tessema 2015) addresses a longstanding concern (only anecdotally addressed) that incumbent political parties are able to use ISPs to their benefit (e.g. to finance their political campaigns) by granting import licenses to particular fertilizer companies in exchange for receiving funds from overstating the cost of imports.[16] Shimeles, Gurara, and Tessema (2015) find an inverse correlation between government effectiveness and the gap between world fertilizer prices and retail prices in the country. The study suggests another important incentive that incumbent political parties may have to continue large-scale ISPs. Several institutional recipients of development assistance funds, while not officially supporting ISPs, have also promoted them by offering technical support to African governments in the design and implementation of ISPs.

[16] Sources in the fertilizer industry in Nigeria provide an illustrative example that has been repeated by other fertilizer sources in other countries: government officials and a chosen firm may agree that the firm will invoice the government for $800 per ton even though the actual costs associated with delivering the fertilizer to inland markets is only $600, an excess of $200 per ton over the landed cost of importing fertilizer. The treasury pays the firm $700, allowing it to earn monopoly profits of $100 over its costs plus normal profits, while the party receives $100 per ton imported to finance its political campaigns or other off-the-books expenses.

4. EVIDENCE OF TARGETING AND IMPACTS

In the years since the 2005 sea change and revival of ISPs in Africa, the empirical literature on the targeting and impacts of the programs has been expanding rapidly. In this section we synthesize the findings from econometric- and simulation-based studies that estimate: (i) the *ceteris paribus* effects of various household, community, and other characteristics on the probability or level of participation in ISPs in SSA; and (ii) the *ceteris paribus* effects of participation in a given ISP (measured in various ways) on household- and more aggregate-level outcomes, including fertilizer and improved seed use, crop yields, area planted, and production, crop prices, and wage levels.

4.1. Targeting

Eligibility criteria for ISP participation vary markedly across (and sometimes within) countries (see Table 3.1. and Appendix A). Some programs officially target 'resource-poor' households (e.g., Kenya's National Accelerated Agricultural Inputs Access Program, NAAIAP) or those that cannot afford fertilizer at unsubsidized prices (e.g., Malawi's Farm Input Subsidy Program, MFISP). Other programs officially give priority to female-headed households (e.g., Malawi's MFISP and Zambia's Food Security Pack Program). Still others have a minimum or maximum landholding- or area cultivated-related eligibility criterion (e.g., Zambia's Farmer Input Support Program (ZFISP) and Kenya's NAAIAP). Given this heterogeneity, one approach would be to evaluate each ISP against its stated targeting criteria. In many cases, however, there is little correlation between the official targeting criteria and *de facto* characteristics of farmers and households actually receiving input subsidies (Ricker-Gilbert, Jayne, and Chirwa 2011; Pan and Christiaensen 2012; Mason, Jayne, and Mofya-Mukuka 2013; Sheahan et al. 2014; Kilic, Whitney, and P. Winters 2015).

Despite this disconnect, all programs share the common objective of raising use of the inputs distributed through the ISP. Another approach is to assess targeting performance against this goal. As shown by Xu et al. (2009a), Ricker-Gilbert, Jayne, and Chirwa (2011), Mason and Jayne (2013), Jayne et al. (2013), and Mather and Jayne (2015), on average and other factors constant, the potential for positive impacts of ISPs on fertilizer use are greatest when they are administered in areas where the private sector has been inactive and among households that cannot afford fertilizer at commercial prices. ISPs are particularly effective at increasing fertilizer use when beneficiaries include female-headed households and relatively poor households, be it in terms of land, assets, income, or consumption. We therefore begin this sub-section with a synthesis of the empirical record on the extent to which these factors affect household participation in ISPs. We then turn to the empirical record on the politicization and *elite capture* of ISPs. Table 4.1. summarizes empirical findings on the targeting of ISP inputs.

4.1.1. Targeting by Gender of the Household Head[17]

Looking across the various country ISPs and studies, the weight of the evidence suggests that female-headed households and male-headed household are equally likely to participate in ISPs and receive the same quantity of inputs on average, other factors constant (Table 4.1.). This is the case for all reviewed studies on Ghana's Fertilizer Subsidy Program (GFSP) [G1], Kenya's NAAIAP [K1], Zambia's ZFISP [Z1 to Z4], and Nigeria's ISPs prior to the Growth Enhancement Support Scheme (GES) [N1, N2]. It is also true for the bulk of studies on

[17] Throughout the remainder of Section 4, we cite studies according to their bracketed references in Tables 4.1, 4.3, and 4.4. See Appendix C for the full citations corresponding to these bracketed references and for brief summaries of the data and methods used in each study.

Malawi's MFISP (Table 4.1.). Where there are differences for the latter program, the findings suggest that female-headed are less likely to receive MFISP inputs or receive a smaller quantity of MFSIP inputs [M3, M5, M8]. Thus, ISPs in SSA generally fail to meet the criterion of favoring female-headed households.

Table 4.1. Empirical Findings on the Targeting of ISP Inputs

Country		Empirical Findings
By gender of the household head (FHH=female-headed, MHH=male-headed)		
Ethiopia	–	NA
Ghana	–	No differences: A study of smallholder rice farmers in the Volta region of Ghana finds that approximately 25% of both beneficiaries and non-beneficiaries are female, and gender had no significant c.p. impact on the likelihood of participation [G1].
Kenya	–	No FHH-MHH differences in probability of receiving NAAIAP voucher, c.p. [K1].
Malawi	–	**No differences:** No FHH-MHH differences in probability of receiving [M12, M24, M28], value or number of MFISP vouchers [M7, M28], or kg of MFISP fertilizer or maize seed [M16, M17. M24] received, c.p. HHs with female plot managers equally likely to participate in MFISP as HHs with only male plot managers, c.p. [M20].
	–	**Differences:** FHH less (equally) likely to receive MFISP fertilizer or seed+fertilizer (seed only), c.p. [M8]. FHH receive 12 kg less MFISP fertilizer, c.p. [M3]. Respondents in FHH less likely to receive MFISP, c.p. [M5].
Nigeria	–	No FHH-MHH differences in quantity of FMSP, KSVP, or TSVP fertilizer acquired, c.p. [N1, N2]
Tanzania	–	Male headed households were significantly more likely to receive vouchers than female-headed households (T1)
Zambia	–	No FHH-MHH differences in receipt of ZFISP fertilizer or hybrid maize seed, c.p. [Z1, Z2, Z3, Z4].
By landholding size		
Ethiopia	–	NA
Ghana	–	Mean plot size for both beneficiary and non-beneficiary smallholders in Volta is 2 hectares, but after controlling for other factors there is a negative and statistically significant correlation between plot size and subsidy participation [G1]
	–	Mean total crop area among beneficiaries is slightly lower in the Northern region (3.7 ha versus 4.2 ha amongst non-beneficiaries) [G4]
Kenya	–	HHs with more than 5 ha of land 7-9 p.p. less likely to receive NAAIAP voucher, c.p. [K1]. HHs with more land get slightly more NCPB fertilizer, c.p. (3.1 kg more per 1-ha increase in landholding) [K2].
Malawi	–	Value of MFISP vouchers higher among HHs with more land, c.p. [M7]. Probability of receiving MFISP vouchers increases by 1.3-1.6 p.p. with 1-ha increase in landholding, c.p. [M12]. Probability of participating in MFISP and # of coupons received increasing in HH landholding (at a decreasing rate), and highest among largest land quintile, c.p. – e.g., HHs in this group are 18.9 p.p. more likely to get MFISP than HHs in the smallest landholding quintile [M28].
	–	1-ha increase in landholding raises FISP fertilizer acquired by 3.3-11.3 kg, c.p. [M3, M16, M17], but has no effect on kg of FISP maize seed [M16].
	–	Probability of MFISP receipt is increasing in the number of plots cultivated by the HH, c.p. [M20].
	–	Probability of receiving MFISP fertilizer voucher and kg of MFISP fertilizer acquired increasing in HH area cultivated, c.p. [M24].

Nigeria	–	No c.p. landholding effects on quantity of FMSP fertilizer acquired [N1]. 1-ha increase in landholding raises fertilizer received through KSVP and TSVP, c.p. (APE not reported) [N2].
Tanzania	–	No significant relationship between landholding size and households receiving vouchers (T1)
Zambia	–	HHs with more land get slightly more ZFISP inputs, c.p. (0.2 kg more hybrid maize seed [Z2] and 2.5 kg more fertilizer [Z5] per 1-ha increase in landholding). No c.p. landholding effect in some studies e.g., [Z4].
By assets, wealth, or ex ante poverty status		
Ethiopia	–	NA
Ghana	–	Asset wealth was found to be 44% greater amongst beneficiaries compared to those not receiving fertilizer subsidies in the cross-sectional data from the Volta region [G1]
Kenya	–	HHs in highest asset quintile 8-12 p.p. less likely to receive NAAIAP voucher, c.p. [K1]. No c.p. effect of farm assets on quantity of NCPB fertilizer [K2].
Malawi	–	Value of MFISP vouchers received lower among poor HHs, c.p. [M7]; some evidence that poor HHs less likely to receive FISP vouchers, c.p. [M8]. Poor HHs 1.9-2.8 p.p. less likely to receive MFISP vouchers, c.p. [M12]. HHs that consider themselves to be poor less likely to receive MFISP voucher and receive less MFISP fertilizer, c.p. [M24].
	–	[M3] finds that an increase in value of assets raises MFISP fertilizer acquired, c.p. But [M17] and [M24] find no c.p. effects of asset wealth on MFISP fertilizer acquired (or probability – M24). [M16] find the same for MFISP maize seed, but find that MFISP fertilizer kg acquired is decreasing in asset wealth, c.p.
	–	[M20] find that probability of MFISP participation is decreasing in a wealth index and access to non-farm labor income but increasing in an agricultural implement access index and access to non-farm non-labor income, c.p.
	–	[M28] find that middle 3 wealth quintiles more likely to participate in MFISP (by 6-10 p.p.) than poorest and richest wealth quintiles, c.p. No stat. sig. difference in participation between poorest and richest wealth quintiles, c.p. But top four wealth quintiles all get significantly more FISP coupons, c.p., with the largest effect in quintile 4 [M28].
	–	An increase in the district poverty rate increases the % of HHs receiving MFISP in 2007/08 but an increase in the district % of HHs reporting a food shortage or famine does not, c.p. [M6].
Nigeria	–	No c.p. asset (livestock) effects on quantity of FMSP (KSVP and TSVP) fertilizer acquired [N1, N2, N6].
Tanzania	–	Voucher recipients more likely to be non-poor in the prior survey than non-recipients (T1)
Zambia	–	Panel data regressions suggest no farm asset effects, c.p. [Z1, Z2, Z4]. Cross-sectional regressions suggest that ZFISP fertilizer and seed recipients have more farm assets, c.p. [Z3; Z10 for 5 provinces only].
By political factors		
Ethiopia	–	NA
Ghana	–	More vouchers targeted to districts lost by the ruling party in the last presidential election, c.p.; number of vouchers received is increasing in the ruling party's margin of loss [G2]. Notably, the incumbent party that initiated GFSP lost the following presidential election by a slim margin. [G3]
Kenya	–	Some evidence that increase (decrease) in const.-level electoral threat (support for runner-up) in last election reduces (increases) NAAIAP and NCPB fertilizer receipt, but election data questionable [K2].

By political factors		
Malawi	–	[M16] find that HHs in districts won by Bingu wa Mutharika in the 2004 presidential election got 13.2 kg (1.7 kg) more MFISP fertilizer (maize seed) in 2006/07 and 2008/09 than HHs in districts lost by Mutharika, c.p.
	–	[M23] finds no evidence that districts with more Mutharika core supporters were favored with MFISP vouchers, c.p., in 2008/09 (just before the 2009 election) relative to earlier and later years. Districts with more swing voters appear to have been allocated more MFISP vouchers in 2008/09, c.p., at the expense of districts with more opposition core supporters, c.p. Also, no evidence that core supporters were rewarded with more MFISP vouchers after the 2009 election, c.p.
	–	A larger % of HHs received MFISP in 2007/08 in districts where the incumbent lost in 2004, c.p., but the winning party in 2004 had no c.p. effect [M6].
	–	[M5] find that respondents' partisan affinities in 2008 had no c.p. effect on their likelihood of receiving MFISP in 2009.
	–	[M17] find that HHs in communities with a resident MP get 7.5 kg more MFISP fertilizer, c.p., but [M28] find no c.p. of this on probability of participating in MFISP or number of coupons received.
	–	HHs in villages with resident or recent visit of MP 2.7 p.p. more (2.5 p.p. less) likely to receive MFISP fertilizer voucher only (fertilizer and maize seed voucher), c.p. [M12].
Nigeria	–	1-km decrease in distance from LGA to the district of origin of the state governor increases the mean FMSP fertilizer acquired by HHs in the LGA by 22-30 kg, c.p. [N6].
Tanzania	–	Vouchers disproportionately targeted to households having elected officials and village voucher committee members (T1).
Zambia	–	Through 2010/11, HHs in const. won by the MMD (ruling party) in the last presidential election got 23.2 kg more ZFISP fertilizer, and 0.5 kg more per p.p. increase in MMD margin of victory, c.p. [Z6]
By social capital factors (non-political)		
Ethiopia	–	NA
Ghana	–	NA
Kenya	–	NA
Malawi	–	HHs with heads originating from outside the district 3.0-7.7 p.p. less likely to receive MFISP vouchers, c.p. [M12].
	–	1-year increase in time HH head has lived in the village raises MFISP fertilizer receipt by 0.09 kg, c.p. [M3].
	–	HHs with village head, Village Development Committee (VDC), or traditional authority in their networks 13-14 p.p. more likely to participate in MFISP, c.p. [M28].
Nigeria	–	Relatives of farm group leaders (chairperson, secretary, or treasurer) get more subsidized fertilizer through KSVP but not TSVP, c.p. [N2, N5].
Tanzania	–	Households more likely to receive vouchers if they participate in public meetings, are members of farmer associations and/or talk to government officials at least once a month [T1]
Zambia	–	HHs related to chief/headman get 0.6 kg more ZFISP hybrid maize seed, c.p. [Z4]. No evidence of similar effects on ZFISP fertilizer acquired.
By select other factors		
Ethiopia	–	NA
Ghana	–	Age, experience (years farming) and plot fertility (self described) are all roughly the same on average, but beneficiaries are 30% (1.5 km) closer to the nearest extension agent distributing vouchers. The negative correlation is statistically significant, all else held constant [G1].

Kenya	–	HHs that did not use fertilizer in previous year(s) 8-12 p.p. less likely to receive NAAIAP voucher, c.p. [K1]. 1-km increase in distance from motorable road reduces NCPB fertilizer by 19.0 kg, c.p. [K2].
Malawi	–	Value of MFISP vouchers received lower among maize net buyers, c.p. [M7].
	–	1-km increase in distance from major road increases probability of MFISP voucher receipt by 0.03 p.p., c.p. [M12]. 1-km increase in distance from nearest paved road raises MFISP fertilizer receipt by 0.08 kg, c.p. [M3]. But [M16] and [M17] find no c.p. effects of distance to paved road, district capital, or main market on kg of MFISP fertilizer and/or maize seed acquired.
	–	An increase in soil quality in the HH's area is associated with an increase in the probability of participation in MFISP and the number of MFISP coupons received, c.p. [M28].
Nigeria	–	1-hr increase in travel time to nearest 20k+ town reduces FMSP fertilizer by 0.7 to 1 kg, c.p. [N1]. 1-km increase in distance to main market raises fertilizer received through KSVP, c.p. (APE not reported) [N2].
Tanzania	–	
Zambia	–	1-km increase in distance from feeder road reduces ZFISP fertilizer by 1.1-2.5 kg, c.p. [Z1].

Notes: c.p. = *ceteris paribus;* results are average partial effects (APE) and stat. sig. at the 10% level or lower. "No effect" indicates no statistically significant effect at the 10% level or lower. NA = no analyses to date. HH = household. MMD = Movement for Multi-Party Democracy. p.p. = percentage point. Const. = constituency. Electoral threat is the share of votes won by the runner-up divided by the share of votes won by the presidential winner. KSVP = Kano State voucher program in 2009. TSVP = Taraba State voucher program in 2009. See Appendix C for full references for the studies cited here, and for brief overviews of the data and methods used.

4.1.2. Targeting by Landholding Size

The empirical record generally suggests that households with more land are more likely to receive ISP inputs or receive a larger quantity of such inputs on average, *ceteris paribus* (Table 4.1.). Of the more than 70 studies reviewed, only one suggests that households with more land are *less* likely to receive ISP inputs [K1], and only a handful suggest that an increase in landholding size has no effect on ISP receipt (Table 4.1.). However, despite the consistent findings that households with more land are favored by the programs, the magnitudes of the landholding effects are small: a one-hectare increase in household landholdings is associated with increases in subsidized fertilizer received of just 2.5-11.3 kg on average under Kenyan, Malawian, and Zambian programs. With recommended fertilizer application rates of 400 kg/ha in Zambia, for example, these effects are minimal.

Perhaps more striking are the unconditional probabilities of participation in ISPs by landholding size. As shown in Table 4.2., there is a much larger spread across landholding quintiles in the probability of participation in ZFISP than in MFISP. While only 13% of Zambian smallholders in the lowest landholding quintile participated in ZFISP in 2010/11, 43% of their Malawian counterparts participated in MFISP in 2009/10. This is compared to 47% and 62% of Zambian and Malawian smallholders, respectively, in the largest landholding quintile (a 34 percentage point spread for Zambia but only 19 percentage points for Malawi). This may be related to the minimum landholding requirement for ZFISP (0.5 ha in 2010/11) or the broader coverage of MFISP (which reached 54% of smallholders during the years in question compared to just 30% for ZFISP). While participation in ISPs is generally higher among households with more land, the extent to which this is the case varies considerably across countries.

However, participation rates alone can mask even larger disparities in the share of total subsidized inputs received by households in different landholding quintiles. Even in countries where the input pack size is supposedly standardized (e.g., 200 kg/household in Zambia in

2010/11, 100 kg/household in Malawi throughout the duration of MFISP), the quantities received often vary markedly across beneficiary households; households with more land are often both more likely to receive inputs from the programs and receive larger quantities, on average, upon participating (Ricker-Gilbert, Jayne, and Chirwa 2011; Mason and Ricker-Gilbert 2013; Mason and Jayne 2013). As shown in Appendix A, Zambian smallholders in the smallest landholding quintile garner just 6% of all ZFISP fertilizer distributed, while those in the largest landholding quintile (who are most likely to be able to afford fertilizer at commercial prices) receive 41% of it. This exacerbates *crowding out* of commercial input demand by the programs, reduces impacts on total fertilizer use (and hence incremental maize production), and attenuates poverty reduction effects.

Table 4.2. Malawi FISP Participation in 2009/10 and Zambia FISP Participation in 2010/11 by Landholding Quintile

Landholding Quintile	Share of HHs participating in:		Share of total subsidized fertilizer acquired
	MFISP	ZFISP	ZFISP
1 (smallest)	0.43	0.13	0.06
2	0.50	0.23	0.12
3	0.54	0.30	0.16
4	0.59	0.40	0.25
5 (largest)	0.62	0.47	0.41
All	0.54	0.30	1.00

Sources: Kilic, Whitney, and Winters (2015) for MFISP, and authors' calculations based on the CSO/MAL/IAPRI Rural Agricultural Livelihoods Survey (2012) data for ZFISP.
Note: Landholding quintiles defined separately for each country.

4.1.3. Targeting by Assets, Wealth, or Ex ante Poverty Status

After controlling for landholding size and other factors, the empirical evidence on the effects of assets, wealth, and *ex ante* poverty status on ISP receipt are mixed, especially in the case of Malawi (Table 4.1.). While some studies for Malawi suggest that relatively poorer (wealthier) households are less (more) likely to receive MFISP inputs or receive smaller (larger) quantities [M3, M7, M8, M12, M24, M28], some find the opposite [M16, M20, M24], and still others find no wealth effects at all [M16, M17]. In a cross-sectional study of GFSP receipts, it was found that asset wealth in Ghana's Volta region was 44% greater amongst beneficiaries compared to those not receiving fertilizer subsidies [G1]. There is no evidence of wealth-related targeting in Nigeria's pre-GES ISPs (Table 4.1.). *De facto* targeting under Kenya's NAAIAP favored households in the bottom four wealth quintiles [K1], while no farm asset effects are found for the country's universal National Cereals and Produce Board (NCPB) fertilizer subsidy program [K2]. Cross-sectional evidence from Zambia suggests that a higher level of farm assets is associated with receiving more ISP fertilizer and seed, but these estimated effects are not statistically significant after controlling for time-constant farmer characteristics (Table 4.1.). Differences in methodology and the definitions of assets, wealth, or poverty measures likely underlie many of the varying results from Malawi as well.

In the most detailed study of the targeting of MFISP to date, Kilic, Whitney, and Winters (2015, p. 29) argue that Malawi's "FISP is not poverty targeted in that it does not exclusively target the poor or the rich at any level of the programme administration … The multivariate analysis of household programme participation reinforces these findings and reveals that relatively well off in terms of wealth and landholdings, rather than the poor or the wealthiest … have a higher likelihood of program participation and, on average, receive a greater number of input coupons". In Zambia, targeting is decidedly *not* pro-poor, as smallholder households in the lowest income per adult equivalent quintile received just 5% of all ZFISP fertilizer in 2010/11, while those in the highest quintile received 42% of it (Mason and Tembo 2015), mirroring the landholding quintile results in Table 4.2.

Overall, the empirical record for most ISPs suggests little or no targeting by assets or wealth, on average and holding other factors constant. However, there is some evidence that the wealthiest households were less likely to receive subsidized inputs under Kenya's NAAIAP program, which explicitly sought to reach resource-poor farmers.

4.1.4. Targeting and Political Factors

It is widely believed that ISPs in SSA are politicized. The empirical record shows which groups of voters—core supporters of the incumbent party, swing voters, or core supporters of the opposition—are actually targeted. Based on the findings in Table 4.1., there is considerable evidence of politically motivated targeting of ISP inputs, but the groups targeted vary across countries and, in the case of Malawi, different studies reach different conclusions about which groups are targeted. In both Ghana and Kenya, empirical evidence suggests that areas with more opposition supporters in the last presidential election get significantly more subsidized fertilizer [G2, K2]; however, the political logic to such a targeting strategy is questionable as the political payoffs to targeting opposition (versus swing voter) areas are likely to be small. Notably, for example, the incumbent party that initiated GFSP lost the following presidential election by a slim margin in 2008 [G3]. In Zambia, in contrast, results based on multiple nationally-representative surveys (both panel and cross-sectional) consistently suggest that from the late 1990s through 2010, smallholder households in constituencies won by the ruling party (the Movement for Multi-Party Democracy (MMD) at that time) in the last presidential election received significantly more (23 kg) subsidized fertilizer than those in areas lost by the ruling party; moreover, the quantity of subsidized fertilizer received was increasing in the ruling party's margin of victory [Z3, Z6]. The findings from Malawi related to which groups of voters/partisans are targeted are too mixed to draw general conclusions, but the disparate findings are partially driven by differences in data and methods, and in the years under consideration (Table 4.1.). However, for Malawi and Nigeria, there is some evidence that communities with resident elected leaders or communities that are geographically closer to the hometown of those leaders (e.g., MPs in Malawi and state governors in Nigeria) receive significantly more subsidized fertilizer on average, other factors constant [M12, M17]. Overall, there is mounting empirical evidence of the politicization of ISPs in SSA, but the nature of the politicization varies across countries as well as within countries over time (Chinsinga and Poulton 2014; M23).

4.1.5. Targeting, Social Capital, and Elite Capture

In addition to the consistent findings that households with more land get more ISP inputs and the findings in some countries that wealthier households get more, empirical evidence from several SSA countries suggests that social capital factors also leads to elite capture of ISP benefits. In Tanzania, for example, Pan and Christiaensen (2012) found that 60% of the households receiving input vouchers contained a village official as a member. They also found that households with elected officials and voucher committee members were 1.7 and 4 times more likely to receive input vouchers than households without such members. Similarly, evidence from Zambia and Malawi suggests that households with links to traditional authorities are more likely to receive input subsidies [Z4, M28]. In Malawi, locals (either in the sense that they originate from the village or have lived in the village longer) are favored. In Nigeria, relatives of farm group leaders get more subsidized fertilizer under the Kano State voucher pilot program (where a single voucher was given to the farmer group) but not under the Taraba State program (where farmers were each given their own vouchers) [N2, N5]. Thus, in all SSA countries where this issue has been investigated empirically, there is evidence that social capital factors influence access to subsidized inputs.

4.2. Household Level Effects of ISPs

4.2.1. Household-level Effects on Fertilizer and Improved Seed Use

One of the first sets of ISP impacts to be empirically investigated was the effect of the programs on household demand for fertilizer at commercial (unsubsidized) prices. Originally investigated by Xu et al. (2009a, Z7), and followed by numerous studies thereafter (see Table 4.3.), empirical assessments of the extent to which subsidized fertilizer "crowds in" or "crowds out" commercial fertilizer demand are based on the following relationship:

$$\frac{\partial total}{\partial ISP} = \frac{\partial ISP}{\partial ISP} + \frac{\partial comm}{\partial ISP} = 1 + \frac{\partial comm}{\partial ISP} \tag{3}$$

where *total* is the total quantity of fertilizer demanded, *ISP* is the quantity of ISP fertilizer acquired, *comm* is the quantity of commercial fertilizer demanded, and ∂ indicates a partial derivative.[18] The term $\frac{\partial comm}{\partial ISP}$ is estimated by regressing *comm* on *ISP* and other factors, and using econometric techniques to correct for the potential endogeneity of ISP fertilizer to commercial fertilizer demand. A negative (positive) and statistically significant partial effect of *ISP* on *comm* in this regression indicates crowding out (crowding in). When there is crowding out (in), a 1-kg increase in subsidized fertilizer acquired by a household leads to a less (more) than 1-kg increase in total fertilizer demand. Thus understanding the crowding out/in effects of ISPs is critical for understanding the impacts of the programs on total fertilizer use and thus on the incremental production of the crop(s) to which the fertilizer is applied.

Table 4.3. Empirical Findings on the Household-level Effects of ISPs

Country	Empirical Findings
Fertilizer and improved seed use (accounting for crowding out)	
Ethiopia	– Evidence suggests no significant crowding out impact on improved seed or fertilizer use unless households were able to participate in ***both*** a public works program ***and*** OFSP. The probability of such households using improved seeds is estimated at 8.2%, which is roughly 5 percentage points greater than non-participants, all else equal. The probability of participants in both programs using fertilizer is 27%, which is 11 percentage points higher than non-participants, all else equal [E1].
Ghana	– NA (to the best of our knowledge, no studies account for crowding effects)
Kenya	– **Crowding out (fertilizer)**: 49 (58) kg increase in fertilizer use per 100-kg increase in NAAIAP (NCPB) fertilizer, c.p. [K2]. Crowding out of commercial fertilizer purchases worse in medium/ high potential zones, for MHHs, and for HHs in top half of land or assets distribution [K2]. NA for improved seed use.
Malawi	– **Crowding out (fertilizer):** 78 (82) kg increase in fertilizer use per 100-kg increase in MFISP fertilizer, c.p., based on 2 (3) waves of HH panel survey data [M3, M2]. Crowding out worse among HHs with more assets [M3], in high PSA than low PSA areas [M2], and among HHs in top 50% of landholding distribution [M2]. – **Crowding out (seed):** 42 kg increase in improved maize seed use per 100-kg increase in MFISP maize seed received, c.p. [M16]. Simulation results in [M26] consistent with this general finding of seed crowding out.

[18] This relationship has also been used to study the effects of ISP improved maize seed on total improved maize seed demand (Mason and Ricker-Gilbert 2013, Z2, M16).

Country	Empirical Findings
	– Other:
	– No cross effect of MFISP fertilizer on improved maize seed use [Z2]. Increase in value of MFISP vouchers received raises maize fertilizer use intensity, c.p. [M7].
	– In HHs that receive MFISP fertilizer (but do not buy commercial fertilizer), no difference in probability of fertilizer use between male- vs. female-controlled plots, c.p. [M11].
	– No c.p. effects of MFISP vouchers on adoption of modern maize varieties overall (MHH+FHH pooled) but receipt of maize seed+fertilizer MFISP voucher increases probability of modern maize variety use on plots in FHHs by 92.4 p.p., c.p. [M12].
	– [M13] suggests that MFISP fertilizer increases the probability and intensity of fertilizer use, c.p. but [M21] suggests it increases the probability of fertilizer use by 37 p.p. but has no c.p. effect on the kg or kg/ha of fertilizer used.
	– The effect of MFISP participation on fertilizer use is larger on plots managed by women than those managed by men, c.p. [M20].
Nigeria	– **Crowding out**: 100-kg increase in FMSP fertilizer reduces probability of commercial fertilizer use by 10-21 p.p., but has no effect on quantity of commercial fertilizer used among users, c.p. Overall effect not reported [N1]. Earlier working paper results suggest overall crowding out effect of 19-35 kg per 100 kg of FMSP fertilizer [N7].
	– **Crowding in**: 100-kg increase in KSVP raises commercial fertilizer purchases by 26 kg, total fertilizer acquired by 126 kg, [N2], and the probability of using improved maize or rice seed by 8 p.p., c.p. [N3].
Tanzania	–
Zambia	– **Crowding out (fertilizer and seed)**: 87 (51) kg increase in fertilizer (hybrid maize seed) use per 100-kg increase in ZFISP fertilizer (hybrid seed), c.p. [Z1, Z2].
	– **Crowding out (in)** of commercial fertilizer purchases by ZFISP in high (low) PSA areas, c.p. [Z7] or worse in high PSA than low PSA areas, and among MHHs and HHs with more than 2 ha of land [Z1].
	– **Other:** No cross effect of ZFISP fertilizer on commercial maize seed use [Z2]. 10 kg/ha increase in fertilizer application rate per 100-kg increase in ZFISP fertilizer, c.p. [Z3].
Crop yields	
Ethiopia	– Estimated yield impacts for maize varies regionally and ranges from 3.8 to 4.5 marginal kg of cereal per kg of fertilizer applied [E2]
Ghana	– Wiredu et al.2015 –Land productivity is similar between subsidy program recipients and non-recipients, but labor productivity of participants is lower.
Kenya	– NAAIAP participation raises maize yields by 299-721 kg/acre, c.p. – see source note for caveat [K3]. No c.p. NAAIAP effects on net crop income/acre [K3]. NA for NCPB.
Malawi	– Receipt of standard MFISP input pack raises maize yields by 447 kg/ha, c.p. [M7]
	– Access to MFISP fertilizer raises maize yields, c.p. [M13]
	– MFISP participation raises the value of crop output/ha by 13-17%, and there is no differential effect by gender of the plot manager, c.p. [M20].
Nigeria	– NA
Tanzania	–
Zambia	– 74.3 kg/ha increase in maize yield per 100-kg increase in ZFISP fertilizer, c.p.; small, positive spillovers on yields of other crops [Z3]. Late delivery of ZFISP fertilizer reduces technical efficiency and maize yields by 4.2% c.p., resulting in 84,924 MT of foregone maize production in 2010/11 [Z11-cross section]
Crop area planted	
Ethiopia	– NA
Ghana	– NA
Kenya	– No c.p. NAAIAP effects on maize or total area cultivated, or on the number of different field crops grown (a rough proxy for crop diversification) [K3]. NA for NCPB.

Country	Empirical Findings
Malawi	– Maize MFISP voucher recipients devote larger shares of land to maize, especially improved varieties, and tobacco, and smaller shares of land to other crops, especially legumes, c.p. [M8]. – Some evidence that MFISP access incentivizes maize intensification and reductions in maize area and share of total area planted, c.p. [M13]. Similar findings in [M21] –e.g., participation in MFISP reduces the share of area planted to maize by 23 p.p. each for improved and traditional varieties, increases share of area planted to legumes and tobacco by 37 and 15 p.p., respectively, and reduces the share of area planted to other crops by 5 p.p. But no c.p. effects on crop diversification [M21].
Nigeria	– NA
Tanzania	–
Zambia	– 0.07 ha increase in maize area planted per 100-kg increase in ZFISP fertilizer, c.p. [Z3]. No c.p. effect on area planted to other crops in general [Z3] or groundnuts [Z8] or cotton [Z12].
Crop production	
Ethiopia	– NA
Ghana	– NA
Kenya	– NAAIAP participation (i.e., receipt of 100 kg of fertilizer and 10 kg of improved maize seed) raises main season maize kg harvested by 187-533 kg (estimates varies by estimator; FE estimate is 361 kg) and raises maize share of total value of crop production by 2-5 p.p., c.p. No c.p. effect on net crop income [K3].
Malawi	– 165 kg increase in maize output per 100-kg increase in MFISP fertilizer, c.p. [M17]. – 100-kg increase in MFISP fertilizer raises the 10th, 25th, 50th, 75th, and 90th percentiles of maize production by 75, 111, 204, 276, and 261 kg, respectively, c.p. [M18]. – HHs receiving MFISP coupons for free had maize production that was 43% higher and were less (more) likely to be maize net buyers (net sellers), c.p. [M14]. – MFISP fertilizer has small, positive effects on tobacco production and net value of rainy season total crop production, c.p. [M17].
Nigeria	– NA
Tanzania	–
Zambia	– 188 kg (106 kg) increase in maize output per 100-kg increase in ZFISP fertilizer (10-kg increase in ISP hybrid maize seed), c.p.; small, positive effects of ZFISP fertilizer on output of other crops, and on net crop income [Z3, Z4, Z13]. In Gwembe district, 224 kg increase in maize output per 100-kg increase in ZFISP inputs (seed or fertilizer) [Z9].
Food security and nutrition	
Ethiopia	– Results are mixed. Participation in public works and OFSP is associated with 0.4 *fewer* months of food security over 2 years, but participants acquire 230 (10%) more calories per week than non-participants and both relationships are significant at the 5% level or lower, all else equal [E1].
Ghana	– NA
Kenya	– NA
Malawi	– HH participation in MFISP raises per capita non-food expenditures by 125% but has no c.p. effect on per capita food consumption or health-related expenditures, or on dietary diversity [M21]. – Among HHs with preschool-aged children, participation in MFISP increases weight-for-height by 2.1 standard deviations overall, and 3.1 (1.5) for male (female) children, on average, c.p., suggesting reductions in wasting as a result of MFISP [M21].
Nigeria	– NA
Tanzania	–
Zambia	– NA (study in progress)
Incomes, poverty, and assets	

Country	Empirical Findings
Ethiopia	– Public work participants experience roughly 45% growth in asset wealth over 3-year period, but non-participant asset growth is 23 percentage points greater and this difference is significant at the 1% level. [E1]
Ghana	– NA
Kenya	– NAAIAP participation has no c.p. effect on total HH income or US$1.25/day poverty incidence but reduces US$1.25/day poverty severity by 4-11 p.p. [K3]. See note on [K6].
Malawi	– Starter Pack participation reduced HH per capita income by 8.2%, but receipt of full MFISP input pack raises HH per capita income by 8.2%, c.p. [M10]. – Increase in MFISP fertilizer has no c.p. on HH assets, off-farm income, or total (farm+off-farm) income [M17]
Nigeria	– NA
Tanzania	–
Zambia	– 100 kg of ZFISP fertilizer (10 kg of ZFISP hybrid maize seed) raises total HH income by 3.9% (1.1%) and reduces US$2/day poverty severity at that HH-level by 1.4 (0.7) p.p., c.p. No c.p. ZFISP seed or fertilizer effects on US$2/day poverty incidence. Similar (and slightly larger impacts on poverty severity) when the US$1.25/day poverty line is used [Z4, Z13].
Soil fertility management practices, fallow land, and forests	
Ethiopia	– NA
Ghana	– No evidence of FSP impact on broadly defined soil and water management after controlling for hired and household labor and other factors. Correlation is positive, but not significant [G1]
Kenya	– NA
Malawi	– MFISP fertilizer has no c.p. effect on probability or intensity of organic manure use [M13, M15], or on intercropping [M13]. – Access to MFISP fertilizer might incentivize planting of new trees but cutting down of naturally occurring trees, c.p. [M13]. – Access to full set of MFISP maize coupons (seed + fertilizer) reduces forest clearing in terms of both total hectares per household and hectares per capita terms, c.p., but receiving only seed or only fertilizer coupon has no c.p. effect [M9].
Nigeria	– NA
Tanzania	–
Zambia	– An increase in ZFISP fertilizer reduces fallowing [Z3, Z14] and intercropping, increases continuous maize cultivation on the same plot over time, and has no effect on use of animal manure, c.p. [Z14]
Dynamic/enduring effects	
Ethiopia	– NA
Ghana	– NA
Kenya	– NA
Malawi	– Long-run (4-year) c.p. effect of 100-kg increase in MFISP fertilizer on maize production of 481 kg (165 kg contemporaneous + 316 kg lagged/enduring effects) [M17], and on commercial fertilizer demand of 13 kg (-7 kg contemporaneous crowding out + 20 kg lagged/enduring effects) [M28]. But [M28] finds no lagged effects on maize production. – No contemporaneous or enduring c.p. effects of MFISP fertilizer on HH assets, off-farm, or total (farm+off-farm) income [M17]. Small, positive contemporaneous effect on HH tobacco production and net value of rainy season total crop production but no enduring effects, c.p. [M17].
Nigeria	– NA
Tanzania	–
Zambia	– NA (study planned for 2016)

Notes: FHH = female-headed HH; MHH = male-headed HH. c.p. = *ceteris paribus;* results are average partial effects and stat. sig. at the 10% level or lower. NA = no analyses to date. HH = household. PSA = private sector activity (fertilizer retailing). KSVP = Kano State voucher program in 2009. TSVP = Taraba State voucher program in 2009. LGA = local government area. See Appendix C for full references for the studies cited here, and for brief overviews of the data and methods used.

Looking across multiple relevant studies for SSA, only two cases show evidence of crowding in: under the Kano State voucher pilot program in Nigeria [N2] and in areas with low private sector commercial retailing activity in Zambia [Z7].[19] All other studies [K2, M2, M3, N1, N7, Z1] suggest crowding out of commercial fertilizer demand by subsidized fertilizer in Kenya, Malawi, Nigeria (under FMSP), and Zambia, and similarly for improved maize seed in Malawi and Zambia [M16, Z2].[20] In general, the extent to which ISP inputs crowd out commercial demand is lower among female-headed households, households with less land or fewer assets, households that did not previously purchase the inputs, in areas with less private sector fertilizer retailing activity, and in areas that have lower agro-ecological potential, *ceteris paribus*. The fact that adverse effects on the private sector are less common in lower potential areas, of course, also raises questions regarding the long-run potential of ISPs in these areas. Specifically, what is the likelihood of sustaining a commercial market where fertilizer use may only be sensible at subsidized prices?

The magnitude of the crowding out effects varies considerably across countries where it has been found. Estimates suggest that an additional 100 kg of ISP fertilizer crowds out 42-51 kg of commercial fertilizer in Kenya [K2], 18 kg in Malawi [M2], 19-35 kg in Nigeria under the Federal Market Stabilization Program (FMSP) [N7], and 13 kg in Zambia. The substantially larger crowding out effects in Kenya are likely due to the fact that the country's private sector fertilizer markets were already well developed and the majority of farmers were already using fertilizer prior to the reintroduction of fertilizer subsidies there [K1, K2].

Thus, although there are a few findings of crowding in, the evidence suggests that most ISPs crowd out commercial demand for subsidized inputs. That is, an additional ton of fertilizer (improved seed) distributed through input subsidy programs raises total fertilizer (improved seed) use, but by less than one ton.

More recently, some studies have estimated that crowding out of commercial fertilizer sales may have been substantially under-estimated due to fertilizer that has been diverted from subsidy program channels into what can be mistaken for commercial sales (Mason and Jayne 2013; Jayne et al. 2013). Both in Malawi and Zambia, comparing the official subsidized fertilizer distribution volumes and the estimated volume of subsidized fertilizer received by farmers according to nationally representative survey data suggests diversion of 25-35% of subsidized fertilizer is common. Diversion of program fertilizer has important income distributional effects, with program implementers receiving a major portion of the program benefits rather than farmers (Jayne et al. 2015).

While the aforementioned studies focus on crowding in/out of commercial *demand*, there have yet to be any comprehensive studies of the extent to which ISPs encourage or deter private sector investment in input distribution.[21] The conventional wisdom is that ISPs distributing

[19] In addition, subsidized fertilizer acquired through the Kano State voucher pilot program, which did not distribute subsidized seed, had positive spillover effects on the probability that households used improved maize or rice seed [N3]. No such cross-input effects have been found for Malawi and Zambia, whose ISPs distribute both subsidized fertilizer and improved maize seed [M16, Z2].

[20] [Z1] revisits fertilizer crowding out in Zambia using an additional wave of panel data beyond the two waves used by [Z7] and with additional corrections for endogeneity.

[21] Note that private sector activity can be either commercial or non-commercial, where firms act as distribution agents for government subsidy programs. Hence it is indeed possible that an ISP program could attract new private sector investment in input distribution at the same time that it crowds out commercial fertilizer sales to farmers.

inputs through parallel government channels are more likely to crowd out private sector market participation, whereas ISPs operating through vouchers redeemable at private agro-dealers are more likely to crowd in private sector participation. However, little empirical evidence either supports or refutes this claim. A study on this topic is underway in Tanzania, but otherwise the subject remains a large knowledge gap.

4.2.2. Household-Level Effects on Crop Yields

In addition to raising the use of fertilizer and improved seed, another common goal of ISPs is to raise the productivity of the crops for which these inputs are intended. Despite the centrality of this goal, the econometric evidence on these effects is surprisingly thin.[22] In the countries where this issue has been examined (Kenya, Malawi, and Zambia), the findings suggest positive ISP effects on maize yields [K3, M7, M13, Z3]. There is also some evidence of positive spillovers of ZFISP fertilizer on the yields of non-maize crops in Zambia [Z3]. And while participation in Malawi's MFISP raises the total value of crop output/ha [M20], this is not the case for Kenya's NAAIAP program, where it appears that positive increases in maize yields are offset by reduced productivity of other crops [K3].

Comparing the magnitudes of ISP yield impacts across countries is difficult due to the different ways in which ISP participation is measured, differences in econometric approaches, and the difficulty in computing effect sizes given that many studies do not report standard errors. We can conclude from the available evidence, however, that ISPs do raise maize yields. However, crowding out by and late delivery of ISP inputs [Z7, Z11] are likely attenuating these effects, as are poor soil quality and the minimal use of complementary practices to raise crop yield response to fertilizer (Marenya and Barrett 2009; Burke 2012; Jayne and Rashid 2013).

4.2.3. Household-Level Effects on Crop Area Planted

The empirical record is mixed as to whether ISPs induce an expansion of crop area planted or changes in the shares of land planted to different crops (Table 4.3). In land-scarce Kenya, NAAIAP appeared to have no effect on farmers' area planted to maize or total area planted, on average and other factors constant [K3]. In relatively land-abundant Zambia, ZFISP incentivizes an expansion of total and maize area, such that the maize share of total area increases without affecting the area of land (in absolute terms) devoted to other crops [Z3, Z8, Z12]. The results from Malawi are again difficult to generalize. While [M8] suggests that smallholders increase the share of land devoted to maize in response to MFISP, [M13] and [M21], which draw on different datasets from each other and from [M8], suggest that MFISP incentivizes maize intensification and a reduction in the maize share of total area planted. We thus conclude that ISPs have heterogeneous effects on the area planted to maize and other crops.

4.2.4. Household-Level Effects on Crop Production

Raising crop production is another core goal of most ISPs. The empirical findings summarized in Table 4.3. suggest that ISPs have had modest, positive *ceteris paribus* effects on household-level maize production in all countries where this issue has been examined (Kenya, Malawi, and Zambia). Here the magnitudes of the effects are somewhat easier to compare across countries, though still not perfectly. In Kenya, participation in NAAIAP[23] raises maize production by 361 kg on average, other factors constant [K3]. The increases in Malawi (165 kg of maize per 100 kg of MFISP fertilizer) and Zambia (188 kg of maize per 100 kg of ZFISP fertilizer) are considerably smaller [M17, Z3]. While this could be due to minor methodological differences or because the latter two estimates are for fertilizer only whereas the Kenya/NAAIAP estimate is

[22] Not only is the evidence base thin on yield effects, but there has also been virtually no research done on the effects of ISPs on labor productivity or total factor productivity.

[23] Receipt of 100 kg of fertilizer and 10 kg of improved maize seed if a household obtains a full input pack.

for fertilizer *and* seed, differences in the design and implementation of the three ISPs might also contribute to the differences in the estimated impacts on maize production. Of the three programs, only Kenya's NAAIAP successfully targeted resource-poor farmers and distributed inputs to farmers through vouchers redeemable at registered agro-dealers' shops. These differences, coupled with ecological differences leading to generally higher maize yield response to fertilizer in Kenya compared to Zambia and Malawi, may have contributed to the larger impacts of Kenya's ISP on maize production despite the larger crowding out effects there [K3].

Looking beyond the impacts on maize alone, the empirical evidence on the effects of ISPs on net crop income (or net value of crop production) is more variable. Estimates for Kenya's NAAIAP suggest negligible impacts on net crop income overall but increased net crop income among the poor, while evidence from Malawi and Zambia suggests that MFISP and ZFISP do have small positive effects of net crop income overall [K3, M17, Z13].

Finally, looking *beyond the mean*, quantile regression results from Malawi suggest that MFISP fertilizer has larger effects on higher percentiles of the maize production distribution. For example, a 100-kg increase in MFISP fertilizer raises the 10^{th} percentile of the maize production distribution by only 75 kg whereas it raises the 90^{th} percentile by 261 kg on average, ceteris paribus [M18].

In general, the empirical record suggests that ISPs have modest, positive effects on maize production and on net crop income for some segments of the population. However, the magnitudes of these effects vary at different points in the distribution of maize production.

4.2.5. Household-Level Effects on Food Security and Nutrition

Improving household food security is another common ISP objective; however, to date, very little research has been conducted on this topic (Table 4.3.). The only study we are aware of [M21] suggests participation in Malawi's MFISP raises per capita *non-food* expenditures by 125% on average, other factors constant, but has no effects on food consumption, health-related expenditures, or dietary diversity. However, there is some evidence that MFISP participation reduces wasting (increase weight-for-height) among preschool-aged children [M21].[24]

Though not technically an ISP, Ethiopia's Food Security Program (EFSP) also has mixed and limited empirical results. Participation in public works and the Other Food Security Program (OFSP, see Appendix A for details) is associated with 0.4 *fewer* months of food security over two years, but participants acquire 230 (10%) more calories per week than non-participants on average, all else equal [E1]. Given the dearth of research on this topic, it is difficult to know if these results are generalizable.

4.2.6. Household-Level Effects on Incomes, Poverty, and Assets

Several econometric studies have estimated the effects of ISPs on income, poverty, and/or asset wealth at the household level (Table 4.3.). Results for Kenya's NAAIAP and Zambia's ZFISP suggest that while these ISPs reduce poverty severity by several percentage points, the programs do not reduce poverty incidence [K3, Z4, Z13]; all else equal, the effects of the programs on the incomes of the poor, on average, are not large enough to move them above the poverty line. The lack of an ISP effect on household-level poverty incidence in Zambia could be due to elite capture of a disproportionate share of ISP benefits.[25]

---

[24] Research on the effects of Zambia's ZFISP on household food security and children's nutritional status is underway but results are not yet available. The study by Ward and Santos (2010) has only been released in draft form and explicitly states that the results should not be cited.

[25] Poverty severity is equal to zero for households with income at or above the poverty line, and equal to the squared

The results for Malawi, again, are mixed: [M10] suggests that receipt of the full MFISP input pack raises per capita incomes by 8.2%, but [M17] finds no significant MFISP fertilizer effects on household assets, total income, or off-farm income. Overall, the literature suggests that ISPs have the potential to raise incomes and reduce poverty severity at the household level but are less likely to decrease the probability that households fall below the poverty line.[26]

4.2.7. Household-Level Effects on Soil Fertility Management Practices, Fallow Land, and Forests

In addition to the oft-stated objectives, ISPs could have spillover effects on other outcomes, such as use of other soil fertility management practices. Experimental evidence from Mali suggests that access to free fertilizer induces households to increase fertilizer use but also to re-optimize their use of other inputs, such as herbicide or labor (Beaman et al. 2013).

A handful of studies have examined the extent to which ISPs encourage (or discourage) use of other soil fertility management practices. [G1] finds no evidence that Ghana's ISP has an impact on soil and water management after controlling for hired and household labor availability and other factors. Both [M13, M15] and [Z3] find that ISP fertilizer does not affect Malawian and Zambian smallholders' use of organic manure; however, while [Z14] finds some evidence that ZFISP reduces intercropping in Zambia, [M13] finds no such effects for MFISP. [Z14] also finds that ZFISP discourages crop rotation and encourages continually planting maize on the same plot. In addition, results from Zambia suggest that ZFISP discourages fallowing [Z3, Z14]. High soil acidity and low soil organic matter levels on many Zambian smallholders' maize fields reduce fertilizer use efficiency but intercropping, crop rotation and fallowing can improve soil quality. By encouraging maize monocropping within seasons and over time, and by discouraging fallowing, Zambia's ZFISP may be undermining the effectiveness of inorganic fertilizer distributed through the program. Thus, while ISPs aim to increase soil fertility, there may be unintended negative consequences of the programs on the use of inputs or management practices that are complementary to inorganic fertilizer use.

Turning to the effects of ISPs on forest cover and trees (naturally occurring and planted), the empirical record is again mixed. All studies to date on this topic in SSA have been for Malawi. [M9] finds that receipt of a full set of MFISP coupons (fertilizer plus maize seed) reduces pressure on surrounding forests. Based on a different dataset, [M13] finds that MFISP increases both the planting of new trees and the cutting down of naturally occurring trees. Key takeaways are that ISPs can alter incentives for various soil fertility and land management practices and much remains to be learned about how ISPs affect adoption of crops and inputs beyond those being promoted.

4.2.8. The Dynamic or Enduring Effects of ISPs on Farm Households

The studies discussed in the previous sections focus on the contemporaneous effects of ISPs. However, a common argument made for ISPs is that by stimulating learning about the inputs, by helping farm households break out of poverty traps, or by building private sector input markets and increasing demand for inputs, ISPs could kick-start dynamic growth processes and have effects beyond their current year (Chirwa and Dorward 2013). In addition, phosphorous in the fertilizers distributed through many ISPs can continue to have effects on crop productivity for

proportion difference between household income and the poverty line for households with incomes below the poverty line (Foster, Greer, and Thorbecke 1984).

[26] See also Awotide *et al.* (2013) and Carter, Laajaj, and Yang (2014) for randomized controlled trial (RCT) based estimates of the income and poverty effects of a small certified rice seed voucher pilot program in Nigeria and the income (and other) effects of a government ISP pilot program in Mozambique, respectively. Unlike the above mentioned studies for Kenya and Zambia, Awotide et al. (2013) find that participation in the seed voucher pilot program in Nigeria does reduce the probability of household income falling below the poverty line.

several years after its initial application. Whether there is empirical evidence of dynamic or enduring effects of ISPs depends on the outcome variable and the context.

In Malawi, the weight of the evidence suggests the absence of enduring/lagged effects of MFISP on household maize production, assets, and income (total, farm, and off-farm) [M17, M28] but possible lagged crowding in effects on demand for commercial fertilizer after an initial period of crowding out [M28]. In Mozambique, where far fewer households use fertilizer than in Malawi (and potential for learning effects may be greater), Carter, Laajaj, and Yang's (2014) RCT results for a pilot ISP suggest substantial, positive enduring effects on many but not all of the outcome variables considered. Some of these dynamic effects in Mozambique might be due to concurrent efforts by IFDC to strengthen agro-dealer networks and fertilizer supply as part of the pilot program. Thus depending on the outcome variable and context, ISPs may or may not have lasting, positive effects on farm households beyond the year of receipt.

4.3. Market-Level and General Equilibrium Effects of ISPs

As demonstrated above, ISPs have generally had positive (though in several cases, relatively small in magnitude) effects on household fertilizer use, crop yields, production, and incomes. The effects of ISPs on these outcomes at more aggregate or national levels, and ISPs' partial- and general equilibrium effects on food prices and labor markets may differ. We examine the literature on these issues in this sub-section, and conclude with a discussion of the empirical evidence on the extent to which ISPs affect voting patterns and election results. See Table 4.4. for a summary of the aggregate level effects of ISPs.

4.3.1. Aggregate Fertilizer Use

Based on the micro-econometric evidence discussed above, most ISPs partially crowd out demand for commercial fertilizer. However, a substantial share (roughly one third in Malawi and Zambia) of fertilizer intended for ISPs is diverted by program implementers before reaching intended beneficiaries and resold as commercial fertilizer at or near commercial prices [Z1, Z15, Z16].

Such diversion needs to be taken into account when moving from household-level estimates of crowding out to national level estimates of the impacts of ISPs on total fertilizer use.[27] Based on diversion estimates of 33%, one MT of ISP fertilizer injected into the system raises total fertilizer use by just 0.38 MT in Kenya, 0.55 MT in Malawi, and 0.58 MT in Zambia (ibid., Table 4.4.). Thus, although ISPs raise total fertilizer use, there are major inefficiencies and diversion by program implementers representing another form of elite capture of ISP benefits.

Table 4.4. Empirical Findings on the Aggregate-level Effects of ISPs

Country	Empirical Findings
Fertilizer use (accounting for crowding out and diversion)	
Ethiopia	– NA
Ghana	– NA
Kenya	– 1 MT increase in subsidized fertilizer (NCPB or NAAIAP) raises national fertilizer use by 0.57 MT with no diversion, and 0.51 (0.38) MT with 10% (33%) diversion, c.p. [K2, K4].

[27] We contend that failure to take account of diversion of program fertilizer (as in Mason and Jayne 2013, and Jayne et al. 2013 and 2015) is one reason for the divergence in conclusions between these studies and that of Arndt, Pauw, and Thurlow 2014. When Arndt, Pauw, and J. Thurlow do take account of crowding out (not diversion), their assessment of the Malawi program becomes decided less favorable, but these factors were not part of their baseline results on which their main conclusions rest.

Country	Empirical Findings
Malawi	– With 33% diversion, 1 MT increase in MFISP fertilizer raises national fertilizer use by 0.55 MT, c.p. [M1, M2].
Nigeria	– NA
Tanzania	–
Zambia	– With 33% diversion, 1 MT increase in ZFISP fertilizer raises national fertilizer use by 0.58 MT, c.p. [Z1, Z15, Z16].
Crop production, food self-sufficiency	
Ethiopia	– NA
Ghana	– NA
Kenya	– NA
Malawi	– Based on CGE model, 2006/07 MFISP raised national maize production by 174,300-307,300 MT (9-15%) and net maize exports by 44,900-122,500 MT (132-188%) [M22]. – Based on partial equilibrium model of the informal rural economy, [M27] estimate MFISP raises maize production by 11-23% per year across all HHs, and 31-39% among target (poor) HHs. – Based on an administrative area-level cross sectional dataset (2008/09), a 1% increase in the percentage of HHs receiving MFISP raises administrative area maize yields by approximately 0.2%, c.p. [M26].
Nigeria	– NA
Tanzania	– $300 million in NAIVS cost produced 2.5 million additional tons of maize and rice over the course of the program [T4]
Zambia	– NA
Food price levels	
Ethiopia	– NA
Ghana	– NA
Kenya	– NA
Malawi	– Doubling scale of MFISP (fertilizer quantity distributed) reduces retail maize prices by 1-3% [M4]. – Based on CGE model, 2006/07 MFISP reduced real maize prices by 2-4%, and reduced food prices in general by 2-3% [M22]. – Based on partial equilibrium model of the informal rural economy, [M27] estimate that MFISP raises mean pre-harvest (post-harvest) wage-to-maize price ratios by 5-26% (32-73%) through both wage-increasing and maize price-reducing effects.
Nigeria	– Increase in scale of FMSP in an LGA (i.e., increase in mean kg/HH or share of HHs receiving subsidized fertilizer) has no stat. sig. or very weak negative effect on local rice, sorghum, and maize price inter-season growth rates, c.p. [N6]
Tanzania	–
Zambia	– Doubling scale of fertilizer ZFISP (quantity distributed) reduces retail maize prices by 2-3% [Z17].
Agricultural labor wage rates and supply/demand	
Ethiopia	– No evidence of any significant positive correlation between EFSP participation and entering labor markets , agricultural or otherwise [E1].
Ghana	– NA
Kenya	– NA
Malawi	– **Ganyu labor supply:** Among ganyu labor supplying smallholders HHs (all smallholder HHs), a 100-kg increase in MFISP fertilizer reduces (has no effect on) the probability of supplying ganyu labor by 2.3 p.p., and reduces the number of days supplied by 10.7 days (2.9 days), c.p. – **Ganyu labor demand:** A 100-kg increase in MFISP fertilizer has no effect on the days of ganyu labor demanded (both among all HHs and ganyu-demanding HHs), but raises the probability of ganyu labor demand by 1.6 p.p. among all HHs, c.p. [M18]

Country	Empirical Findings
	– **Agricultural wage rates:** A 10-kg increase in the average quantity of MFISP fertilizer acquired by HHs in a community raises the median agricultural wage rate in the community by 1.4%, c.p. This is equivalent to an increase in average annual income of about US$1.40-1.86. [M18]. – **Based on CGE model:** 2006/07 MFISP increased the average farm wage by 4-7 p.p. (5-8%) [M22]. – **Based on partial equilibrium model** of the informal rural economy, [M27] estimate that MFISP raises mean pre-harvest (post-harvest) wage-to-maize price ratios by 5-26% (32-73%) through both wage-increasing and maize price-reducing effects.
Nigeria	– NA
Tanzania	–
Zambia	– NA
Incomes and poverty	
Ethiopia	– NA
Ghana	– NA
Kenya	– NA
Malawi	– Based on CGE model, 2006/07 MFISP reduced the national poverty rate by 1.6-2.7 p.p., the rural poverty rate by 1.5-2.7 p.p., and the urban poverty rate by 1.5-2.9 p.p. [M22]. Slightly higher reduction in urban poverty rate due to reduction in food prices and increase in wages [M22]. – Based on partial equilibrium model of the informal rural economy, [M27] estimate real income increases as a result of MFISP of 3-11% per year across all HHs, and 6-31% among target (poor) HHs.
Nigeria	– NA
Tanzania	–
Zambia	– NA
Voting patterns and election results	
Ethiopia	– NA
Ghana	– NA
Kenya	– NA
Malawi	– MFISP increased support for Bingu Wa Mutharika's DPP party, c.p. [M5, M6]. More specifically, [M5] find that respondents' whose HH received MFISP in 2009 were 6-7% more likely to 'feel close to' the DPP in 2010, c.p. – [M6] find that a 1-p.p. increase in the % of HHs receiving MFISP raised the DPP's parliamentary electoral margin over their closest rival in the constituency by 2%, c.p.
Nigeria	– NA
Tanzania	–
Zambia	– An increase in % of smallholder HHs receiving FISP, the mean kg of ZFISP fertilizer received per HH, or the total (administrative) allocation of ZFISP fertilizer to the district had no c.p. on the number or share of votes won by the incumbent in the 2006 and 2010 presidential elections [Z6].

Notes: c.p. = *ceteris paribus;* results are average partial effects and stat. sig. at the 10% level or lower. NA = no analyses to date. HH = household. KSVP = Kano State voucher program in 2009. TSVP = Taraba State voucher program in 2009. LGA = local government area. See Appendix C for full references for the studies cited here, and for brief overviews of the data and methods used.

4.3.2. Aggregate Crop Production and Food Self-Sufficiency

Many ISPs aim to raise national crop production to achieve food self-sufficiency or increase net crop exports. The only studies that directly estimate these effects have been conducted for Malawi and take either a partial equilibrium or computable general equilibrium (CGE) modeling approach [M26 and M27, respectively].[28] These studies suggest increases in national maize production as a result of MFISP (e.g., in 2006/07) of 9-23% (with even larger percentage increases among targeted households), and increases in net maize exports of 132-188%.

4.3.3. Food Price Levels

Though typically not stated as an explicit objective of ISPs, if the programs reduce food prices (by increasing food supply), the programs could benefit urban consumers and net food buyers, including many poor rural households. The effects of ISPs on food prices have been estimated for Malawi [M4, M22, M27], Nigeria [N6], and Zambia [Z17]. Though using different approaches, [M4, M22, and Z17] all suggest modest reductions in retail maize prices as a result of Malawi's MFISP and Zambia's ZFISP on the order of 1-4%. [M22] also suggests that MFISP reduced overall food prices (i.e., maize and other food items) by 2-3%. Though not directly comparable, [M27]'s findings suggest a decrease in the maize-to-wage price ratio as a result of MFISP due to both reductions in maize prices and increases in wages. Only for Nigeria is there little evidence of ISP effects on food prices [N6] (Table 4.4.). Thus, in general, the empirical evidence suggests that ISPs in SSA reduce food prices but by substantively small magnitudes.

4.3.4. Agricultural Labor Wage Rates And Supply/Demand

ISPs could further benefit poor non-beneficiary households, who often engage in agricultural wage labor, if the programs increase demand for such labor and therefore put upward pressure on agricultural wages. Only for Malawi is there empirical evidence on the effects of ISPs on agricultural wages or supply and demand. Collectively, the results suggest that MFISP does raise agricultural wages, but the magnitudes of the effects vary across studies (Table 4.4.). CGE model results suggest increases in average farm wages of 5-8% as a result of MFISP [M22], whereas micro-econometric estimates suggest increases of 1% [M18]. MFISP also appears to result in small increases (decreases) in labor demand (supply) [M18].

4.3.5. Incomes and Poverty

Apart from the household-level poverty impacts discussed above, ISPs could reduce the national poverty rate and, more specifically, notoriously stubborn rural poverty rates. That said, there is very little empirical evidence to examine these relationships. CGE modeling work from Malawi [M22] suggests that the 2006/07 MFISP reduced the national poverty rate by 1.6-2.7 percentage points and that reductions in poverty in rural and urban areas were similar, if not slightly greater in urban areas (Table 4.4.).

4.3.6. Voting Patterns and Election Results

Once established, ISPs often become entrenched features of countries' agricultural sector policies. The conventional wisdom is that scaling back of ISPs is politically damaging, whereas establishing or scaling up ISPs is politically beneficial. However, does the empirical record support these claims? Again, the answer depends on the context, both in terms of the political dynamics and the design and implementation of the ISP. Evidence from Malawi suggests that MFISP substantially increased support for Bingu Wa Mutharika and his Democratic Progressive Party (DPP) in the 2009 election [M5, M6]. But in Zambia, [Z6] find no evidence that ZFISP affected the number or share of votes won by the incumbent in the 2006 and 2011 presidential elections, on average and other factors constant.

There are several reasons ISPs may have affected voting patterns in Malawi but not in Zambia. First, the run-up to the 2009 election in Malawi was unique. After being elected in 2004,

[28] [Z15 and Z16] also estimate the effects of ISPs on national maize production for Kenya, Malawi, and Zambia but do so indirectly by multiplying the total ISP fertilizer injected into the system by the estimated changes in total fertilizer use per the previous sub-section, and further multiplying this quantity by the country-specific estimated maize yield response to fertilizer.

President Mutharika left his former party (the United Democratic Front, UDF) and started his own party (the DPP) in 2005. His old party controlled parliament, so Mutharika needed a large-scale and highly publicized policy initiative to garner support for re-election in 2009 [M5, M6, Chinsinga and Poulton 2014]. There was no such seismic political imperative in Zambia. Second, MFISP reaches a much larger share of Malawian smallholders than ZFISP does in Zambia (Table 4.2.). Third, the benefits of ZFISP are much more highly concentrated in the hands of relatively better off farmers than are the benefits of MFISP (Table 4.2). Together, these differences in the Malawian and Zambian contexts could explain the differential effects of ISPs on voting patterns in the two countries. It would be useful to test whether the MFISP played a similarly important role in elections in Malawi after 2009, when Mutharika's DPP was well established.

5. CONCLUSIONS

Agricultural input subsidy programs (ISPs) are among the most contentiously debated type of public program in Africa. Over the past decade, ISPs have become the centerpiece of many African countries' agricultural development and food security strategies. Seven countries alone spent $1.05 billion annually on such programs in 2010 (Jayne and Rashid 2013). The magnitude of these public expenditures on input subsidy programs by African governments has stayed roughly constant over the 2011-2014 period as shown in Table 3.1. We further believe that the full extent of expenditures on ISPs in some countries may not be fully reported in Table 3.1.[29] Given the high proportion of total public expenditures to agriculture that ISPs account for in numerous African countries, greater clarity is needed on their contribution to national policy goals compared to other potential uses of those resources.

This study reviews the evidence on the recent wave of input subsidy programs in Africa and identifies components of a holistic and sustainable agricultural productivity growth strategy that could improve the contribution of input subsidy programs to African governments' national development objectives. Our conclusion is that much, if not most, of the divergent findings in the applied studies of fertilizer subsidy programs are due to differing assumptions about (i) crop response rates to fertilizer use, (ii) the contribution of subsidy programs to total fertilizer use after accounting for diversion of program fertilizer and crowding out of commercial fertilizer demand, and (iii) the strength of multi-market effects on food prices and employment.[30] Fortunately, many studies have been carried out in recent years, and the weight of the evidence has coalesced around some particular findings that most can agree on.

5.1. Summary/Synthesis of Main Findings

5.1.1. Significant Effects on Food Production

Without question, large-scale input subsidy programs have raised national food yields and food production. Most studies show that the receipt of subsidized fertilizer raises beneficiary households' crop yields and production levels, at least in the year that they receive the subsidy. However, the production effects of subsidy programs tend to be smaller than originally thought because of low crop yield response to fertilizer on most smallholder-managed fields and because of the tendency of subsidy programs to partially crowd out commercial fertilizer demand. Hence, the national production response to subsidy programs, while significant, has typically been lower than expected.

5.1.2. Fertilizer Use Inhibited By Diversion and Crowding Out

There is strong evidence that recent subsidy programs, even those asserted to conform to smart subsidy criteria, have remained vulnerable to diversion and crowding out of commercial fertilizer demand. Panel survey data show that subsidy programs often distribute fertilizer to beneficiaries who consistently purchased commercial fertilizer in the past, which can result in fewer purchases from commercial sources after being given several bags of subsidized or free fertilizer. The magnitude of crowding out of commercial fertilizer depends on many factors, the most important being the characteristics of targeted beneficiary farmers. Crowding out tends to be smallest when beneficiaries are those who have not purchased commercial fertilizer in the past and in areas where commercial fertilizer sales are low or non-existent. Under such conditions, crowding in of commercial fertilizer purchases may even occur. Crowding out tends to be

[29] Underreporting may be due to expenditures being reported for federal governments only and not include state government expenditures in the case of Nigeria, and because some public expenditures related to ISPs may have exceeded our computed costs on the basis of c.i.f. pricing to main distribution areas.

[30] See, for example the widely divergent findings of Jacoby (2015) and Ricker-Gilbert, Jayne and Chirwa (2011) on the one hand, and Arndt, Pauw, and Thurlow (2014) on the other hand regarding Malawi's Farm Inputs Support Programme.

highest when subsidy programs target farmers who routinely purchase commercial fertilizer and in areas of high commercial sales.

5.1.3. Crop Response Rates of Smallholder Farmers Are Highly Variable and Usually Low

Production impacts of fertilizer subsidy programs also tend to be lower than previously envisaged because of new evidence that a large proportion of smallholder farmers do not use fertilizer efficiently. Robust empirical findings from recent large-scale household surveys show that smallholder farmers tend to obtain marginal and average products of fertilizer that are substantially lower than those obtained from studies of researcher-managed trials and experiment stations. See Section 2, Table 2.1. for more evidence on this point. These findings suggest that well designed extension and service delivery programs might enable farmers to utilize complementary inputs and management practices that raise their crop response rates to fertilizer application and hence raise the benefit-cost ratio of ISPs.

5.1.4. Fertilizer Use in Much of Africa Is Low by International Standards but not Necessarily Sub-Optimal According to Economic Criteria

Because of low efficiency of fertilizer use on the majority of smallholder farms, and based on prevailing input/output price ratios, which have stayed remarkably constant over the past several decades, fertilizer use does not appear to be clearly profitable for many farmers and especially in the semi-arid areas with variable rainfall. While Africa is often compared unfavorably to Asia in terms of fertilizer use, high intensity of fertilizer use in areas experiencing their green revolutions were confined largely to irrigated areas or areas with significant potential for water control (e.g., through widespread use of treadle pumps), where the risks of fertilizer use are relatively low and where the expected returns tend to be higher (Gautam 2015). Areas of dryland Asia also tend to have relatively low fertilizer use rates and application rates comparable to many drought-prone areas of Africa (Jayne and Rashid 2013).

5.1.5. Relatively Small and Transitory Effects on the Incomes of Beneficiary Households

Recipient households tend to significantly increase their net farm incomes (gross farm incomes minus production costs) in the year in which they receive subsidized fertilizer, first because they pay only a fraction of the cost of the fertilizer and because of the additional output obtained from the fertilizer. Studies examining the effects of subsidy receipt on area expansion and crop substitution sometimes show statistically significant but relatively small effects. Impacts on yield are the most important route by which subsidy programs could contribute to the value of crop output. However, much improvement is possible if more attention is given to improving crop response rates to subsidized inputs, and to reducing crowding out of commercial demand. Low yield response and crowding out are, in all likelihood, directly linked to the relatively small transitory effects of ISP participation on incomes and poverty.

5.1.6. Little Effect on Food Prices and Wage Rates

Studies examining the effect of fertilizer subsidy programs on national maize prices tend to find either insignificant or significant but small impacts. The factors explaining small food price effects vary by country. Sometimes, the production effect of subsidy programs can be quite large, as in Malawi, but not large enough to totally displace cereal imports, such that most of the country remains at import parity price levels both before and during the subsidy program period (e.g., Ricker-Gilbert et al. 2013). In other cases, the production effects of national subsidy programs are not large enough to have major effects on food markets or rural wage rates.

5.1.7. Fertilizer Subsidy Programs Do Produce Major Beneficiaries Who May Lobby Forcefully for the Continuation of Such Programs Once Initiated

Findings in Shimeles, Gurara, and Tessema (2015), Mason and Jayne (2013), Banful (2009), and Jayne et al. (2015) suggest that some of the major beneficiaries of fertilizer subsidy programs may be government employees and even political leaders. There is also mounting statistical evidence that the geographic distribution of fertilizer subsidies reflect the influence of political and election-related motives; however, these effects tend to be relatively minor.

5.1.8. Limited Evidence That Fertilizer Subsidy Programs Kick-Start Dynamic Growth Processes

While only a few studies exist on the potential enduring effects of fertilizer subsidy programs, the evidence is mixed. Carter, Laajaj, and Yang (2014) finds enduring production and income impacts for Mozambican farmers receiving a subsidy two years in a row, but the impacts seem to decay after two years. Another study shows little impact on fertilizer use or crop production even one year after Malawian farmers graduated from the subsidy program following three years of participation (Ricker-Gilbert and Jayne 2015). This question of whether fertilizer subsidies can kick-start dynamic growth processes that put recipient farmers on a higher long-term income trajectory is an area where more research is needed.

5.2. Moving Forward: Implications for the Design and Implementation of Subsidy Programs

Smart subsidy programs could be more than a slogan. The scope for improving subsidy program impacts could be substantial in the following areas.

5.2.1. Effort to More Effectively Target Recipients

Appropriate target criteria are difficult to define because they depend on program objectives, which tend to be variously articulated in Africa. Many African governments state their ISP objectives in vague and inconsistent terms, making it difficult to identify the extent to which beneficiaries conform to targeting criteria. *Ex post* assessments show that recipients of vouchers and fertilizers were generally better off initially than non-recipients in terms of farm sizes, asset wealth, and political/social connections, suggesting that ISPs tend to be disproportionately targeted to, or captured by, the better-off members of rural communities. Recipients also tend to have already been using fertilizer in prior years compared to non-recipients. Targeting areas where fertilizer use is low and yield response potential is sufficiently high (i.e., where use is hindered primarily by credit constraints) will more likely contribute to increased fertilizer use and increased production and productivity. Programs that target households already purchasing commercial fertilizer or operate in areas where commercial fertilizer use is already high tend to have less positive impact.

We propose that those designing ISPs define clear and consistent program objectives (improved yields? poverty reduction? increased national production? all of the above?). Then, the technologies to be included in the subsidy program and the targeting criteria can logically flow from these objectives.

5.2.2. Targeted vs. Untargeted Universal Subsidy Programs?

Decentralized targeting systems have been considered attractive because they reduce the costs of targeting effectively by tapping into local knowledge. However, local political systems have their own political economy challenges, and it is not clear that programs relying on village-level targeting outcomes necessarily improves the distribution of recipients compared to universal subsidy programs through the market or what random allocations of vouchers would have yielded (e.g., Pan and Christiaensen 2012). Since many, if not most, studies assessing ISP targeting show regressive targeting *in practice,* it might be asked whether the benefits of ISPs based on targeting (as opposed to non-targeted allocations such as the universal subsidy programs as in much of Asia) outweigh the significant costs involved in the process of determining recipients.

However, universal subsidy programs do have major disadvantages too. Past experiences across the world indicate that larger farmers disproportionately benefit from universal subsidies. Moreover, it is questionable whether many governments would find a truly universal, unrationed fertilizer subsidy program financially feasible (or desirable given the high opportunity cost, the probably that some portion of the fertilizer would end up in other countries, etc.).

5.2.3. Minimizing Crowding Out

To minimize the potential for crowding out of commercial fertilizer demand, one suggestion from the evidence would be to avoid areas where the private sector is already highly active. Of course, this would imply focusing on areas of low private sector activity, but one must then consider *why* the private sector has not been active. If the reason is that low response rates render fertilizer use unprofitable at commercial prices, fertilizer subsidies are not a viable tool (at least in the long run) for reducing poverty or increasing production. In such a case, one of the alternative strategies discussed below (e.g., agricultural research, development, and extension) is probably more appropriate. If, on the other hand, high transfer cost is the factor driving down profitability, again, fertilizer subsidies are at best a short-term solution to a long-term problem, and again, an alternative strategy (investments to lower transfer costs) will probably be more effective.

Alternatively, a subsidy program could aim to employ the private sector distribution network, rather than supplanting it. The most promising option using this approach is voucher-based ISPs, but this strategy has potential drawbacks as well. First, most pilot voucher programs also remain vulnerable to the problem of diversion (of vouchers instead of bags of fertilizer). Secondly, relying on the private sector *does* accompany the risk of “leaving behind” those underserved by the private sector for whatever reason. This brings us back to the question of *why* the private sector is not active in some places, and whether input subsidies are the best (or at least not the only important) strategy for long term poverty reduction and productivity growth.

5.2.4. Transparency of ISP Costs

Many ISPs in Africa seem to suffer from under-reporting or hidden program costs. Some governments do not publish the fiscal costs of their ISPs. Others report the budgeted costs but not actual *ex post* expenditures, which have sometimes been found to be substantially higher (Mason 2011). On top of this is the potential problem of diversion of public resources associated with fertilizer subsidy programs. Widespread anecdotal reports suggest that governments and fertilizer import companies may collude to over-invoice the cost of delivering fertilizer to designated supply points. The only study that we are aware of on this topic is by Shimeles, Gurara, and Tessema (2015), who examine the fertilizer retail-import price gap in 14 African countries between 2002 and 2013 and find that the price differentials between the retail fertilizer price and the world market price is negatively correlated with measures of government effectiveness. They conclude that the quality of institutions both in terms of executing public policy and delivering services is, on average, likely to affect retail-import price gaps.

5.2.5. Implications for Complementary Public Sector Actions to Increase the Returns to ISPS

There is robust evidence that smallholder farmers respond to incentives. Farmers will demand more fertilizer if obtaining higher crop response to fertilizer enables them to utilize it more profitably. Doing so will require that farmers obtain higher response rates to fertilizer application, which will in turn require greater public investment in effective systems of agricultural research, development, and extension that emphasize bi-directional learning between farmers of varying resource constraints and agro-ecologies, extension workers, and researchers.

Variations in crop response to fertilizer application are primarily due to variation in soil quality and farmer management practices that affect soil quality and yield. Examples include: timeliness of planting, row spacing, seed spacing, intercropping and crop rotations, management of soil pH levels, practices that recycle organic matter into the soil, use of fertilizers that are appropriate for the specific soil deficiencies of a particular plot which can be understood through periodic soil testing, appropriate fertilizer dose rates, timeliness of fertilizer application, sufficient weeding, plot drainage, terracing in hilly terrains, and adoption of conservation farming practices such as planting basins, ripping, and mulching. Many of these practices/technologies are promising in some agro-ecologies and not in others. Some may also not be feasible for resource-constrained farmers, and must be adapted through bi-directional learning between farmers and researchers to fit the conditions of different types of farmers.

There is currently a lack of specific information on the profitability of the different soil-crop-fertilizer combinations that could be employed in most countries' diverse agro-ecologies and soil types. The lack of location-specific information on crop-fertilizer profitability and the various farmer management factors that can favorably influence response rates means that researchers and extension agents are not in an informed position to provide guidance to farmers about best practices. Sub-optimal farmer practices with regard to soil fertility management increases yield risk, impedes farmers' incentives to use fertilizer, and results in foregone agricultural output. Knowledge of soil characteristics and processes regulating nutrient availability is essential to raise productivity per unit of fertilizer.

Therefore, the contribution of ISPs—and fertilizer use in general— to sustainable growth could be much greater if the soil-related constraints on agricultural productivity were addressed through a holistic program of soil fertility management. The general elements of such a holistic program are as follows:

- public sector research and development programs to identify region-specific best practices for amending soil conditions, given the great micro-variability in agro-ecological conditions in each country

- public agricultural extension programs to transfer region-specific best practices to farmers as well as provide bi-directional learning between researchers and farmers to refine best practices in light of farmers' experiences in their fields, and

- input distribution systems that make available a full range of products and services required by farmers. Input distribution systems for a wider set of soil enhancing products, such as organic fertilizer, lime, and new lines of inorganic fertilizer (e.g., deep placement, slow release types, etc.), will be developed once there is proven effective demand for such products. Developing the effective demand will in turn require research to determine site-specific soil diagnostics and extension systems that effectively link farmers to researchers. The point is that input distribution systems do not develop spontaneously – they typically require public investments to generate effective demand among farmers for new inputs.

- Ancillary public support services, such as investments in port, rail and road infrastructure to reduce costs of delivering fertilizer to rural areas and goods to markets; collective action in some cases, e.g., public comprehensive spraying in cash crop producing areas where total coverage is required to arrest pest and disease problems and where full compliance by individual farmers cannot be relied upon to produce favourable outcomes; rural electrification,[31] small-scale irrigation schemes.

To move from general thrusts to concrete steps, the following proposals are offered for consideration.

1. Provide support to existing research institutions in countries' diverse agro-ecologies and regions to develop best practices with regard to crop and soils management. Site-specific recommendations on best practices require a better understanding of the factors that might constrain productivity. Soils maps need to be updated to reflect soil functional properties (rather than soil taxonomic class) as well as more spatial detail on the variation of these functional soil properties. Affordable techniques are available for wide-scale soil testing and analyses. Building the capacity to conduct wide-scale soil testing services in rural areas of Africa would provide an important foundation to provide farmers with improved knowledge of how to manage their soils and improve their incomes from farming.

2. Benchmark landscapes would need to be identified and characterized in terms of their current soil fertility status (and variability herein) by means of multi-locational diagnostic trials. Diagnostic trials give insight into the actual soil health constraints and means to overcome apparently large yield gaps. Linking the constraint envelopes to particular landscape positions will help to map soil health constraints for the wider landscape.

3. Based on the diagnostics trials *best bet* soil management practices to address the observed soil health constraints can be identified. Local extension services could then provide soil management recommendations that would include nutrient management options in combination with other soil amendments for the various crops, and using improved varieties, aiming to improve the agronomic efficiencies of the fertilizer use, which would in turn raise the demand for fertilizer.

4. Extensive testing of the recommended soil management practices on farmers' fields will allow local research institutes to determine crop response to the various inputs and would support the formulation of recommended input packages to raise farmers' expected returns to investment. Use of locally available (organic) resources should be considered as part of the solution. This will involve the collection, collating and analyzing existing secondary data and primary data, and use of appropriate crop and soil fertility models.

5. A review of available information on the existing mineral fertilizers and its use under the current agro-ecological conditions provides the basis for further research on fertilizer product development (to achieve balanced crop nutrition) and formulation of alternative soil fertility management strategies for the various agro-ecological conditions, land

[31] A recent study by Muraoka (2015) has linked rural electrification to improved livestock breeding and increased availability and application rates of organic matter on crops.

degradation status and farm type. Extensive field demonstrations and extension guides may be needed in support of more site-specific recommendations.

6. Science-based monitoring and evaluation of yields on the fields of farmers who have adopted the recommended practice should allow for gradual development towards a *best fit* solution that reflects the farmer's socio-economic situation. There are advanced ICT tools available that can be used for data collection. Such an approach would require reform of the extension services and better collaboration with already existing rural development initiatives and with the research community.

7. Promote local community awareness campaigns to develop and implement strategies to address bush fires. Bush fires are a major contributor to the current low levels of soil organic matter in parts of Africa. Uncontrolled bush fires consume vegetation cover and crop residues on agricultural land, and undermine nutrient recycling to improve soil fertility. Inadequate enforcement of bush fire laws impedes farmers from adopting sustainable soil management strategies. Community level strategies in Northern Ghana have been successful at enforcing rules and reducing rates of bush fire. In light of this, we recommend that local authorities (e.g., District Assemblies) sensitize their constituents and develop modalities to implement bush fire prevention programs at community level as a means to safeguard life and properties, and boost organic matter content in the soil.

8. Domesticate Fertilizer Quality Regulations to protect farmers. On-going efforts to identify how to reduce potential problems associated with fertilizer quality and product adulteration should be encouraged. For example, West African governments could identify areas that need strengthening in terms of their capacity to adapt the regional regulatory framework signed by ECOWAS in 2012. This is important to ensure that farmers access fertilizers with correctly specified nutrient content, which has implications for crop response rates.

9. Review of policies affecting fertilizer use and response rates. Specific government policies may have unintended adverse consequences on government's efforts to promote fertilizer use. For example, police checkpoints and road taxes increase the price that farmers pay for fertilizer and reduce the price that they receive for crops. These taxes reduce farmers' incentives to use fertilizer.

In some countries, fertilizer-importing companies pay multiple fees from different regulatory bodies involved in fertilizer control at the clearing stage. In Tanzania's case, for example, this includes the Tanzania Fertilizer Regulatory Authority (TFRA); Weight and Measures Authority; Radiation Commission; and Chief Government Chemist; and the Tanzania Bureau of Standards. Because of this multiplicity of bodies, there are multiple fees, which are inevitably passed onto to farmers through higher prices.

5.3. Concluding Remarks

It is commonly argued that intensification of agriculture has been associated with major increases in the use of chemical fertilizers in every region of the world, that fertilizer use must increase rapidly in Africa to achieve sustainable agricultural growth, and that fertilizer promotion policies and programs are therefore imperative.

There is little disagreement on this issue, but it is increasingly apparent that this line of argument is often taken out of context, with too little attention given to how fertilizer use must be raised (and what other interventions are needed) in order to contribute meaningfully to African governments' national policy goals. Fertilizer use can increase in ways that are neither sustainable nor effective in promoting agricultural productivity. Sustainable agricultural intensification may need to take place differently in much of Africa compared to South and East Asia. Sub-Saharan Africa will remain much more dependent on rainfed production. Sustained increases in fertilizer use will require that long-term soil fertility issues are acknowledged and addressed in government programs so that farmers find its sustained use to be *profitable*, leading to robust effective demand. This can only occur by funding research that acknowledges that soils throughout Africa were often born earlier (on a geological timescale) and from parent material that is fundamentally different than most other parts of the world. In combination with the patterns of weathering that have prevailed on the continent for millennia, and decades of farming with unsustainable use levels of "modern inputs", this has resulted in soil conditions that are physically, chemically and biologically unique, meaning input prescriptions appropriate in other regions may not be the best options in African contexts. Other major components for sustainable agricultural intensification include investments in physical infrastructure, agricultural R&D, and a policy environment supportive of private investment and competition in agri-food value chains.

Assuming that African governments will continue to run ISPs for some time to come, we believe that these programs can more effectively achieve their goals in the following ways: (a) targeting the subsidies to households that could use fertilizer profitably but could not afford to do (or whose purchases are well below optimal levels) due to liquidity constraints; (b) involving the private sector to a greater degree than is currently done in most cases, e.g., through the use of vouches that are redeemable at any private retail store; and (c) confront and tackle the problem of diversion of subsidy program fertilizer by authorities. Perhaps even more important is for the public sector to make fertilizer use more profitable for farmers and thereby raise effective commercial demand. This would involve: (d) identifying how to streamline costs and reduce risks in fertilizer supply chains to reduce the price of fertilizer at the farm gate (e.g., Jayne et al. 2003; IFDC 2013); (e) supporting reliable and competitive output markets through policies that promote new investment and competition in agri-food value chains (e.g., World Bank 2007); and (f) promoting farmer training and education programs to improve the efficiency with which farmers use fertilizer, within the context of a more comprehensive soil fertility management program (e.g., Dreschel et al. 2001; Tittonell and Giller 2013). Point (f) will involve more widespread soil testing services, more specific fertilizer blends appropriate for farmers' specific conditions, investment in drainage to prevent water-logging, ameliorating soil acidity conditions which impede plant uptake of nutrients, deep placement application, appropriate plant populations for specific locations, and restoring soil organic matter through soil fertility management practices including minimum tillage, use of green manures, and intercropping with shrubby legumes, among others.

It should also be noted that by most accounts, implementing the strategies summarized in point (f) should be affordable given governments' demonstrated willingness to invest in productivity enhancements. Based on interviews with high-ranking Zambian officials, for example, Burke (2012) discusses a plan to invest in plots where agents would work with farmers to illustrate the long-term (3 to 7 years) benefits of managing soil pH. Managing one such small plot in 800 district camps (covering nearly 50% of the country) would have a marginal cost of less than the government's annual allocation to an Agricultural Show— a fair-like event hosted in the capital as part of the farmer outreach strategy. The apparent affordability, high leverage potential and low risk of implementing such marginal strategy diversifications merits more attention.

REFERENCES

Reference list for Tables 4.1.- 4.4. and those bracketed in Section 4 are in Appendix C.

Alliance for a Green Revolution in Africa (AGRA). 2009. Developing Rural Agricultural Input Supply Systems for Farmers in Africa. Nairobi: AGRA.

Anderson, J.R., J.L. Dillion, and B. Hardaker. 1977. *Agricultural Decision Analysis*. Ames, Iowa: The Iowa State University.

Ariga, J. and T.S. Jayne. 2011. Fertilizer in Kenya: Factors Driving the Increase in Usage by Smallholder Farmers. In *Yes Africa Can: Success Stories from a Dynamic Continent,* ed. P. Chuhan-Pole and M. Angwafo. Washington, DC: World Bank.

Awotide, B.A., A. Karimov, A. Diagne, and T. Nakelse. 2013. The Impact of Seed Vouchers on Poverty Reduction among Smallholder Rice Farmers in Nigeria. *Agricultural Economics* 44.6: 647-658.

Bamber, P., A. Abdulsamad, and G. Gereffi. 2014. Burundi in the Agribusiness Global Value Chain: Skills for Private Sector Development. Center on Globalization, Governance and Competitiveness. Durham, NC: Duke University.

Banful, A.B. 2009. *Operational Details of the 2008 Fertilizer Subsidy in Ghana-Preliminary Report.* Ghana Strategy Support Program (GSSP) Background Paper No. 18. Washington, DC: International Food Policy Research Institute.

Bates, R. H. 1981. *Markets and States in Tropical Africa: The Political Basis of Agricultural Policies.* Berkeley, CA: University of California Press.

Bationo, A., C.B. Christianson, W.E. Baethgen, and A.U. Mokwunye. 1992. A Farm-Level Evaluation of Nitrogen and Phosphorus Fertilizer Use and Planting Density for Pearl Millet Production in Niger. *FertilizerResearch* 31.2: 175-184.

Beaman, L., D. Karlan, B. Thuysbaert, and C.R. Udry. 2013. *Profitability of Fertilizer: Experimental Evidence from Female Rice Farmers in Mali.* National Bureau of Economic Research (NBER) Working Paper No. 18878. Cambridge, MA: NBER.

Berhane, G., J. Hoddinott, N. Kumar, et al. 2011. Evaluation of Ethiopia's Food Security Program: Documenting Progress in the Implementation of the Productive Safety Nets Programme and the Household Asset Building Programme. Washington DC: International Food Policy Research Institute. Mimeo.

Burke, W.J. 2012. Determinants of Maize Yield Response to Fertilizer Application in Zambia: Implications for Strategies to Promote Smallholder Productivity. Ph.D. dissertation, Michigan State University.

Burke, W.J., E. Frossard, S.Kabwe, and T.S. Jayne. Forthcoming. *Understanding Fertilizer Effectiveness and Adoption in Zambia.* MSU International Development Working Paper Forthcoming. East Lansing, MI: Michigan State University.

Carter, M.R., R. Laajaj, and D. Yang. 2014. *Subsidies and the Persistence of Technology Adoption Field Experimental Evidence from Mozambique.* NBER Working Paper No. 20465. Cambridge, MA: NBER.

Chibwana, C., M. Fisher and G. Shively. 2012. Cropland Allocation Effects of Agricultural Input Subsidies in Malawi. *World Development* 40.1: 124-133.

Chirwa, E. and A. Dorward. 2013. *Agricultural Input Subsidies: The Recent Malawi Experience.* Oxford, UK: Oxford University Press.

Chinsinga, B. and C. Poulton. 2014. Beyond Technocratic Debates: The Significance and Transience of Political Incentives in the Malawi Farm Input Subsidy Programme. *Development Policy Review* 32.S2: S123-S150.

Christiaensen, L., L. Demery, and J. Kuhl. 2011. The (Evolving) Role of Agriculture in Poverty Reduction -- An Empirical Perspective. *Journal of Development Economics* 96.2: 239-254.

Commission Nationale d'Agriculture (CNA). 1991. *Rapport Préliminaire, Vol. II: Appuis à la Production Agricole,* Draft report. Kigali: CNA.

CSO/MAL/IAPRI (Central Statistical Office, Ministry of Agriculture and Livestock and Indaba Agricultural Policy Research Institute) 2012-2015. Rural Agricultural Livelihoods Survey Data. : IAPRI, Lusaka, Zambia: CSO/MAL/IAPRI.

Dorward, A.R. and E. Chirwa. 2011. The Malawi Agricultural Input Subsidy Programme: 2005/06 to 2008/09. *International Journal of Agricultural Sustainability* 9.1: 232-47.

Dorward, Andrew, Ephraim Chirwa, Valerie Kelly, et al. 2008. Evaluation of the 2006/07 Agricultural Input Subsidy Programme, Malawi. Final Report. Lilongwe, Malawi: Ministry of Agriculture and Food Security.

Drechsel, P., L. Gyiele, D. Kunze, and O. Cofie. 2001. Population Density, Soil Nutrient Depletion, and Economic Growth in Sub-Saharan Africa. *Ecological Economics* 38.2: 251-258.

Druilhe, Z. and J. Barreiro-Hurlé. 2012. *Fertilizer Subsidies in Sub-Saharan Africa*. Agricultural Development Economics Division (ESA) Working Paper No. 12-04. Rome, Italy: ESA, Food and Agriculture Organization of the United Nations.

Duflo, E., M. Kremer, and J. Robinson. 2008. How High Are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya. *American Economic Review: Papers and Proceedings* 98.2: 482-488.

Dugger, C. 2007. Ending Famine, Simply by Ignoring Experts. *New York Times*, 2 December, 2007.

Economist Intelligence Unit (EIU). 2008. Lifting African and Asian Farmers out of Poverty: Assessing the Investment Needs. Research report for the Bill and Melinda Gates Foundation.

Ekasingh, B., P. Gypmantasiri, K. Thong Ngam, and P. Grudloyma. 2004. *Maize in Thailand: Production Systems, Constraints, and Research Priorities.* Mexico, DF: CIMMYT.

Fan, S., A. Gulati, and S. Thorat. 2008. Investment, Subsidies, and Pro-poor Growth in Rural India. *Agricultural Economics* 39.2: 163-170.

Food and Agriculture Organization (FAO). 1975. Planning and Organization of Fertilizer Use Development in Africa. Rome, Italy: FAO.

Foster, J., J. Greer, and E. Thorbecke. 1984. A Class of Decomposable Poverty Measures. *Econometrica* 52.3: 761-766.

Fuentes, P.A., B.L. Bumb and M. Johnson. 2012. Improving Fertilizer Markets in West Africa: The Fertilizer Supply Chain in Mali. IFDC and IFPRI report. Can be accessed at http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=E87A6046004F1F492018DA0A40CD45E5?doi=10.1.1.590.1554&rep=rep1&type=pdf.

Gautam, M. 2015. Agricultural Subsidies: Resurging Interest in a Perennial Debate. Agriculture Global Practice. *Indian Journal of Agricultural Economics* 70.1: 83-105.

Ghana Ministry of Food and Agriculture. Accra, Ghana. Accessed at http://mofa.gov.gh.

Giller, K. and G. Cadisch. 1995. Future Benefits from Biological Nitrogen Fixation: An Ecological Approach to Agriculture. *Plant and Soil* 174: 255-277.

Giller, K., E. Rowe, N. de Ridder, and H. van Keulen. 2006. Resource Use Dynamics and Interactions in the Tropics: Scaling up in Space and Time. *Agricultural Systems* 88.1: 8-27.

Gilligan, D.O., J. Hoddinott, and A.S. Taffesse. 2009. The Impact of Ethiopia's Productive Safety Net Programme and its Linkages. *The Journal of Development Studies* 45.10: 1684-1706.

Gulati A. and T. Narayanan. 2003. *The Subsidy Syndrome in Indian Agriculture*. New Delhi: Vedams Books.

Harrigan, J. 2008. Food Insecurity, Poverty and the Malawian Starter Pack: Fresh Start or False Start? *Food Policy* 33.3: 237-49.

Hoddinott, J., G. Berhane, D. Gilligan, et al. 2012. The Impact of Ethiopia's Productive Safety Net Pprogramme and Related Transfers on Agricultural Productivity. *Journal of African Economies* 21.5: 761-786. http://doi.org/10.1093/jae/ejs023

IFDC. IFDC prices available at http://213.193.193.214/IFDC_ReportServer/Pages/ReportViewer.aspx?/IFDC_Reports/Monthly+National+Prices&rs:Command=Render).

IFDC. 2011. An Assessment of the Potential for Increased Private Sector Involvement in the Fertilizer Supply System in Rwanda: A Survey of Distributors and Agro-Dealers. Privatization of Rwanda's Fertilizer Import and Distribution System (PReFER). Muscle Shoals, AL: IFDC.

IFDC. 2013. Growth Enhancement Support Scheme 2013: Lessons Learned. Abuja, Nigeria. Muscle Shoals, AL: IFDC.

IFDC. 2013b. Support Plan for the New National Fertilizers Subsidy Program in Burundi (PAN-NFSPB). Quarterly Activities 2nd Report (1st April – 30th September 2013). Submitted to the Netherland Embassy in Burundi by IFDC, International Fertilizer Development Center. Muscle Shoals, AL: IFDC.

International Fertilizer Development Corporation (IFDC). 2014. GES-TAP (Growth Enhancement Support Touch-and-Pay) Final Report. Muscle Shoals, AL: IFDC.

International Food Policy Research Institute (IFPRI). 2011. *Global Food Policy Report: 2011*. Washington, DC: IFPRI.

IFPRI. 2015. Data Set. Statistics on Public Expenditures for Economic Development (SPEED). Washington, DC: International Food Policy Research Institute.

Jacoby, H. 2015. Smart Subsidy? Welfare and Distributional Implications of Malawi's FISP. Report, Development Economics (DEC) Research Group, Washington, DC: The World Bank.

Jayne, T.S., D. Mather, N.M. Mason, and J. Ricker-Gilbert. 2013. How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion, and Benefit/Cost Assessments. *Agricultural Economics* 44.6: 687-703.

Jayne, T.S., D. Mather, N.M. Mason, et al. 2015. Rejoinder to the comment by Andrew Dorward and Ephraim Chirwa on Jayne, T.S., D. Mather, N.Mason, and J. Ricker-Gilbert. 2013. How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion and Benefit/Cost Assessments. Agricultural Economics 44.6: 687-703. *Agricultural Economics* 46: 745-755.

Jayne, T.S. and S. Rashid. 2013. Input Subsidy Programs in Sub-Saharan Africa: A Synthesis of Recent Evidence. *Agricultural Economics* 44.6: 547-562.

Jayne, T.S., T. Yamano, M. Weber, et al. 2003. Smallholder Income and Land Distribution in Africa: Implications for Poverty Reduction Strategies. *Food Policy* 28.3: 253-275.

Jebuni, C. and W. Seini. 1992. *Agricultural Input Policies under Structural Adjustment: Their Distributional Implications*. Cornell Food and Nutrition Policy Program Working Paper No. 31. Ithaca, NY: Cornell University.

Johnston, B.F. and P. Kilby. 1975. *Agriculture and Structural Transformation: Economic Strategies in Late Developing Countries*. New York: Oxford University Press.

Jones, A., H. Breuning-Madsen, M. Brossard, et al. 2013. *Soil Atlas of Africa*. European Commision, Luxembourg: Publications Office of the European Union.

Kalibata, A.M. 2010. CAADP Implementation in Rwanda: Initiatives, Successes, Lessons Learnt and Challenges, CFS36 Agenda Item VII Rwanda; National Initiatives for Food Security and Nutrition: Case Studies. Rwanda: CAADP.

Karera, T. and J.M. Byakweli. 2010. Crop Intensification Program (2008-2009), Evaluation Report; Catalyze Accelerated Agricultural Intensification for Social and Environmental Stability (CATALIST) Project in Central Africa's Great Lakes Region. Rwanda

Kasanga, J., O. Daka, J. Chanda, and A. Undi. 2010. Model and Implementation Plan for the Expanded Food Security Pack Programme. Lusaka, Zambia: IMCS Limited.

Kelly, V. 2005. Farmers' Demand for Fertilizer in Sub-Saharan Africa. East Lansing, MI: Michigan State University.

Kilic, T., E. Whitney, and P. Winters. 2015. Decentralised Beneficiary Targeting in Large-Scale Development Programmes: Insights from the Malawi Farm Input Subsidy Programme. *Journal of African Economies* 24.1: 26-56.

Kenya Ministry of Agriculture. Various dates. Unpublished Data Files for Nakuru Fertilizer Prices. Nairobi, Kenya: Ministry of Agriculture.Market Information Bureau for Maize Prices.

Kenya Ministry of Agriculture (KMOA). 2007. The National Accelerated Agricultural Inputs Access Program (NAAIAP): Program Design and Implementation Framework. Nairobi, Kenya: KMOA.

Kherallah, M., C. Delgado, E. Gabre-Madhin et al. 2002. *Reforming Agricultural Markets in Africa,* Baltimore: Johns Hopkins University Press.

KMOA. 2010. The National Accelerated Agricultural Inputs Access Program (NAAIAP): Progress and Way Forward for NAAIAP. Nairobi, Kenya: KMOA.

KMOA. 2013a. Memo Re: NAAIAP Progress Reports (April 23, 2013). Nairobi, Kenya: KMOA.

KMOA. 2013b. NAAIAP Progress Report, April 2013. Nairobi, Kenya: KMOA.

Lal, R. 2011. Sequestering Carbon in Soils of Agro-ecosystems. *Food Policy* 36.Supplement 1: S33-S39.

Levy, S., ed. 2005. Starter Packs: A Strategy to Fight Hunger in Developing and Transition Countries? Lessons from the Malawi Experience, 1998-2003. Wallingford, UK: CABI.

Lipton, M. 2006. Can Small Farmers Survive, Prosper, or Be the Key Channel to Cut Mass Poverty? *Journal of Agriculture and Development Economics* 3.1: 58-85.

Liverpool-Tasie, L.S.O. 2014. Fertilizer Subsidies and Private Market Participation: The Case of Kano State, Nigeria. *Agricultural Economics* 45.6: 663-678.

Liverpool-Tasie, L.S.O. 2014a. Fertilizer Subsidies and Private Market Participation: The Case of Kano State, Nigeria. *Agricultural Economics* 45.6: 663-678.

Liverpool-Tasie, L.S.O. 2014b. Do Vouchers Improve Government Fertilizer Distribution? Evidence from Nigeria. *Agricultural Economics* 45.4: 393-407.

Liverpool-Tasie, L.S.O. 2014c. Farmer Groups and Input Access: When Membership is Not Enough. *Food Policy* 46 (June): 37-49.

Liverpool-Tasie, S.B. Omonona, A. Sanou, and W. Ogunleye. 2015. Is Increasing Inorganic Fertilizer Use in Sub-Saharan Africa a Profitable Proposition? Evidence from Nigeria. Policy Research Working Paper No. 7201. Washington, DC: World Bank Group, Africa Region.

Liverpool-Tasie, L.S., and S. Salau. 2013. *Spillover Effects of Targeted Subsidies: An Assessment of Fertilizer and Improved Seed Use in Nigeria*. IFPRI Discussion Paper No. 01260, Washington, DC: International Food Policy Research Institute, Development Strategy and Governance Division.

Liverpool-Tasie, S. and H. Takeshima. 2013. Input Promotion within a Complex Subsector: Fertilizer in Nigeria. *Agricultural Economics* 44.6: 581-594.

Logistics Unit. 2015. Final Report on the Implementation of the Agricultural Inputs Subsidy Programme, 2014-15. Lilongwe, Malawi: Logistics Unit.

Lunduka, R., J. Ricker-Gilbert, and M. Fisher. 2013. What Are the Farm-Level Impacts of Malawi's Farm Input Subsidy Program? A Critical Review. *Agricultural Economics* 44.6: 563-579.

Marenya, P. and C. Barrett. 2009. State-Conditional Fertilizer Yield Response on Western Kenyan Farms. *American Journal of Agricultural Economics* 91.4: 991-1006.

Mason, Nicole M. 2011. Marketing Boards, Fertilizer Subsidies, Prices, and Smallholder Behavior: Modeling and Policy Implications for Zambia. Ph.D. dissertation. Michigan State University.

Mason, N.M., T.S. Jayne, and R. Mofya-Mukuka. 2013. Zambia's Input Subsidy Programs. *Agricultural Economics* 44.6: 613-628.

Mason, N.M. and J. Ricker-Gilbert. 2013. Disrupting Demand for Commercial Seed: Input Subsidies in Malawi and Zambia. *World Development* 45(May): 75-91.

Mason, N.M. and S.T. Tembo. 2015. *Do Input Subsidy Programs Raise Incomes and Reduce Poverty among Smallholder Farm Households? Evidence from Zambia.* Indaba Agricultural Policy Research Institute Working Paper No. 92. Lusaka, Zambia: IAPRI.

Masters,W., T. Bedingar, and J. Oehmke. 1998. The Impact of Agricultural Research in Africa: Aggregate and Case Study Evidence. *Agricultural Economics* 19: 81-86.

Mather, D. and T.S. Jayne. 2015. Fertilizer Subsidies and the Role of Targeting in Crowding Out: An Assessment of Smallholder Fertilizer Demand in Kenya. Selected paper prepared for the International Conference of Agricultural Economics, 9-14 August. Milan, Italy.

Matsumoto, T. and T. Yamano. 2011. Optimal Fertilizer Use on Maize Production in East Africa. In *Emerging Development of Agriculture in East Africa: Markets, Soil, and Innovations,* ed. T. Yamano, K. Otsuka, and F. Place. The Netherlands: Springer.

Maur, J.C. and B. Shepherd. 2015. *Connecting Food Staples and Input Markets in West Africa: A Regional Trade Agency for ECOWAS Countries*. Washington, DC: The World Bank.

Mellor, J. 1976. *The New Economics of Growth.: A Strategy for India and the Developing World* A Twentieth Century Fund Study. Ithaca, NY: Cornell University Press.

MINAGRI. 2007 Strategy for Developing Fertilizer Distribution Systems in Rwanda. Kigali: Ministry of Agriculture and Animal Resources.

Minot, N. 2009. Smart Fertilizer Subsidies in Sub-Saharan Africa: New Wine or Just New Bottles? Panel on Smart Input Subsidies and Sustainable Development, Washington, DC: IFPRI. Available at: https://www.ifpri.org/file/34788/download

Minten, B., B. Koru, and D. Stifel. 2013. The Last Mile(s) in Modern Input Distribution: Pricing, Profitability, and Adoption. *Agricultural Economics*, 44: 629–646. doi: 10.1111/agec.12078.

Minten, B., D. Stifel and S. Tamru. 2014. Structural Transformation of Cereal Markets in Ethiopia Structural Transformation of Cereal Markets. *The Journal of Development Studies* 50.5: 611–629. http://doi.org/10.1080/00220388.2014.887686

Monitor Group, The. 2012. The Business Case for Investing in the Import and Distribution of Fertilizer in Rwanda. Prepared for USAID, 13 April 2012. Martinez, GA: The Monitor Group.

Morris, M., V. Kelly, R. Kopicki, and D. Byerlee. 2007. *Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines*. Washington, DC: World Bank.

Msolla, M.M. 2014. Effects of the Subsidy Voucher Program on Fertilizer Markets: Example from Tanzania. Paper presented at the IFDC Training on Fertilizer Value Chain-Supply System Management and Servicing Farmers' Needs, 14-18 April. Accra, Ghana.

Muraoka, R. 2015. Three Essays on Land and an Intensive Farming System in Sub-Saharan Africa: Evidence from Kenya. Unpublished PhD dissertation. Michigan State University. ISBN: 9781321736038.

National Cereals and Produce Board (NCPB). 2013. NCPB Fertilizer Business Portfolio. Powerpoint presentation by NCPB official. Nairobi, Kenya: NCPB.

National Fertilizer Subsidy Program. 2014. National Fertilizer Subsidy Program. 2014. Training Manual: The Functioning of the National Fertilizer Subsidy Program in Burundi. Bujumbura, Burundi: Ministry of Agriculture and Livestock (MINAGRIE).

Nigeria Federal Ministry of Agriculture and Rural Development (NFMARD). No date. Accessed July 2015 at http://www.fmard.gov.ng/Growth-Enhancement-Scheme.

OANDA.com. Accessed August 2015 at https://www.oanda.com/.

Oehmke, J. and E. Crawford. 1996. The Impact of Agricultural Technology in Sub-Saharan Africa. *Journal of African Economies* 5.2: 271-292.

Pan, L. and L. Christiaensen. 2012. Who Is Vouching for the Input Voucher? Decentralized Targeting and Elite Capture in Tanzania. *World Development* 40.8: 1619-1633.

PNSEB. 2015. Personal communication with PNSEB Staff.

Powlson, D., P. Gregory, W. Whalley, et al. 2011. Soil Management in Regional to Sustainable Agriculture and Ecosystem Services. *Food Policy* 36.Supp. 1: S72-S87.

Programme Against Malnutrition (PAM). 2005. The Targeted Food Security Pack for Vulnerable but Viable Farmers: Programme Implementation Guidelines for the 2005/2006 Agricultural Season. Lusaka, Zambia: PAM.

Rada, N. 2013. Assessing Brazil's Cerrado Agricultural Miracle. *Food Policy* 38: 146-155.

Ragasa, Catherine, Antony Chapoto, and Shashi Kolavalli. 2014. *Maize Productivity in Ghana*. GSSP Policy Note 5. Washington, DC: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128263

Rashid, A. 2010. Agro-economic Feasibility of Fertilizer Use for Wheat Cultivation in Rainfed Regions of Pakistan. *Journal of Agricultural Research* 48.3: 353-359.

Rashid, S., R. Cummings, and A. Gulati. 2007. Grain Marketing Parastatals in Asia: Results from Six Case Studies. *World Development* 35.11: 1872-1888.

Rashid, S., N. Tefera, N. Minot, and G. Ayele. 2013. Can Modern Input Use Be Promoted without Subsidies? An Analysis of Fertilizer in Ethiopia. *Agricultural Economics* 44.6: 595-611.

Republic of Burundi. 2013. La subvention des engrais, une voie pour atteindre la securite alimentaire durable au Burundi Bujumbura: Presidence de La Republique. http://www.presidence.bi/spip.php?article3567.

Republic of Rwanda. 2014. National Fertilizer Policy. Kigali: The Ministry of Agriculture and Animal Resources.

Resnick, D. and D. Mather. 2015. *Agricultural Inputs Policy under Macroeconomic Uncertainty: Applying the Kaleidoscope Model to Ghana's Fertilizer Subsidy Program (2008-2015).* IFPRI/MSU draft working paper. Washington, DC and East Lansing: IFPRI and MSU.

Ricker-Gilbert, J. and T.S. Jayne. 2012. Do Fertilizer Subsidies Boost Staple Crop Production and Reduce Poverty across the Distribution of Smallholders in Africa? Quantile Regression Results from Malawi. Selected Paper for the Triennial Meeting of the International Association of Agricultural Economists, 18-24August, Foz Do Iguacu, Brazil.

Ricker-Gilbert, J. and T.S. Jayne. 2015. What Are the Dynamic Effects of Fertilizer Subsidies on Commercial Fertilizer Demand and Maize Production? Panel Evidence from Malawi. Paper prepared for presentation at the symposium on Using Smart Subsidies to Support Small Scale Farmers in Africa, International Conference of Agricultural Economists, 18 August. Milan, Italy.

Ricker-Gilbert, J., T.S. Jayne, and E. Chirwa. 2011. Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi. *American Journal of Agricultural Economics* 93.1: 26-42.

Ricker-Gilbert, J., N. Mason, F. Darko, and S. Tembo. 2013. What Are the Effects of Input Subsidy Programs on Maize Prices? Evidence from Malawi and Zambia. *Agricultural Economics* 44.6: 671-686.

Sauer, J. and H. Tchale. 2009. The Economics of Soil Fertility Management in Malawi. *Review of Agricultural Economics* 31.3: 535-60.

Sheahan, M., R. Black, and T. Jayne. 2013. Are Kenyan Farmers Under-utilizing Fertilizer? Implications for Input Intensification Strategies and Research. *Food Policy* 41: 39-52.

Sheahan, M., J. Olwande, L. Kirimi, and T.S. Jayne. 2014. *Targeting of Subsidized Fertilizer Under Kenya's National Accelerated Agricultural Input Access Program* (NAAIAP). Tegemeo Institute of Agricultural Policy and Development Working Paper No. 52. Nairobi, Kenya: Tegemeo Institute.

Shimeles, A., D.Z.Gurara, and D.B. Tessema. 2015 *Market Distortions and Political Rent: The Case of Fertilizer Price Divergence in Africa*. Institute for the Study of Labor Discussion Paper No. 8998, Bonn, Germany: Institute for the Study of Labor.

Snapp, S., M. Blackie, R. Gilbert, et al. 2010. Biodiversity Can Support a Greener Revolution in Africa. *Proceedings of the National Academy of Sciences* 107.48: 20840-20845.

Snapp, S., T.S. Jayne, W. Mhango, et al. 2014. *Maize Yield Response to Nitrogen in Malawi's Smallholder Production Systems.* IFPRI Working Paper No. 9, Malawi Strategy Support Program. Washington, DC: International Food Policy Research Institute.

SPEED data available at: (http://www.ifpri.org/book-39/ourwork/programs/priorities-public-investment/speed-database).

Stoorvogel, J.J. and E. Smaling. 1990. *Assessment of Soil Nutrient Depletion in Sub-Saharan Africa: 1983–2000. Nutrient Balances per Crop and per Land Use System*. Report No. 28, Vol. 2. Wageningen, The Netherlands: Winand Staring Center.

Takeshima, H. and L.S.O. Liverpool-Tasie. 2015. Fertilizer Subsidies, Political Influence and Local Food Prices in Sub-Saharan Africa: Evidence from Nigeria. *Food Policy* 54(July): 11-24.

Takeshima, H. and E. Nkonya. 2014. Government Fertilizer Subsidy and Commercial Sector Fertilizer Demand: Evidence from the Federal Market Stabilization Program (FMSP) in Nigeria. *Food Policy* 47(August): 1-12.

Tittonell, P. and K. Giller. 2013. When Yield Gaps Are Poverty Traps: The Paradigm of Ecological Intensification in African Smallholder Agriculture. *Field Crops Research* 143: 76-90.

Tittonell, P., S. Zingore, Mark T. Van Wijk, et al. 2007. Nutrient Use Efficiencies and Crop Responses to N, P, and Manure Applications in Zimbabwean Soils: Exploring Management Strategies across Soil Fertility Gradients. *Field Crop Research* 100.2-3: 348-368.

van de Walle, N. 2001. *African Economies and the Politics of Permanent Crisis, 1979–1999*. Cambridge: Cambridge University Press.

Vanlauwe, B., J. Kihara, P. Chivenge, et al. 2011. Agronomic Use Efficiency of N Fertilizer in Maize-Based Systems in Sub-Saharan Africa within the Context of Integrated Soil Fertility Management. *Plant and Soil* 339.1: 35-50.

Wanzala-Mlobela, M., P. Fuentes, and S. Mkumbwa. 2013. NEPAD Policy Study: Practices and Policy Options for the Improved Design and Implementation of Fertilizer Subsidy Programs in Sub-Saharan Africa. Midrand, South Africa: NEPAD Planning and Coordinating Agency.

Ward, M. and P. Santo. 2010. Looking beyond the Plot: The Nutritional Impact of Fertilizer Policy. Selected paper prepared for presentation at the Agricultural and Applied Economics Association 2010 AAEA, CAES, and WAEA Joint Annual Meeting, 25-27 July. Denver, Colorado.

Whitbread, A., A. Sennhenn, and K. Grotelüschen. 2013. *Nitrogen-use-efficiency in Maize-Based Farming Systems in Malawi: A Simulation Study and Meta-Analysis of Literature*. Göttingen, Germany: Faculty of Agricultural Sciences, University of Goettingen.

World Bank. 2007. World Bank Assistance to Agriculture in Sub-Saharan Africa: An IEG Review. Washington, DC: World Bank.

World Bank. 2008. World Development Report 2008: Agriculture for Development. Washington, DC: World Bank.

World Bank. 2009. *Awakening Africa's Sleeping Giant: Prospects for Commercial Agriculture in the Guinea Savannah Zone and Beyond*. Morris, Michael, Hans Binswanger, Derek Byerlee, et al. 2009. Directions in Development; Agriculture and Rural Development. Washington, DC: World Bank.

World Bank. 2014. World Bank. 2014. Tanzania — Strengthening National Comprehensive Agricultural Public Expenditure in Sub-Saharan Africa: National Agricultural Input Voucher Scheme (NAIVS). Public Expenditure Review (PER). Washington DC: World Bank Group. http://documents.worldbank.org/curated/en/2014/02/19456105/tanzania-strengthening-national-comprehensive-agricultural-public-expenditure-sub-saharan-africa-national-agricultural-input-voucher-scheme-naivs

Xu, Z., W.J. Burke, T.S. Jayne., and J. Govereh. 2009a. Do Input Subsidy Programs 'Crowd In' or 'Crowd Out' Commercial Market Development? Modeling Fertilizer Use Decisions in a Two-Channel Marketing System. *Agricultural Economics* 40.1: 79-94.

Xu, Z., Z. Guan, T.S. Jayne, and R. Black. 2009b. Profitability of Applying Fertilizer on Maize for Smallholder Farmers in Zambia. *Agricultural Economics* 40.4: 437-446.

Yanggen, D., V. Kelly, T. Reardon, and A. Naseem. 1998. *Incentives for Fertilizer Use in Sub-Saharan Africa: A Review of Empirical Evidence on Fertilizer Response and Profitability*. MSU International Development Working Paper No. 70. East Lansing, Michigan: Michigan State University.

Yawson, D.O., F. Armah, E.K. Afrifa and S.K.N. Dadzie. 2010. Ghana's Fertilizer Subsidy Policy: Early field lessons from farmers in Central Region. *Journal of Sustainable Development - Africa* 12.3: 191-203.

You, L., C. Ringler, U. Wood-Sichra, et al. 2012. What Is the Irrigation Potential for Africa? A Combined Biophysical and Socioeconomic Approach. *Food Policy* 36.6: 770-782.

ZMACO (Zambian Ministry of Agriculture and Cooperatives), Agricultural Consultative Forum, and Food Security Research Project. 2002. *Developments in Fertilizer Marketing in Zambia: Commercial Trading, Government Programs, and the Smallholder Farmer*. Food Security Research Project Working Paper No. 4. Lusaka, Zambia: FSRP, ZMACO. Available at http://aec.msu.edu/fs2/zambia/wp4zambia.pdf.

Zambia Ministry of Agriculture and Livestock (ZMAL). Various years. Farmer Input Support Programme Implementation Manual. Lusaka, Zambia: ZMAL.

ZMAL. 2012. Farmer Input Support Programme Implementation Manual, 2012/2013 Agricultural Season. Lusaka, Zambia: ZMAL.

ZMAL. 2014. Farmer Input Support Programme Implementation Manual, 2014/2015 Agricultural Season. Lusaka, Zambia: ZMAL.

Zambia Ministry of Finance and National Planning (ZMFNP). Various years. Estimates of Revenue and Expenditure: Activity Based Budget. Lusaka, Zambia: Government Printer.

Zambia Central Statistical Office. Various dates. Unpublished Retail Price Data Files. Lusaka: Government of Zambia.

APPENDIX A. OVERVIEWS OF SPECIFIC INPUT SUBSIDY PROGRAMS IN AFRICA

This section provides brief overviews of the major government ISPs in SSA, with a focus on Ethiopia, Ghana, Kenya, Malawi, Nigeria, Tanzania, and Zambia. We focus on these countries because each has been the subject of multiple econometric- or simulation-based studies of (*de facto*) program targeting and/or impacts—results that are synthesized in the next section. There are several other government ISPs in SSA, including in Burkina Faso, Mali, Senegal, Burundi, and Rwanda. These programs are not covered here because there have been few, if any, *ceteris paribus* analyses of the programs' targeting or impacts.[32] These are major knowledge gaps in need of future research.

We begin our programs overview with Malawi, which in 1998 was the first country to explicitly implement a major fertilizer subsidy program after the structural adjustment period of the 1980s to mid-1990s.[33] Malawi continues to garner the most attention of all countries implementing ISPs, most likely due to the media attention that it garnered after a front-page New York Times article in 2007. Nigeria began subsidizing fertilizer in 1999 and Zambia established its new Fertilizer Support Programme in 2002. After pledges were made at the 2006 Africa Fertilizer Summit, Kenya joined the field in 2007, followed soon after by Ghana, Ethiopia, and Tanzania in 2008 (Druilhe and Barreiro-Hurlé 2012; Jayne and Rashid 2013).[34]

A.1. Malawi

A.1.1. Starter Pack, 1998/99-1999/2000

Malawi's initial ISP in the wake of structural adjustment was the Starter Pack program. In place during the 1998/99 and 1999/2000 agricultural seasons, the Starter Pack grew out of the recommendations of the Malawi Maize Productivity Task Force, which had been established to explore policy options for addressing the country's chronic national food shortages (Harrigan 2008). The task force identified declining soil fertility and maize productivity as two major contributors to the food shortage problem. The Starter Pack entitled all Malawian smallholder farm households to 15 kg of inorganic fertilizer, 2 kg of hybrid maize seed, and 1 kg of legume seed for free; the maize inputs were sufficient to plant approximately 0.1 ha of maize (Harrigan 2008; Druilhe and Barreiro-Hurlé 2012). The original, main objectives of the program were to raise agricultural productivity by introducing farmers to best bet technologies in a risk-free way, to kick-start agricultural development, and to achieve national food self-sufficiency (Harrigan 2008; Levy 2005), not social protection (Dorward and Chirwa 2011).

National maize production increased markedly in Malawi in the years of the Starter Pack (likely due in part, but not entirely, to the program), but the program was unpopular with donors, who highlighted its high fiscal cost, negative effects on the development of private sector input

---

[32] See Appendices A and B for overviews of Burundi's and Rwanda's ISPs, respectively. For information on programs not covered in this study, see Wanzala-Mlobela, Fuentes, and Mkumbwa (2013) for Burkina Faso and Senegal; Druilhe and Barreiro-Hurlé (2012) for Burkina Faso, Mali, and Senegal; Fuentes, Bumb and M. Johnson (2012) for Mali; Fuentes, Bumb and M. Johnson. (2012) for Senegal; and Chirwa and Dorward (2013) for Mali and Senegal.

[33] Malawi implemented various fertilizer subsidy programs in most years since its independence, but through the 1990s these were generally small. The Zambian government initiated various fertilizer-on-credit schemes for farmers in several years during the 1990s, with fertilizer obtained through the program sold at or near market prices. However, default rates on the fertilizer loans were high (e.g., 35% in 1999/2000), so a large percentage of program participants received the fertilizer at an implicit subsidy rate of approximately 90%, having paid only the 10% down payment for the fertilizer (ZMACO et al. 2002; Mason, Jayne, and Mofya-Mukuka 2013).

[34] Kenya actually started distributing subsidized fertilizer through its National Cereals and Produce Board in the 2001 but the quantities were small (NCPB 2013; Mather and Jayne 2015). We use 2007 to mark the return of major ISPs to Kenya as this is the year in which it first implemented a large-scale targeted ISP, the National Accelerated Agricultural Inputs Access Program. Both programs are discussed further below. Also, as noted in Jayne and Rashid (2013), although the Ethiopian government subsidizes the retail price of fertilizer in various ways, it does not refer to this as a fertilizer subsidy program as such.

markets, and late delivery, among other challenges (Harrigan 2008). Donor opposition including pressure from the International Monetary Fund to reduce expenditures on the Starter Pack eventually led to its scaling down and transformation into the Targeted Inputs Programme (TIP) (ibid.).[35] Under TIP, the emphasis shifted from raising agricultural productivity and food self-sufficiency to providing a safety net for poor smallholder farm households.[36]

A.1.2. Targeted Inputs Programme, 2000/01-2004/05

TIP was essentially a "targeted version of the Starter Pack" (Druilhe and Barreiro-Hurlé 2012, p.18). Its scale varied over time with 1.5 million free inputs packs distributed in 2000/01, 1 million in 2001/02, 2.8 million in 2002/03 (following the 2002 food crisis), 1.7 million in 2003/04, and 2 million in 2004/05; this is in contrast to the 2.8 million input packs distributed in each year of the Starter Pack (Harrigan 2008). In its last year (2004/05), the TIP input pack size increased to 25 kg of fertilizer, 5 kg of OPV maize seed and 1 kg of legume seed.[37]

A.1.3. Agricultural Inputs Subsidy Programme/Farm Input Subsidy Programme, 2005/06-Present

Malawi's present-day ISP, the Farm Input Subsidy Programme (MFISP), also referred to as the Agricultural Inputs Subsidy Programme, was established in 2005/06. The program's core objectives are raising household and national food security, food self-sufficiency, and incomes by improving resource-poor smallholders' access to improved agricultural inputs (Dorward and Chirwa 2011; Lunduka, Ricker-Gilbert, and Fisher 2013; Kilic, Whitney, and Winters 2015).

The number of smallholder farm households that MFISP has aimed to reach has varied over time, but has been 1.5 million per year during the three most recent agricultural years (2012/13 through 2014/15) (Logistics Unit 2015). Other key features of the program, including the total quantities of subsidized inputs distributed, the fertilizer subsidy rate, and program costs are summarized in Table 4.1. As of 2014/15, beneficiary farmers were to each receive vouchers for fertilizer, maize seed, and legume seed:

- Two fertilizer vouchers: one for a 50-kg bag of NPK as basal dressing, and one for a 50-kg bag of urea as top dressing. When redeeming their vouchers for the fertilizer, farmers had to pay a MK500/50-kg bag top-up fee.

- One maize seed voucher for 5 kg of hybrid maize seed or 8 kg of OPV maize seed for free, although seed companies could apply a discretionary top-up fee of MK100 on the voucher.[38]

- One legume seed voucher for 3 kg of soybean seed or 2 kg of other legume seed (beans, cowpeas, pigeon peas, or groundnuts) for free (Logistics Unit 2015).[39]

---

35 See Levy (2005) and Harrigan (2008) for further details on the Starter Pack.

36 According to Harrigan (2008, p. 245), "These objections [to the Starter Pack] coincided with an evolution of donor food security policies towards a more holistic livelihoods approach as well as an elevation of the social safety net programme in Malawi. Hence, donors were willing to endorse a scaled down free inputs programme and to recast it in the light, not of a production enhancing technological transfer, but as one of many targeted social safety nets, albeit not necessarily the most effective".

37 See Levy (2005) for a discussion of the other key differences between the 2004/05 program and previous years.

38 Maize seed quantities have varied over time. For example, in the early years of the program, seed coupons were for 2 kg of hybrid seed or 4-5 kg of OPV seed (Lunduka, Ricker-Gilbert, and Fisher 2013).

39 As discussed in Dorward and Chirwa (2011), in the early years of the program MFISP included maize and tobacco fertilizers and OPV maize seed (but no hybrid or legume seed). Hybrid maize seed was added in 2006/07; legume seed as well as cotton seed and chemicals were added in 2007/08; and fertilizers for tea and coffee, and storage chemicals for maize were added in 2008/09. Tobacco, cotton, tea, and coffee inputs were subsequently phased out. See Dorward and Chirwa (2011) for a summary of other program changes from 2006/07 through 2008/09.

In August 2015, the Malawian government announced that the farmer contributions would increase to MK3,500 per 50-kg bag of fertilizer, and MK1,000 and MK500 for the above-mentioned quantities of maize and legume seed, respectively (*The Daily Times* Malawi, August 7, 2015, p.1. http://www.times.mw/fisp-price-goes-up/). This is equivalent to a fertilizer subsidy rate of approximately 70% -- much lower than the greater than 90-95% subsidy rates that have prevailed in recent years (ibid.)

Table A4.1. Key Features of the Malawi Farm Input Subsidy Programme (MFISP), 2005/06-2014/15

Cropping year	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Total fertilizer subsidized (MT) - planned	137,006	150,000	170,000	170,000	160,000	160,000	140,000	154,440	150,000	150,000
Total fertilizer subsidized (MT) - actual	131,388	174,688	216,553	202,278	161,074	160,531	139,901	153,846	149,821	149,813
Total maize seed subsidized (MT)	NA	4,524	5,541	5,365	8,652	10,650	8,244	8,582	8,268	8,434
Total legume seed subsidized (MT)	0	0	24	NA	1,391	2,727	2,562	2,968	3,042	3,027
Redemption price (MK/50 kg maize fertilizer)	950	950	900	800	500	500	500	500	500	500
Redemption price (US$/50 kg maize fertilizer)	8.02	6.98	6.43	5.69	3.54	3.32	3.19	2.01	1.37	1.18
Fertilizer subsidy rate (%)	64	72	79	91	95	90				
Total program cost (US$ million)	55.71	88.69	114.62	274.92	114.6	127.47	151.25	207.03	168.21	126.83
Total cost as % of agricultural budget	NA	61	61	74	62	61	52	38	53	52
Total cost as % of national budget	5.6	8.4	8.9	16.2	8.2	6.5				

Sources: Lunduka et al. (2013, Table 2), Dorward and Chirwa (2011), and Logistics Unit (2011, 2012, 2013, 2014, 2015). Notes: NA = information not available. All redemption prices converted from MK to US$ using the official exchange rate per World Development Indicators. For 2011/12 through 2014/15, program costs exclude government operational costs and voucher printing, and do not reflect funds recuperated through farmers' top-up fees.

Beneficiary farmers redeem their fertilizer coupons at government-run outlets (Agricultural Development Marketing Corporation (ADMARC) and Smallholder Farmers Fertilizer Revolving Fund of Malawi (SFFRFM) locations) and their seed vouchers at registered, private agro-dealers' shops (Logistics Unit 2015; Kilic, Whitney, and Winters 2015). That is, fertilizer for MFISP is distributed through government, not private sector, channels.[40] Until 2013/14, all MFISP coupons were paper, but an electronic voucher (e-voucher), scratch-card based system was piloted for seed in six Extension Planning Areas (EPAs) in 2013/14 and expanded to 18 EPAs in 2014/15. Fertilizer e-vouchers were piloted in 2014/15 in the six EPAs where seed e-vouchers had been piloted in 2013/14 (Logistics Unit 2015).

The fertilizer e-voucher is to be expanded to eight districts and used to distributed 30,000 MT of the 150,000 MT of fertilizer intended for the 2015/16 MFISP (*The Daily Times* Malawi, August 7, 2015, p. 1. http://www.times.mw/fisp-price-goes-up/).

MFISP beneficiary selection and coupon allocations occur as follows (per Kilic, Whitney, and Winters 2015; Wanzala-Mlobelauentes, and Mkumbwa 2013; and Lunduka, Ricker-Gilbert, and Fisher 2013). First, the Ministry of Agriculture and Food Security (MoAFS) allocates coupons to districts in proportion to their number of farm households. Second, within each district, the District Commissioner, in conjunction with the District Agricultural Development Officer, traditional authorities, NGOs, and religious leaders determine how to allocate the district's coupons to EPAs within the district, and to villages within the EPAs. Third, within each village, beneficiary village residents are to be selected through community-based targeting in open forums. In general, MFISP beneficiaries are to be full-time smallholder farmers who cannot afford one or two bags of fertilizer at commercial prices (Dorward et al. 2008). Priority is to be given to resource-poor households (e.g., those with elderly, HIV-positive, female, child, orphan, or physically challenged household heads or household heads that were taking care of elderly or physically challenged individuals) (Kilic, Whitney, and Winters 2015).

A.2. Nigeria

A.2.1. Federal Market Stabilization Program, 1999-2011

The federal government of Nigeria reintroduced fertilizer subsidies in 1999 with the establishment of the Federal Market Stabilization Program (FMSP), after having abolished fertilizer subsidies in 1997 due to their high fiscal cost (Liverpool-Tasie and Takeshima 2013).[41] The FMSP ran through 2011 and under the program the federal government provided fertilizer to Nigerian state governments at a 25% subsidy. See Table A4.2. for the quantities of fertilizer nutrients distributed through the program each year from 2000 through 2008. The goal of the program was to improve farmers' timely access to fertilizer, in terms of both quantity and quality (Wanzala-Mlobela, Fuentes, and Mkumbwa 2013).

FMSP was a universal ISP in the sense that there were no targeting criteria and, in theory, any farmer could obtain subsidized fertilizer through FMSP; moreover, there was no cap on the quantity that an individual farmer could receive. However, the quantity of subsidized fertilizer distributed to each state was rationed (Takeshima and Liverpool-Tasie 2015).

[40] In 2005/06, both fertilizer and seed vouchers had to be redeemed at ADMARC and SFFRFM outlets. In 2006/07 and 2007/08, seed vouchers were redeemable at private seed retailers while fertilizer vouchers were redeemable at private fertilizer retailers and ADMARC/SFFRFM. But since 2008/09, fertilizer vouchers are only redeemable at ADMARC/SFFRFM (Dorward and Chirwa, 2011; Logistics Unit 2015). Government selects, via a tender process, companies to import and deliver fertilizer to SFFRM and ADMARC locations (Wanzala-Mlobela, Fuentes, and Mkumbwa 2013).

[41] See Liverpool-Tasie and Takeshima (2013) for a summary of Nigeria's ISPs from the 1940s to 2013.

To obtain FMSP subsidized fertilizer, each state submitted its total fertilizer request to the federal government based on estimates of the farm area in the state and recommended fertilizer application rates (Takeshima and Nkonya 2013). The federal government then determined the quantity of subsidized fertilizer to allocate to each state.

Table A4.2. Fertilizer Distributed through Nigeria's Federal Market Stabilization Program, 2000-2008

Year	Subsidized fertilizer nutrients distributed ('000 MT)
2000	54
2001	20
2002	52
2003	43
2004	91
2005	66
2006	117
2007	134
2008	255

Source: Takeshima and Nkonya (2014) based on information from the Nigeria Federal Department of Fertilizer.

The federal government purchased fertilizer for FMSP from importers through a tender process (Liverpool-Tasie and Takeshima 2013). It then delivered and sold the fertilizer to the states at a 25% subsidy (Takeshima and Liverpool-Tasie 2015). States and Local Government Areas could add their own subsidies on top of the federal subsidy, and use their resources to increase the quantities of subsidized fertilizer beyond the quantities allocated by the federal government; the typical subsidy rate by the time the fertilizer reached farmers was approximately 75% (ibid.). The fertilizer was mainly distributed to farmers through Agricultural Development Project outlets (a state-level public institution that provided extension services and inputs to farmers), but also distributed through other outlets. No vouchers were used in the distribution of FMSP fertilizer, and there was no seed component to the program. Late delivery, and diversion and sale of fertilizer intended for FMSP as commercial (unsubsidized) fertilizer were common, as was leakage, i.e., the resale of FMSP fertilizer by subsidy recipients (Liverpool-Tasie and Takeshima 2013; Liverpool-Tasie 2014a).

A.2.2. Targeted Fertilizer Subsidy Voucher Pilot Programs, 2009-2011

In the lead up to its 2010 pronouncement that it aimed to withdraw from fertilizer procurement by 2012 and instead support the development of private sector agro-dealer networks, in 2009 the federal government of Nigeria began piloting targeted fertilizer subsidy voucher programs in collaboration with select state governments. The pilot programs were run in two states in 2009 (Kano and Taraba), with two more added in 2010 (Bauchi and Kwara) (Wanzala-Mlobela, Fuentes, and Mkumbwa 2013). The FMSP continued to be implemented alongside of the voucher pilot programs in these states, as well as in the states without pilot programs. To our knowledge, all of the empirical evidence on the *ceteris paribus* targeting and impacts of the pilot programs is based on the Kano and Taraba experiences, so we focus on those two programs in the remainder of this sub-section.

The federal and state governments partnered with the International Fertilizer Development Center (IFDC), three major private fertilizer suppliers, and over 150 agro-dealers to implement the Kano and Taraba state pilots (Liverpool-Tasie 2014). Together, the IFDC, federal, and state governments determined what portion of the FMSP fertilizer earmarked for each state to distribute through the voucher pilot program, wherein selected smallholder farmers were given paper vouchers that they could redeem for a discount on fertilizer at participating agro-dealers' shops. The federal government still procured the fertilizer and delivered it to the states as in the standard FMSP; only the means of distribution to farmers differed (ibid.). (The rest of the FMSP fertilizer earmarked for each state was distributed to farmers through the standard FMSP government distribution system.)

While the Kano and Taraba state pilot programs had these features in common, there were also three important differences between the programs. First, the number of bags of fertilizer and value of the vouchers allocated to beneficiary farmers in the two states differed. In Kano state, each participating farmer was to get a 2,000 Naira (US$13.50) discount on each of two 50-kg bags of NPK and one 50-kg bag of urea, for a total subsidy value of US$40.50 (or about 60% and 65% off the market price of NPK and urea, respectively) (Liverpool-Tasie 2014a). In Taraba state, participating farmers still got a 2,000 Naira discount per bag, but were entitled to two 50-kg bags of NPK and two 50-kg bags of urea, for a total subsidy value of US$54. These represented subsidy rates of about 55% for both types of fertilizer, slightly lower than in Kano state (Liverpool-Tasie 2014b). In both states, farmers paid the difference between the voucher value and the market price of the fertilizer.

A second set of differences between the two states' programs relate to the eligibility requirements and who received (and redeemed) the vouchers. In Kano state, which had a long history of farmer organizations, beneficiaries were required to be a member of such a group. Only one voucher was given to the entire farmer group. It then entitled every member of the group to the aforementioned fertilizer discounts. Any member of the farmer group leadership (chairperson, treasurer, or secretary) could redeem the voucher on behalf of all group members (Liverpool-Tasie 2014a). However, in Taraba state, where farmer organizations were less well established, beneficiaries were only required to members of some sort of organization or group (be it farmer-related or otherwise) (Liverpool-Tasie 2014c). Moreover, each beneficiary received his/her own vouchers. As will be discussed in the section on empirical evidence related to the targeting of ISP fertilizer, these differences in who received vouchers had important implications for elite capture of the subsidy program benefits (ibid.).

Third and finally, the scale of the two pilot programs in 2009 differed. While the Kano state program aimed to reach 140,000 smallholders (Liverpool-Tasie and Salau 2013), the Taraba state program only targeted 76,000 (Liverpool-Tasie 2014).

A.2.3. Growth Enhancement Support Scheme, 2012-present

Drawing on the experiences of and lessons learned from the targeted fertilizer voucher pilot programs of 2009 to 2011, in 2012 the federal government of Nigeria established the Growth Enhancement Support Scheme (GES), which scaled the pilot programs up to the national level with some important changes (Liverpool-Tasie and Takeshima 2013). First, instead of being paper-based, the GES delivered vouchers to beneficiary farmers electronically through a mobile phone platform called the e-wallet system; farmers then used the vouchers to obtain subsidized inputs at their assigned Redemption Center (a selected private agro-dealer's shop).[42] Second, under GES, the private sector is responsible for the procurement and distribution of the fertilizer (ibid.). Third, the GES includes subsidies for maize and rice seed (ibid.). GES focuses on "resource constrained" farmers and its overall objective is to provide a "series of incentives to encourage the critical actors in the fertilizer value chain to work together to improve productivity, household food security and income of the farmer" (NFMARD n.d.).

[42] Note that the e-wallet system is different from the e-vouchers piloted to date in Malawi and Zambia. The latter are electronic on the agro-dealer end but paper scratch cards (similar to cellphone talk time scratch cards) on the farmer end.

At its launch in 2012, the GES aimed to reach 5 million farmers per year for four years, and beneficiary farmers were to receive 25 kg of certified rice seed or 20 kg of certified maize seed for free, and two 50-kg bags of fertilizer at a 50% subsidy (Maur and Shephard 2015). However, seed supplies were insufficient to cover these quantities, so the seed quantities were reduced to 12.5 kg (ibid.). Another challenge faced by GES is that many Nigerian smallholders do not own mobile phones or live outside of mobile phone network coverage areas; in response, offline processes are also being developed (Makepeace, Lee, and Wolfe 2013; IFDC 2014).[43] In 2013, GES was implemented in all 36 Nigerian states as well as in the Federal Capital Territory, and involved 4.8 million farmers, 500,000 MT of fertilizer, and 23,000 MT of improved seed (IFDC 2013). See IFDC (2013) for more details on how GES works.

With the transition to the new government of President Muhammadu Buhari in 2015, there have been some challenges with GES. Agro-dealers participating in program under former President Goodluck Jonathan have not been paid and the 2015 distribution of subsidized inputs has been delayed.[44]

A.3. Zambia

Zambia's main ISP since structural adjustment has been the Farmer Input Support Programme (ZFISP), which was originally called the Fertilizer Support Programme. This program has been in place since 2002/03. ZFISP is implemented by the Ministry of Agriculture and Livestock (ZMAL). The Ministry of Community Development, Mother and Child Health has implemented its own, substantially smaller ISP since 2000/01: the Food Security Pack Programme. We describe these programs in turn below.

A.3.1. Farmer Input Support Programme, 2002/03-present

Established in 2002/03 in the wake of a severe drought in southern Africa, ZFISP was originally envisaged as a temporary program to be phased out after three years (ZMACO et al. 2002); instead it has grown in scale over the last 13 years and has seemingly become a permanent feature of Zambia's agricultural policy landscape. (See Table A4.3. for key features of ZFISP, including the number of intended beneficiaries, quantities of subsidized inputs distributed, and subsidy rates over time.) ZFISP is a targeted ISP, the overall objectives of which are "to improve the supply and delivery of agricultural inputs to small-scale farmers through sustainable private sector participation at affordable cost, in order to increase household food security and incomes" (ZMAL 2014 p. 6). The program is one of Zambia's two major agricultural sector Poverty Reduction Programs, the other being the Food Reserve Agency, a maize marketing board/strategic food reserve.

Fertilizer and seed for maize production have been central to ZFISP since its inception. In the early years of the program (2002/03-2008/09), participating farmers received 400 kg of fertilizer (200 kg each of compound D and urea), and 20 kg of hybrid maize seed at a 50% subsidy. The input pack size was halved to 200 kg of fertilizer and 10 kg of hybrid maize seed from 2009/10 onward. Small quantities of rice seed were added to the program in 2010/11, and sorghum, cotton, and groundnut seed were added in 2011/12; in 2014/15 cotton seed was dropped and the groundnut seed quantity increased more than 10-fold (Table A4.3.).

[43] See Makepeace, Lee, and Wolfe. (2013) and IFDC (2013) for a discussion of other challenges with GES in 2012 and 2013, respectively.

[44] Yusuf, Vincent A. "Agro Dealers Stop Farm Inputs Supply over N38bn Debt." *Daily Trust*, 30 July 2015. Read more at http://www.dailytrust.com.ng/daily/index.php/agriculture/61217-agro-dealers-stop-farm-inputs-supply-over-n38bn-debt#3leHoec1SG38RiYC.99

Subsidy rates have varied over time, ranging from 50-79% for fertilizer, and 50-100% for seed (Table A4.3.).

Based on the 2014/15 official eligibility criteria, targeted beneficiaries were to be small-scale farmers (i.e., cultivating less than 5 ha of land); registered with ZMAL and actively engaged in farming; members of a farmer organization that had been selected to participate in ZFISP; and not concurrent beneficiaries of the Food Security Pack Programme. They also needed to have the financial means to pay the farmer share of the input costs (e.g., approximately US$65 total for 200 kg of fertilizer and 10 kg of hybrid maize seed in 2014/15). In previous years of the program, there was also a requirement that beneficiaries have the capacity to cultivate a minimum area of land (e.g., 1 ha in 2012/13) (ZMAL 2012). Farmers apply to, pay their contributions to, and collect the subsidized inputs from their farmer organization. ZFISP beneficiaries are selected by Camp Agriculture Committees, which include representatives of the local chief, farmer organizations, other community based organizations, and public offices other than ZMAL, and for which ZMAL, through the Camp Extension Officer, serves as the secretariat.[45]

To date, no vouchers are used in ZFISP, local agro-dealers are not involved in any way, and inputs for the program are distributed through what is essentially a government system.[46] In recent years, the parastatal Nitrogen Chemicals of Zambia has provided the compound D for the program, and private firms are selected via a tender process to import the urea. Private sector transporters are then selected via a tender process to transport the inputs to main depots in the districts and ultimately to the farmer organizations.

[45] Camps are the most disaggregated spatial unit in ZMAL's system.

[46] Preparations are underway to pilot an electronic voucher system for ZFISP in 2015/16 in 13 districts.

Table A4.3. Key Features of the Zambia Farmer Input Support Programme (ZFISP), 2002/03-2014/15

Cropping year	Number of intended beneficiaries	Quantities of subsidized inputs (MT) Fertilizer	Maize seed	Rice seed	Sorghum seed	Ground-nut seed	Fertilizer subsidy rate (%)	Seed subsidy rate (%)	Total program cost (US$ million)	Total cost as % of agricultural expenditures	Total cost as % of national expenditures
2002/03	120,000	48,000	2,400	0	0	0	50	50	4.04	10.4	0.5
2003/04	150,000	60,000	3,000	0	0	0	50	50	10.56	17.2	1.1
2004/05	115,000	46,000	2,500	0	0	0	50	50	20.52	26.8	1.6
2005/06	125,000	50,000	2,500	0	0	0	50	50	31.36	26.9	1.9
2006/07	210,000	84,000	4,234	0	0	0	60	60	51.08	25.5	2.4
2007/08	125,000	50,000	2,550	0	0	0	60	60	51.10	18.0	2.2
2008/09	200,000	80,000	4,000	0	0	0	75	50	131.37	37.6	3.5
2009/10	500,000	100,000	5,342	0	0	0	75	50	111.99	42.5	3.7
2010/11	891,500	178,000	8,790	30	0	0	76	50	122.78	29.9	3.4
2011/12	914,670	182,454	8,985	39	0	0	79	53	184.21	30.1	4.4
2012/13	877,000	183,634	8,770	143	60	150	--	--	165.68	50.3	3.1
2013/14	900,000	188,312	9,000	159	107	130	50	100	113.22	30.2	1.9
2014/15	1,000,000	208,236	10,000	127	119	1,357	--	--	--	--	--

Sources: ZMAL (various years), ZMFNP (various years).

Notes: -- information not available. Input quantities rounded to the nearest MT.

From 2010/11 through 2013/14, ZFISP aimed to reach approximately 900,000 beneficiaries per year. Over this time period, spending on the program averaged 35% of the Zambian government's total agricultural sector spending (Table A4.3.).

A.3.2. Food Security Pack Programme, 2000/01-present

The Food Security Pack Programme is intended to target farmers that do not have the resources to pay the ZFISP farmer contribution or, when there was a minimum land requirement for ZFISP participation, farmers that could not meet it. More specifically, the Food Security Pack Programme targets 'vulnerable but viable' farmers, whom it defines as households with less than one hectare of land, adequate labor, not in gainful employment, and also having at least one of the following characteristics: female-, child/youth-, elderly- or terminally-ill headed, or caring for orphans or disabled individuals (PAM 2005). In addition, participating farmers are trained in conservation farming techniques and are required to prepare their field(s) using these practices (ibid.). Community Welfare Assistance Committees or Area Food Security Committees select program beneficiaries.

The contents of a Food Security Pack vary by agro-ecological region but generally consist of seed and fertilizer to plant 0.5 ha of cereals (maize, rice, sorghum, or millet), legume seed for 0.25 ha, sweet potato vines or cassava cuttings, and, in areas with acidic soils, 100 kg of lime. Fertilizer quantities are either 50 or 100 kg depending on the cereal seed received (ibid.). The objective of the program is "to empower the targeted vulnerable but viable households to be self-sustaining through improved productivity and household food security and thereby contribute to poverty reduction" (PAM 2005, p.1). Beneficiaries are not required to make a cash contribution for the Food Security Pack inputs; rather, they are required to pay in-kind a fraction of the value of the inputs received (e.g., 100 kg of maize for those receiving input packs containing maize seed).

The scale of the Food Security Pack Programme has generally been much smaller than ZFISP. While at its peak in 2003/04 it reached 145,000 households, nearly as many as ZFISP (Table A4.3.), by the late 2000s and early 2010s the Food Security Pack Programme only received enough funding to reach about 15,000 households per year (compared to 900,000 under ZFISP) (Kasanga et al. 2010).

Although small, the Food Security Pack Programme has been considerably more innovative than ZFISP. For example, it has taken a more holistic approach to raising smallholder productivity and incomes by including a significant extension component (training farmers in conservation farming) and by including inputs other than just maize seed and fertilizer. In addition, since 2012/13, it has piloted in three districts an "Expanded Food Security Pack Programme", which utilizes e-voucher scratch cards redeemable at private agro-dealers' shops for the aforementioned inputs and a chaka hoe, a specialized hoe designed for digging planting basins, the hand-hoe variant of conservation tillage promoted in Zambia. The program also includes a social cash transfer component: each beneficiary household receives ZMW100 (approximately US$16.25 in 2014) in January, near the peak of the lean season and when school fees are due (personal communication with H.P. Melby, February 2015). The Expanded Food Security Pack Programme has been funded by the Royal Norwegian Embassy in Lusaka; the pilot is due to end after the 2015/16 agricultural season, by which time the program hopes to have reached 27,000 total households. Discussions are underway to determine if the Ministry of Community Development, Mother and Child Health will adopt and roll out the Expanded Food Security Pack Programme model to other districts in Zambia after the pilot ends.

A.4. Kenya

Kenya has had two major ISPs since structural adjustment – one targeted (the National Accelerated Agricultural Inputs Access Program (NAAIAP)) and one universal (through the National Cereals and Produce Board (NCPB). We describe each of these in turn.

A.4.1. National Accelerated Agricultural Inputs Access Program, 2007/08-2013/14

The Kenyan government initiated NAAIAP in the 2007/08 agricultural year, shortly after the 2006 Africa Fertilizer Summit and in the midst of the 2007-2008 food, fuel, and fertilizer price crisis. The program ran through 2013/14, after which county-level governments assumed responsibility for ISPs in Kenya. The main goal of NAAIAP was "to improve farm input (fertilizer and seeds) access and affordability of smallholder farmers to enhance food security/availability at the household level and generate income from the sale of surplus produce" (KMOA 2007, p. 7). Additional objectives included raising smallholders' productivity and production levels, and reducing poverty (KMOA 2007, 2010). The ISP portion of NAAIAP, called Kilimo Plus, provided targeted beneficiaries with a voucher redeemable at accredited agro-dealers' shops for 100 kg of fertilizer (50 kg each of basal and top dressing) and 10 kg of improved maize seed.[47] The inputs were fully subsidized; no farmer top-up payment or contribution was required.

NAAIAP aimed to target 'resource-poor' farmers who were unable to afford inputs at market prices, who grew maize, had 1-2.5 acres of land, and who were "vulnerable members of society", with female- and child-headed households given priority (KMOA 2007, p. 19). Beneficiaries were selected by stakeholder forums, which included farmers, other community members, and representatives from the Ministry of Agriculture, Livestock, and Fisheries (KMOA 2007). NAAIAP was not implemented in all districts; rather, districts were selected based on their suitability for maize production and poverty level. Over the life of the program, NAAIAP was implemented in 149 districts (out of 200+ districts in Kenya at the time) (KMOA 2013a). The scale of NAAIAP varied over time, and the program peaked in 2009/10 at 176,000 intended beneficiaries or about 5% of Kenyan smallholder households. See Table A4.4. for a summary of the number of beneficiaries and approximate voucher values from 2007/08 through 2011/12 (the only years for which data are publicly available).

Table A4.4. Key Features of the Kenya National Accelerated Agricultural Inputs Access Program (NAAIAP), 2007/08-2011/12

	2007/08	2008/09	2009/10	2010/11	2011/12	Total
Total number of beneficiaries	36,000	92,876	175,973	125,883	63,737	494,469
Number of districts covered	40	70	131	95	63	149
Voucher value (US$)	103.67	93.95	76.03	81.25	95.69	

Source: KMOA (2013b).

[47] There was also a subsidized credit component to NAAIAP called Kilimo Biashara, which targeted credit-constrained farmers who were relatively better off and ineligible for Kilimo plus. Throughout the remainder of the paper we use the term NAAIAP to refer to the Kilimo Plus part of the program.

Table A4.5. Quantities of Subsidized Fertilizer Distributed through Kenya's National Cereals and Produce Board, 2001/02-2011/12

Year	MT of subsidized fertilizer distributed
2001/02	1,403
2002/03	2,207
2003/04	6,827
2004/05	11,131
2005/06	6,167
2006/07	16,137
2007/08	9,506
2008/09	52,608
2009/10	8,388
2010/11	45,264
2011/12	82,023

Source: NCPB (2013)
Note: More recent data not publicly available.

A.4.2. National Cereals and Produce Board Fertilizer Subsidy Program, 2001-Present

The NCPB is a crop marketing board that has been in place since the colonial era; since 2001, it has also distributed subsidized fertilizer to Kenyan farmers. During the first seven years of the program, the quantities distributed were small (averaging just 7,625 MT per year); then, in 2008/09, the program was scaled up dramatically to 52,608 MT (see Table A4.5.). The Kenyan government justified this increase, as well as the establishment of NAAIAP, as temporary responses to the 2007-2008 price crisis as well as to the post-2007 election violence and associated poor harvest (Ariga and Jayne 2011; Mather and Jayne 2015). According to the NCPB, its vision for the subsidy program is to "take … inputs closer to the farmer", "provide [a] one stop point for the farmer's needs", "to supply the farmer with the right quality at the right time and at competitive prices", and to enable the farmer to buy inputs at the same time that s/he sells maize to the NCPB to cut down on transport and transactions costs (NCPB 2013, p. 6).

NCPB subsidized fertilizer (NPK, DAP, CAN, and SSP) is sold at pan-territorial prices at NCPB depots throughout the country. The program is universal in the sense that (in theory) any farmer can access it. The quantity available to a given farmer is determined roughly based on farm size. Subsidy rates have varied but are typically in the range of 30% (Jayne et al. 2013).

A.5. Ghana

Ghana's history of subsidizing inputs dates back into the 1970s, where, like many other countries, early versions were characterized by government monopolies for importation and distribution. The fertilizer subsidy rate peaked at 65% in the early 1980s. Recognizing that the early program was fiscally unsound and detrimental to Ghana's macroeconomy, and with urging from the World Bank and other donors, the parastatal-led subsidies were phased out during the late 1980s and removed altogether by 1990 (Resnick and Mather 2015; Jebuni and Seini 1992). Thereafter the entire fertilizer supply chain has been managed by the private sector (Resnick and Mather 2015).[48]

Fertilizer subsidies for the country's main cash crop, cocoa, were reintroduced in 2003 and for food crops in 2008. The latter was called Ghana's Fertilizer Subsidy Program (GFSP), and still is, though in 2012 the program expanded to include seed inputs for maize, rice and soybeans

[48] Key features of the Ghana Fertilizer Subsidy Program are discussed here, but for a more thorough review readers are encouraged to see Resnick and Mather (2015).

(Resnick and Mather 2015). The GFSP was intended as a temporary program but it has instead become a perennial (and seemingly permanent) component of Ghana's agricultural budget. The reinvigorated subsidy program came about for several reasons including encouragement from the private sector, fertilizer and food price increases, political popularity and imminent elections in 2008, and the perception that Ghana faced particularly challenging soil infertility problems and below-average fertilizer use (even amongst African nations) (ibid.; Banful 2009)

Unlike Ghana's earlier programs and contemporary programs in other countries, GFSP was heavily reliant upon the private sector. Initially, the government's role was limited to allocating benefits to targeted farmers using paper vouchers. According to several structured interviews summarized by Resnick and Mather (2015), the heavy role for the private sector was motivated by the government's desire to maintain its reputation as business-friendly. Furthermore, donors (including the World Bank) had recently increased funding for Ghana's agricultural budget and strongly advocated for private sector inclusion.

In 2010 still more responsibility was shifted to the private sector as vouchers were abandoned in favor of a waybill design. This required approved farmers to acquire subsidized fertilizer from registered agents. In turn, GFSP agents were to submit receipts to government for approval, shifting the bulk of administrative responsibility to the private sector. This revision also loosened constraints on the time of extension agents, many of whom complained that issuing and monitoring vouchers hindered their ability to carry out their intended duties (Resnick and Mather 2015).

In the 7 years since the program's beginning, motivation for the GFSP has frequently shifted from increasing productivity as an urgent response to price spikes to providing a social safety net for the poor, to demonstrating the benefits of fertilizer to farmers (ibid.). Correspondingly, the intended group of beneficiaries has been a moving target. Under the initial voucher system only smallholder food crop producers were intended to receive the subsidy. Banful (2009) and others, however, found implementation of this criteria often carried out poorly with substantial quantities going to larger farms or being smuggled out of the country and re-sold. Yawson et al. (2010) also report overwhelming dissatisfaction with the timing of fertilizer availability during the period of the voucher system. In 2010, in conjunction with the shift to waybill-based distribution, targets were essentially abandoned and, while the total quantity of subsidized fertilizer was limited, food crop producers of any size were eligible to receive subsidized prices. In 2013, the target shifted back to smallholders, but with geographic and crop priority going to maize, rice, sorghum, and millet farmers in the savannah. Outgrower schemes and female farmers were also given priority (Resnick and Mather 2015).

Despite (or perhaps because of) numerous attempts to revise GFSP, the program has faced numerous points of criticism. These include a lack of transparency, poor monitoring and evaluation, delayed payments to suppliers, the aforementioned shifting and sometimes-unclear objectives, and general uncertainty on a regular basis as to GFSP's design and rollout. In some years GFSP details have not been announced until very near the beginning of the planting season (Resnick and Mather 2015). Partially for these reasons, but most importantly because the government lacked funding to pay importers, GFSP was suspended for the 2014 season. The program was renewed in 2015, but in light of past frustrations at least two of the country's major private importers declined participation (ibid.). Notably, these same companies advocated for instituting the GFSP less than a decade earlier.

The program supplies four types of fertilizer: NPK 15:15:15, NPK 23:10:05, urea (46:0:0) and ammonium sulfate (21:0:0, plus 24% sulfur) (Yawson et al. 2010). The goal during the first two years of the program was to keep subsidized prices consistently at 50% of the market price (ibid.). By best estimates, initial subsidies were actually 30% of the fertilizer's market value on average (Wanzala-Mlobela, Fuentes, and Mkumbwa 2013). This steadily increased until 2012 when the peak subsidy rate was 47% on average, then declined to 26% and 21% in 2013 and 2015 respectively. Similarly, the quantity of subsidized fertilizer has climbed steadily from the initial level of 43,000 MT to roughly 170,000 MT on average from 2011 to 2013. After the 2014 hiatus, announced plans were to distribute 180,000 MT in 2015. The GFSP share of Ghana's agricultural budget naturally followed suit, increasing from 20% to over 50% between 2008 and 2012. When the subsidy rate declined in 2013, the GFSP share of the agricultural budget decreased back to roughly 20%, where it is expected to remain in 2015.

Table A.6.1. Maize Yields by Farming Systems in Ghana (2012)

Maize system	Transition	Guinea Savannah	Sudan Savannah
Local, no fertilizer	756	745	547
Fertilized local	1,208	914	1,339
Fertilized hybrid	1,819	1,444	2,374

Source: Adapted from Ragasa, Chapoto, and Kolavalli 2014.

In 2008 the government budgeted about US $11 million to GFSP, but exceeded this target by more than $3 million. The following year more than $26 million was allocated and was expected to absorb the program's debt from the previous year. Total spending on GFSP in 2015 (for fertilizer and seed) is expected to be roughly equivalent to US$23.5 million, which is less than 70% of peak spending in 2013 (Wanzala-Mlobela, Fuentes, and Mkumbwa 2013)., Resnick and Mather 2015, and government documents referenced therein).

Regarding the effectiveness of fertilizer use, survey data collected in 2012 in various Ghanaian production zones do show noteworthy differences in yield, particularly when fertilizer use is coupled with hybrid seed planting (Table A.6.1., Ragasa, Chapoto, and Kolavalli 2014). On average, local maize seed varieties on fertilized fields are about 70% more productive than when fertilizer is *not* used. Moreover, fertilized fields planted with hybrid seeds are an additional 60% more productive per unit of land than fertilized fields using local varieties. All together, based on these data, fields with fertilized hybrid maize seeds are about 175% more productive than unfertilized fields using local seed (at least in terms of per unit of land. Three important caveats to these results are: i) these means comparisons mask a wide variety in the differences in fertilizer use efficiency across regions (and almost certainly across farms within regions, ii) these results are naïve and potentially subject to some of the biases we've outlined in Section 2; and iii) even the most productive group found in these results (hybrid seed and fertilizer using farmers in the Sudanese Sahel) are obtaining yields (about 2.4 mt/ha) that would be considered low by most standards.

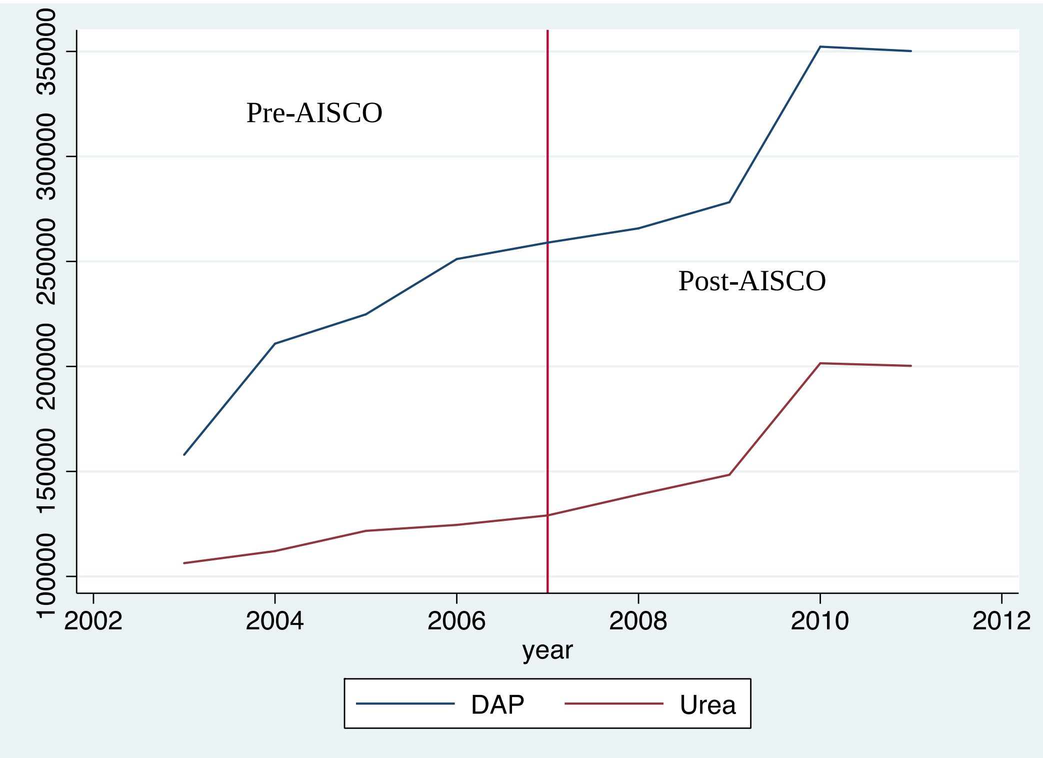
A.6. Ethiopia

Prior to the 1990s the main social safety net in Ethiopia was international food aid. However, food aid was understood to be a weak development strategy that had little or no impact on the underlying causes of Ethiopia's poorly functioning food markets, including high transfer costs associated with a lack of market information, infrastructural investment, and storage capacity (Minten, Stifel, and Tamru 2014). Since the 1990s (and earlier under central planning), fertilizer in Ethiopia has been distributed almost exclusively by government agencies. Early on, this was the Agricultural Input Supplies Corporation (AISCO), later called the Agricultural Input Supplies Enterprise (AISE). AISE-led marketing was generally considered inefficient, however, so in 1992 the New Marketing System (NMS) was an effort to introduce the private sector (Rashid et al.

2013). Private companies were slower to respond than policy makers expected and by the late 90s just four fertilizer companies were active market participants. The next evolution was the growth of companies owned by regional governments and supplying to AISE, and by the early 2000s non-government imports reduced to zero (Rashid et al. 2013). In the mid-2000s farmer organizations became more involved with distribution and allocation. By 2008 roughly 75% of all fertilizer used moved through this market. The system was rife with inefficiencies, though, and in recent years government holding companies have been crowded out of the market and all imports come directly through AISE and what is now called the growth and transformation program (GTP) (Rashid et al. 2013).

The amount of fertilizer to be distributed each year is determined through a consultative process between development agents (extension workers) and policy makers at GTP based on planned planting and centrally decided production targets. During the 2000s fertilizer use did increase rather dramatically, having been applied to 24% of all cereal crops in 2011, up from 16% in 2004 (ibid). Total fertilizer use has similarly increased during that time. Throughout the 70s, for example, fertilizer use was essentially nil, whereas 550,000 tons were applied in 2010 and 2011 (the most recent data available See Figure A.7.1). In addition to subsidizing prices, much of the Ethiopian efforts attempt to address cost buildups in the value chain related to, for example, an inadequate road system. Planned openings of two major breweries were expected to increase fertilizer demand (Rashid et al. 2013), but delays resulted in official openings being pushed to January of 2015. It is not possible to know if this has indeed driven input demand.[49] That said, by the company's own account they are currently "supporting" 6,000 farmers, and expect that number to increase to 20,000 when they are fully operational. In a country of over 100 million, it is unlikely that these relatively fortunate smallholders will have much effect at the national level. Total fertilizer uses for Ethiopia are in Figure A.7.1.

Figure A.7.1. Overall Fertilizer Use in Ethiopia 2003-2012



Source: Fuentes, Bomb, and Johnson 2012.

[49] See also: heinekencompany.com/media/media-releases/press-releases/2015/01/1887644.

The direct costs of running Ethiopia's subsidy plan average roughly $40 million dollars. However, there are frequent miscalculations made on how much should be imported by the government each year. Rashid et al. (2013) reckon the carry over and loss costs have added an additional $30 million in recent years

A second Ethiopian safety net program (which is not officially a subsidy, though public sector agencies are involved in input handling and distribution) comes under the umbrella program called Ethiopia's Food Security Program (EFSP). The first component of EFSP is the Productive Safety Net Program (PSNP), which was also designed to replace food aid as the main social safety net. The PSNP provides direct support in the form of work-for-food or work-for-pay on public work projects, thus simultaneously addressing social welfare and preexisting market constraints (infrastructure building, etc.). Work activities are usually planned to occur from January to June to avoid conflicting with the agricultural season (ibid.; Hoddinott et al. 2012). A small number of recipients (about 15%) receive direct cash transfers if they are deemed very poor, but unable to supply labor (ibid.; Gilligan, Hoddinott, and Taffesse 2009). Work-for-food recipients receive 3 kg of cereal per day. Cash transfers were initially 6 birr/day, which increased with inflation to 8 birr in 2008 and 10 birr (roughly $0.75) in 2010 (Hoddinott et al. 2012; Oanda.com 2015)

The second component of EFSP was first named the Other Food Security Program, which was revised and renamed the Household Asset Building Program (collectively OFSP/HABP) in 2009. OFSP/HABP activities are meant to include access to regular outreach from extension agents regarding soil and water conservation, irrigation and even beekeeping, as well as access to other "modern inputs" including fertilizer and improved seed varieties (Hoddinott et al. 2012; Gilligan, Hoddinott, and Taffesse 2009). While the PSNP was designed as a social safety net, the OFSP/HABP is intended to aid in the growth of smallholders' asset wealth and decrease or eliminate household dependence on government assistance. Early challenges were faced due to a lack of extension agents (Hoddinott et al. 2012). Therefore, after the 2009 reforms, each kebele (a sub-division of woredas, or wards) receiving assistance was assigned three resident development agents specializing in crops, livestock, and natural resource management. Anecdotal evidence from farmer interviews suggests this has improved the situation, but it is also noted that the primary assistance remains highly focused on crops (Berhane et al. 2011). Partially due to EFSP activities, it has also been noted, "the current level of infrastructure development in the county is unprecedented" (Minten, Stifel, and Tamru 2014). This too has theoretically improved access to fertilizers, but these effects, to our knowledge, have not been rigorously quantified. That said, Rashid et al. (2013) have noted that the fertilizer value chain in Ethiopia is "competitive relative to its neighbors", with fertilizer prices 12-35% lower than in neighboring Kenya, Uganda, Rwanda and Tanzania.

Targeting for EFSP is done at the administrative level. Initially, 282 woredas considered rural, poor and food insecure were targeted. The PSNP is said to have delivered support to more than 7 million Ethiopians in 2007, for example (Hoddinott et al. 2012). That said, the definition of *poor* and indeed the household level targeting criteria has been criticized as unclear, and the characteristics of recipients (gender, wealth, political affiliation, etc.) varies widely across woredas (Rashid et al. 2013).

A.7. Tanzania

Input subsidy programs were re-introduced in 2003/04 in Tanzania, though they were quite small (no data as yet available on quantities of fertilizer distributed under the program). Private companies tendered for particular areas; winning firms were allocated fertilizer and seed at fixed prices to provide to farmers. The fixed prices at which they purchased fertilizer at regional depots were below market price; transport costs and part of the cost of fertilizer was provided by Government as a subsidy. The program ended in 2007/08 based on the conclusion that private traders were not passing along the full subsidy to targeted smallholder farmers. It was difficult for government to monitor this because fertilizer was also selling in rural areas through commercial markets, and hence it was difficult to ascertain whether prices paid by farmers were for commercial or subsidized fertilizer. The lack of transparency and ability to properly monitor the extent of subsidy pass through to farmers spelled the end of this program.

This program was replaced by the National Agricultural Inputs Voucher Scheme (NAIVS), which started in 2008/09 for maize and rice. The program was launched in 56 districts, but because food prices remained high and volatile in the aftermath of the world food price rise, the program was expanded in 2009 to 65 districts for a period of three years, with the aim to reach 2.5 million households in 2012. The program was almost entirely financed by the World Bank, and cost roughly US$80-100 million per year (World Bank 2014).

The objectives of the NAIVS were to (i) improve farmers' access to modern inputs; (ii) to create awareness to farmers about the benefits of using fertilizer; (iii) improve crop productivity for the main staple food in the area, mainly maize and rice.

The input package distributed consisted of three vouchers: (1) one for one 50 kg bag of urea; (2) one for a 50 kg bag of Di-Ammonium Phosphates (DAP) or two 50 kg bags of Minjingu Rock Phosphate (MRP) with nitrogen supplement (farmers were supposed to choose); and (3) one for 10 kg of hybrid or open-pollinated maize seeds or 16 kg of rice seeds, sufficient for half a hectare of maize or rice. Vouchers for each input had a face value equivalent to 50% of the market price of the respective input. The remaining 50% was to be paid by the farmers. Agro-dealers then submit the vouchers to the District Agricultural and Livestock Development Officer for approval and then submit them to the appointed bank for redemption.

The program targeted smallholder farmers cultivating not more than one hectare. Priority was given to first-time fertilizer users, female-headed households, and relatively poor farmers (Msolla 2014). Each household was to receive fertilizer for three years only and then graduate from the program, in theory to a higher productivity trajectory.

The number of beneficiaries reached by the NAIVS is reported by Msolla (2014) as follows: 2008/09 (735,000 beneficiaries); 2009/10 (1,500,000); 2010/11 (2,000,000); 2011/12 (1,800,000); 2012/13 (640,873) and 2013/14 (932/100).

The modalities of fertilizer distribution under the NAIVS are described as follows by Pan and Christiaensen (2012). "The central government allocates the vouchers to the target regions, which subsequently distribute it to their districts, which in turn distribute it to the villages in their district. At each level of government a special voucher committee is set up to allocate the vouchers to the lower levels based on the expected demand for inputs using historical production data for maize and rice as well as other related information such as the number of smallholder farmers who grow maize and rice and the average land size per farmer. The last step in the distribution is at the village level. First, the village council, in consultation with the village assembly, organizes the election of the Village Voucher Committee (VVC), which should consist of three men and three women. Then, the VVC draws up a list of beneficiary farmers for approval by the village assembly. After approval, the VVC issues the vouchers to the approved farmers, who can redeem them with local agro-dealers participating in the program."

According to the guidelines given, the VVC should select farmers that: (1) are able to co-finance the inputs purchased with the voucher; (2) are literate; and (3) do not cultivate more than 1 ha of maize and/or rice, with priority to be given to female headed households and households who have used little or no modern inputs on maize or rice over the past five years. As such, these criteria reflect the implicit dual objective of the program: (1) increase overall maize and rice output (e.g., by focusing on non-input using, literate farmers who are more likely to have a higher marginal productivity); and (2) increase access to modern inputs among poor and vulnerable smallholders (e.g., by giving priority to female headed households).

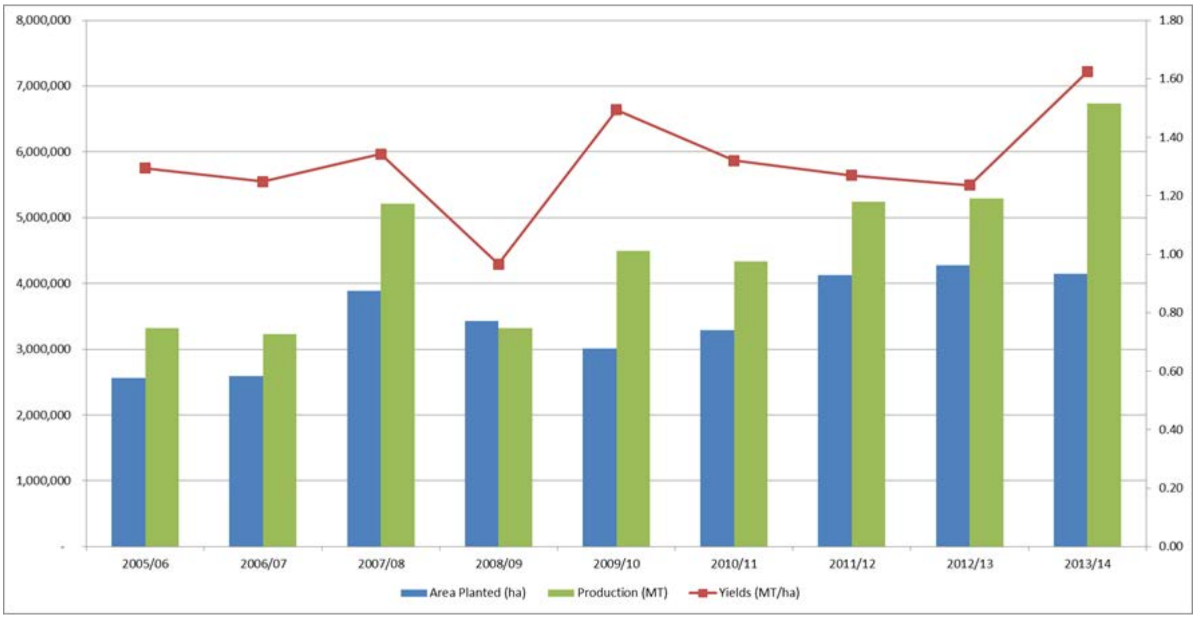
Achievements: NAIVS clearly increased fertilizer use and maize and rice production in Tanzania (World Bank 2014). Msolla (2014) reports that maize production rose from 0.5 mt/ha in 2007/08 to 2.0 mt/ha. However, official Ministry of Agriculture data show the following annual figures for maize yield and production.

Table A.7. Maize Area Planted, Yields, and Production in Tanzania, 2005/06 to 2013/14

	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Area Planted (ha)	2,561,364	2,590,914	3,884,174	3,434,230	3,011,646	3,287,850	4,127,757	4,276,847	4,146,042
Yields (MT/ha)	1.29	1.25	1.34	0.97	1.49	1.32	1.27	1.24	1.62
Production (MT)	3,315,589	3,235,429	5,215,718	3,317,860	4,498,163	4,340,823	5,240,001	5,288,415	6,734,437

Source: Tanzania Ministry of Agriculture.

Figure A.7. 2. Maize Area Planted, Yields, and Production in Tanzania, 2005/06 to 2013/14



Source: Tanzania Ministry of Agriculture

With the exception of the 2013/14 season, Tanzania maize yields have been stagnant over the past decade, even with the NAIVS program operating in every year since 2008/09. Area expansion is the main form of production growth. Anecdotally, the small change in yield suggests a rather low crop response rates to fertilizer given that the program distributed between 100,000 to 200,000 additional tons of fertilizer use each year.

Roughly 3,855 agro-dealers were trained under the program on appropriate methods of fertilizer use, which they were to pass along to farmers participating in the program (Msolla 2014; World Bank 2014).

Msolla (2014) notes several challenges facing the problem: (i) input requirements are higher than what the government can afford, indicating that the government is unable to continue a large-scale program without external assistance; (ii) vouchers were often distributed late under NAIVs, forcing households to apply fertilizer late and suffer some loss of yield as a result; (iii) payments to input suppliers participating in the program often occurred late and was a source of friction between private firms and the government; (iv) there were reports of adulteration and low quality of the inputs provided; and (v) maize output markets and trade was restricted at times by the Government of Tanzania, reducing maize prices received by farmers and hence depressing the value to farmers of the additional production due to NAIVS.

APPENDIX B.1. OVERVIEW OF BURUNDI'S ISP

A number of ISPs in SSA are government-driven (importation, distribution, identification of farmers, etc.) and characterized by delays in delivery to farmers, relatively high costs of implementation, and no exit strategy. The Burundi Ministry of Agriculture and Livestock (MINAGRIE), with technical support from IFDC and US$12 million in financial assistance from the Netherlands (Bamber et al. 2014), adopted the Programme National de Subvention des Engrais du Burundi (PNSEB) or more simply the National Fertilizer Subsidy Program in November 2012. The program ran through March 2015 with the objective of using lessons learned from the design and implementation of other ISPs in SSA to strengthen the program by:

Allowing the private sector to participate in fertilizer trade, which was previously the reserve of the MINAGRIE. A market-based voucher system allowed eight private sector importers to replace the government in importation, distribution, and sales of 25 kg bags of chemical fertilizer sold to farmers across the country at a 40% subsidy.

Adopting a paper-based voucher system to keep track of subsidized fertilizer through the value chain. An international company, Edenred, was selected to manage/implement the voucher system to ensure efficient flow and tracking of subsidies. Instead of transmitting the vouchers through a government system, the vouchers are distributed through the postal service to villages.

Establishing a public-private partnership (PPP) approach throughout the system. The process was opened to allow for inclusion of key stakeholders: producer's organizations, banks and micro-finance institutions, fertilizer importers and distributors, a specialized company in purchase of vouchers and prepaid securities, MINAGRIE, and the Ministry of Finance. A number of stakeholder committees govern the subsidy program under the supervision of MINAGRIE.

Working towards setting up a fund to finance all the operations related to the fertilizer subsidies: these monies were to come from Government and development partners (European Union, Belgium Cooperation, Germany Cooperation, World Bank, USAID, FAO, JICA, and One acre Fund).

According to FAO, Burundi fertilizer consumption averaged 5 kgs/ha in 2013 with total annual national fertilizer consumption at 10,000 MT/year. The PNSEB program aimed at raising this to 60,000 MT/year (Republic of Burundi 2013) using market-based approaches by reducing the price of fertilizer, stimulating the demand for it at farm level, and encouraging private sector involvement.

The PNSEB organized meetings to share information with stakeholders to create public awareness and support for the program including at province, commune, and village committee level in charge of registration of beneficiaries. Local populations were enlisted to identify beneficiary field sizes in order to provide correct amounts of fertilizers to reduce opportunities for side selling. For each beneficiary, information was collected on personal data from valid identity or baptismal card, the size of the fields, and the number of bags of fertilizer needed. Once registered, one does not have to re-register the next season but can confirm their details to still be valid. In 2013 over 500,000 beneficiaries were recorded (IFDC 2013b).

This program covered all subsistence crops and did not target specific groups of producers or geographical region. It was intended to have declining subsidy rates over time and an exit strategy once the private sector had gained foot. The main objective was to increase availability and access to good quality mineral fertilizers while ensuring efficiency and transparency in the subsidy system.

A Kenya-based company was given the contract to sample the soils and provide region- and crop-specific fertilizer recommendations with assistance from other research institutions in Rwanda. This is an important lesson learned from other countries where farmers are provided wrong fertilizers because soil tests have not been carried out for decades. Analyses revealed deficiencies in boron, zinc, and sulfur and soil acidity in some regions.

The process of identifying beneficiaries gained from lessons learned from other countries' challenges in implementing subsidies. To avoid beneficiaries taking fertilizer on credit and not paying for them, the program required beneficiaries to pay a down payment on their orders before they arrive, giving importers a good estimate of the demand. This commits the farmer to the fertilizer and gives an indication of demand to the importers/government so they know roughly how much to import. (This was a key program feature that was touted). Fertilizers come in 25 kg bags in order to target all farm sizes and avoid opening of bags to subdivide to farmers with small plots like happens with 50 kg bags, therefore compromising quality. In May-June 2013 (approximately six months before planting) the beneficiaries paid the down payment (corresponding to about 20% of the non-subsidized price of fertilizers) at the National Post Offices in 116 communes. Then, later in the year when fertilizers arrived, the balance was paid before farmers received vouchers to go and collect fertilizers from the agrodealers, with the MINAGRIE monitoring the process. Farmers who fail to pay the balance lose their advance payment. In 2013, 350,000 farmers paid advances for a total demand of about 18,500 MT of fertilizer. Compared with the previous state-owned subsidy system, this represents an increase of 85% in fertilizer availability and use, even with a number of constraints that are limiting the potential demand. An impact survey after the first year of PNSEB implementation shows a satisfaction rate of about 70% of the beneficiaries, and an average 18% income increase (PNSEB 2015). After verification of purchases, the distributors finally transmit vouchers and pay-in slips to importers for reimbursement from the PNSEB.

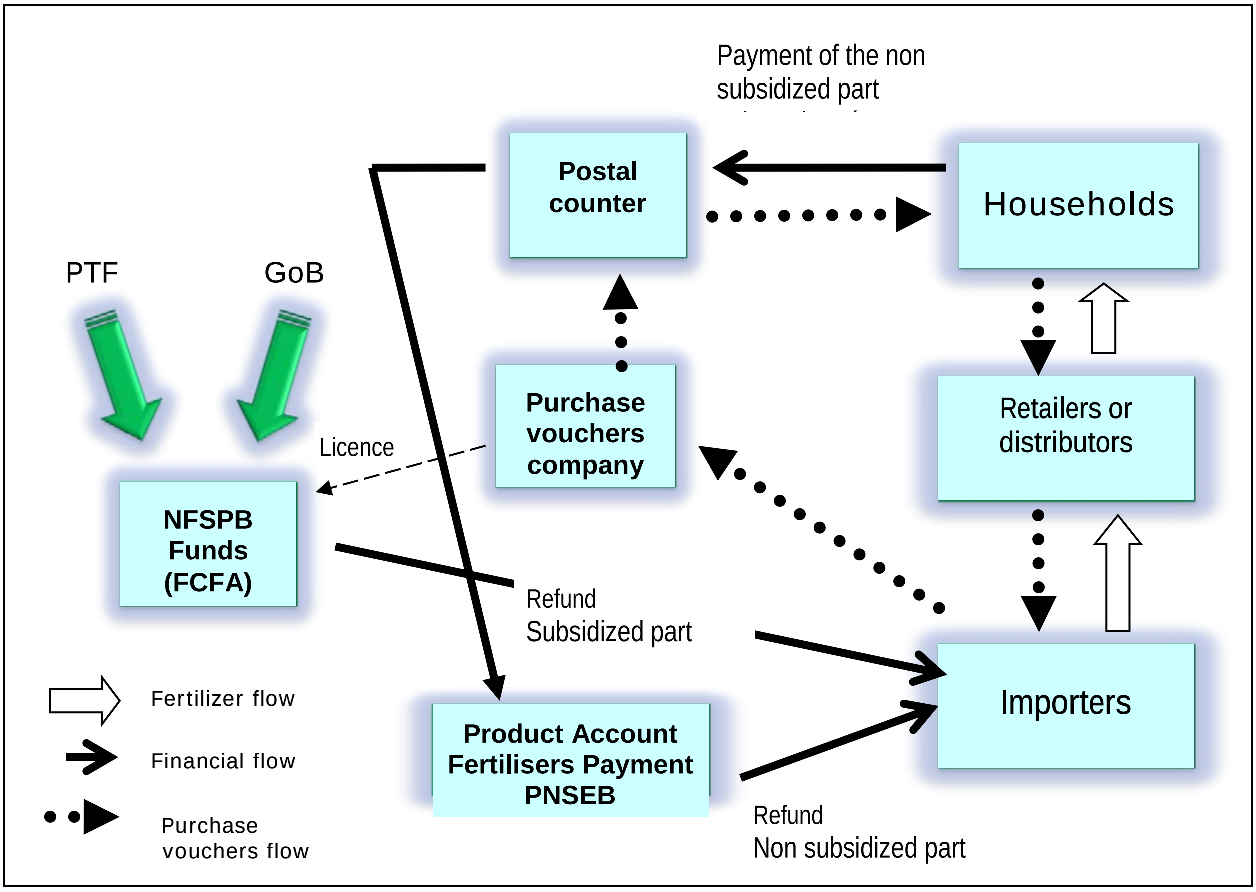
Fertilizer is allocated to 8 importers depending on region by negotiations on prices to avoid monopoly prices. Importers are asked to respond to published requests for expression of interest on bids for various fertilizer batches while providing information on their qualifying characteristics and distribution networks. Importers are assigned regions in the country (they bid for fertilizer in different regions of the country based on the estimates of how much fertilizer farmers want in different parts of the country). Winning importers develop their own agro dealer networks and agrodealers are trained and connected with the importers; importers ensure the agrodealers are paid for what they distribute to farmers

The subsidy rate and the producer price is determined a month after the bids are in. Then the vouchers are printed and made available at post offices throughout the country. The cost of the non-subsided part of the price is calculated on the basis of the weighted average of the prices offered by different importers in dollars and communicated to the public by radio and through local committees.

After the payment of the balance, the beneficiaries receive a pay-in slip and purchase voucher, which they will use to get fertilizer allocations from retailers/distributors where they relinquish the voucher for onward transmission to PNSEB; the retailer passes the voucher to the importer, who requests payment for the subsidy from the Program Subsidy Fund (FCFA) and for the non-subsided portion from the PNSEB; the PNSEB collects farmers payments at post offices in the countryside. Figure B1 shows the flow of money, fertilizer, and vouchers under PNSEB.

Though the system was designed to avoid delays and control for quality, MINAGRIE has faced problems of late delivery of imports and poor distribution networks by some importers who did not have their infrastructure in place. There is also the possibility of farmers selling their fertilizer at retail level or to other farmers, and of large farmers benefiting more than smallholders. The beneficiary cannot recover their 20% down payment if they fail to pay the balance and voucher redemption by importers may take some time with delays in reimbursement. Another disadvantage is that importers are being paid in local currency which increases their currency risk, delaying deliveries as they search for credit and making it difficult for them to extend their credit facilities going forward (PNSEB 2015). The subsidy system needs be computerized from its paper-based structure and opened to more operators to allow more transparency, fair competition, and better performance. The involvement of farmer organizations in the input market and agricultural extension should be strengthened. The first phase of PNSEB ended in March 2015 and the next phase is under consideration. Approximately 600,000 beneficiaries have been recorded so far (PNSEB 2015). The subsidy program makes a significant contribution and plays a role in increasing production and productivity, while reducing production costs at the same time (Republic of Burundi 2013).

Figure B1. The Flow of Fertilizer, Money, and Vouchers under PNSEB



Source: National Fertilizer Subsidy Program 2014.

APPENDIX B.2. OVERVIEW OF RWANDA'S ISPS

Prior to 1990, fertilizers were imported by the Government of Rwanda (GoR) and NGOs/development partners mostly for cash crops, with donor projects using the emerging extension service to promote fertilizer. It was generally assumed that Rwandan soils were fertile and did not require inorganic fertilizers and therefore using organic fertilizers in combination with crop rotations was sufficient to raise production (CNA 1991). The data for the period 1990-1994 is not very reliable since production (and fertilizer use) was disrupted by the civil war.

The period after the war (1995-1998) was characterized by importation and distribution of free or significantly subsidized fertilizer to jumpstart the economy including using farm demonstrations across the country. Fertilizer imported and heavily subsidized by the EU and FAO was distributed through NGOs, the private sector, and farmers' cooperatives for free or some cash; the subsidies fell gradually from 50% to 20% by 1998.

Between 1998 and 2005, the private sector was involved in both importation and distribution of fertilizers (MINAGRI 2007). A policy shift that encouraged private sector participation, reduction in taxes, and extension of credit to the agricultural sector by the World Bank were key developments in this period. By 2000, there were encouraging signs of private sector import growth helped by the intervention of the Ministry of Agriculture and Animal Resources (MINAGRI) in regulating all free fertilizers from donors and NGOs that were giving unfair competition to the private sector.

In 2006 the GoR concluded that the private sector lacked sufficient capacity to deliver fertilizer to farmers. The GoR took over procurement and importation of fertilizers but left the distribution and retailing in the control of the private sector. The GoR did this without warning the private sector, thus creating an uncertain policy environment for private investment (IFDC 2011). In 2006, the GoR and the Clinton Foundation imported 28,000 MT of fertilizer to stimulate demand and offered it at fixed price to buyers in Kigali regardless of quantity purchased, creating disincentives to private sector participants. In order to provide the necessary tools to aid the GoR in making policy decisions on this process while encouraging private businesses to invest, the USAID-funded PReFER project implemented by IFDC recommended increased participation of the private sector with government providing oversight.

By 2007, the GoR had taken definitive steps to start providing subsidies in order to encourage uptake using extension agents in order to raise productivity. The Crop Intensification Program (CIP) was started in 2007 to encourage application of fertilizers on maize, beans, rice, wheat, potatoes, and bananas; it is estimated that CIP accounted for more than 95% of total fertilizer imports into Rwanda. In 2008 the GoR introduced targeted fertilizer vouchers implemented under the CIP as a means to reduce fertilizer costs, increase the supply of fertilizers, and foster fertilizer awareness among farmers. The vouchers were also seen as an important tool in creating a competitive fertilizer supply system that would encourage private sector participation while positively influencing soil fertility, land conservation, and food security.

The program design consisted of a fertilizer auction and the implementation of a fertilizer voucher program. As a first step, CIP determined the amount of fertilizer to be imported by aggregating the land area for eligible beneficiaries consisting of farmers agreeing to participate in land use consolidation in accordance with the requirements of crop regionalization.[50] Then

[50] Crop regionalization refers the strategy encouraged by GOR to shift from diversification and plant crops suited to the agroclimatic and soil conditions of the area. Land use consolidation encourages groups of neighboring smallholders to cultivate the same crop on their land with seed provided by the government.

MINAGRI issued a tender and procured fertilizer from neighboring countries and invited private distributors to an auction to make bids with the highest bid selected to distribute for specific regions of the country. Traders were picked based on their agricultural marketing experience, possessing a trade license and proof of linkages to network of retailers who were trained by IFDC Rwanda Agro-Dealer Development (RADD) project to build their capacity to provide technical information to farmers. A key characteristic of the design of the CIP program is the inclusion of a comprehensive technical package that combines the use of improved seeds, fertilizers and the provision of extension services.

The first fertilizer auction was conducted in 2008 under the supervision of MINAGRI, which was the sole importer of fertilizers at that time. These auctions were an attempt by the government to build a strong private sector agro-input distribution system by involving the private sector in the purchase, sale, and national distribution of government-procured fertilizer inputs. Between 2009 and 2013, private businesses (distributors and agro-dealers) were only involved in the distribution and retailing but not importation of fertilizers. Distributors who won the bids were expected to make a 30% down payment on their bid price, with the balance of the bidding price to be paid to the government after the distributor had received payment from the farmers. Essentially, MINAGRI encouraged distributors to extend this supplier's credit to agrodealers. In turn, agrodealers were expected to extend credit to farmers who would pay the agrodealers once they had harvested and sold their crop, allowing payments to flow back up the supply chain from farmers to MINAGRI.

With this model, MINAGRI sold to 10-15 private sector distributors on a combination of cash and interest-free credit terms. These distributors then sold to agro-dealers who in turn sold fertilizer to farmers at fixed pan-territorial prices set by MINAGRI on a combined cash and credit basis, with the credit to be paid back at harvest time. Both distributors and agro-dealers were allowed a fixed mark-up to cover operating costs and a profit margin. Despite increases in distribution operational costs, these mark-ups have remained constant since 2008 at RWF 65/kg for distributors and RWF 15/kg for agro-dealers (IFDC 2013). However, credit sales recovery from farmers at harvest time was approximately 30-35% and this led to an accumulated debt borne by MINAGRI of about $20 million, adding to government fiscal constraints and making the continued rollout of this subsidy model unsustainable.

The fertilizer subsidy took two forms: a full subsidy (100%) on the international/ regional transport cost, typically from Dar es Salaam or Mombasa to Kigali, and a retail price subsidy of 50% for maize and wheat growers. This voucher-based subsidy was applicable to 50 kg of DAP and 25 kg of urea intended for 0.5 hectares. All fertilizer destined for the CIP crops benefited from the transport subsidy while maize and wheat crops also benefited from the additional retail price subsidy and free improved seed for 0.5 hectare. The retail price subsidy was administered by a targeted voucher scheme with eligible farmers selected by MINAGRI working with local authorities at the district and sector levels using the criteria indicated above.

Aggregate fertilizer use increased substantially compared to previous periods, mainly due to lower prices resulting from subsidies and increased awareness of the benefits of fertilizer use by farmers (Kalibata 2010; Karera and Byakweli 2010). Fertilizer consumption rose from 8,000 MT before the introduction of subsidies in 2007 to approximately 35,000 MT in 2012. This rise was driven by subsidies mostly on fertilizer applied to the CIP priority enterprises (maize, wheat, rice, Irish potatoes, beans, and cassava) as well as the key cash crops (tea and coffee).

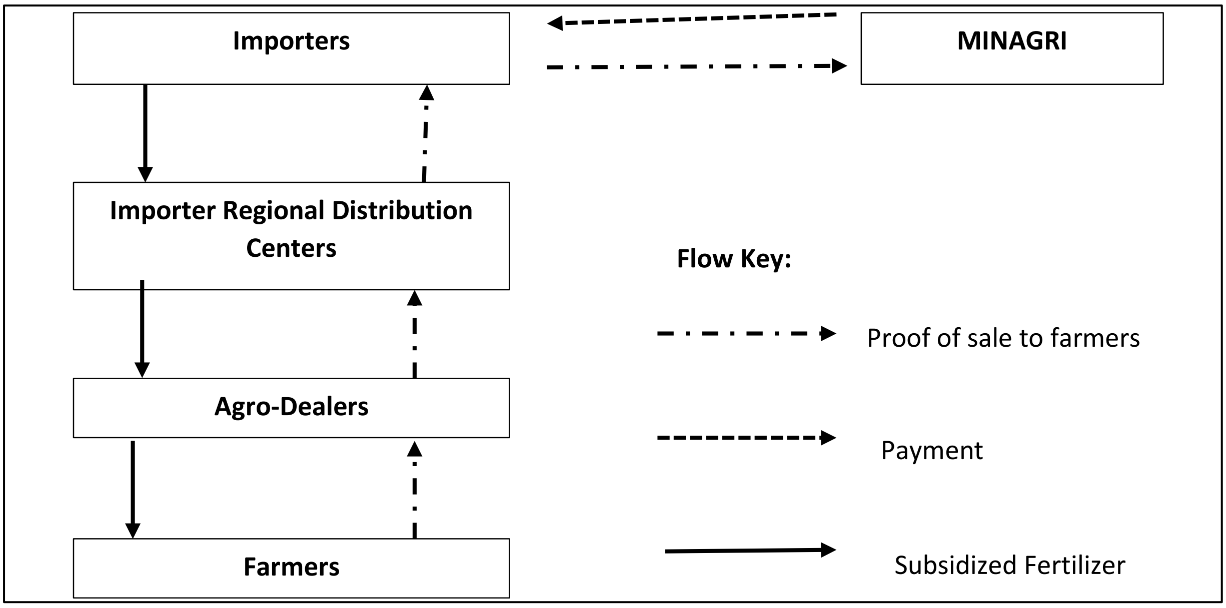
As a result of these fiscal constraints on MINAGRI occasioned by credit defaults by farmers and accompanied by austerity measures due to reduction in donor funding, in April 2013 MINAGRI made changes to the importation and distribution systems for subsidized fertilizer under the CIP, making a significant step towards privatization. The MINAGRI discontinued its involvement in importation of fertilizer and gave concessions through memoranda of understanding (MoUs) to two private companies (ENAS and Top Services) and one NGO, the One Acre Fund (also known as Tubura), to import and distribute 30,000 MT of fertilizer for the 2014 seasons. These three organizations were selected on the basis of financial, managerial and warehouse capacities indicating the ability to finance their own operations without state support.

Though the basic structure of the subsidy remained fairly fixed, there were a few significant changes to the system. MINAGRI now arrived at retail prices together with importers; the full subsidy on international/regional transport costs to Kigali was eliminated while maintaining the subsidy on retail prices. These few importers were assigned regions and encouraged to utilize existing networks built by other distributors who were left out of these concessions. ENAS and Top Services imported 25,000 MT together in 2013 while Tubura/One Acre Fund imported 5,000 MT in the first season. The winning companies had regional distribution monopolies in specified districts to agrodealers at a subsidized pan-territorial price. However, just like the importers, distributors and retailers are also expected to find their own sources of finance for their operations, since the GoR will no longer provide finance. The same is expected from farmers, who will be expected to pay the subsidized price differential up front, whether in cash or with credit (IFDC 2013). It is difficult to get credit due to the history of non-payment by beneficiaries and so initially MINAGRI provided guarantees to jumpstart the private sector.

The implementation of this new subsidy model encountered immediate constraints; the importers were finding it difficult to access sufficient credit for working capital from local commercial banks estimated at millions of dollars and incurring high commercial interest rates; logistics constraints arising from the expansion of distribution areas; building new business relationships with agro dealers in districts not previously served; and agreeing on retail prices (and hence margins at each level) that will allow for uptake while providing profits to value chain participants.

MINAGRI is poised to make further changes to the system by allowing more players at the import level and introducing nutrient-based subsidies to replace the product subsidies that have been in place. The importers in this new approach will have competition in their zones of distribution as more importers are included and existing ones allowed to operate in multiple regions. These importers have to build linkages with more established international players to provide the financial backing and logistical capability they need to survive. Already a number are networking with importers based in Kenya and Tanzania to build such capacities. There is fear that with reduced credit availability, fertilizer supply may reduce and agro-dealers will be impacted with potential losses, lack of credit and/or high cost of credit. The approach by MINAGRI is to gradually reduce the levels of subsidies over time. MINAGRI contracted to pay subsidies equivalent to 15% of the ceiling price for NPK (so importers could sell NPK at retail price minus 15% and government would pay that difference), 30% for urea, and 35% for DAP.

Figure B2. Diagram of New Fertilizer Subsidy Program in Rwanda



Source: Authors.

Figure B2. highlights the flow of fertilizers from importers to farmers and the back-flow of the proof of sale documents followed by payment from MINAGRI to importers in the current universal system.

Due to the difficulties of managing vouchers and the poor targeting, MINAGRI replaced targeted with universal subsidies open to all without vouchers to cut the bureaucracy and the costs of administration. Early indications show more farmers are being reached under this new *voucher-less* subsidy program. Fertilizer sales increased by 10% between 2013 and 2014 although it is likely that the beneficiaries are the relatively well-off farmers since those who still find the subsidized price too high will be unable to participate in the subsidy program.

As of 2014, the subsidies have been reduced from their previous levels of 20-50% to 15% of the retail price for NPK, 30% for urea, and 35% for DAP. Therefore, the CIP program has reduced the price of fertilizers (Republic of Rwanda 2014). However, weak or non-existent agro-dealer networks have not significantly reduced the distance from point of sale to farmers. The printing of vouchers was cumbersome and delayed fertilizer delivery to farmers due to poor access to electricity and other resources.

The implementation of the subsidy has resulted in a substantive increase in total fertilizer consumption in Rwanda from 6,000 MT in 2006 to about 35,000 MT in 2012, of which 30,000 MT was supplied by MINAGRI under CIP. By 2012 it was estimated that 29% of farmers were using fertilizers, up from 14% in 2007 (The Monitor Group 2012). The use of improved seeds by farmers also increased from 3% to 40%, which contributed to higher yields especially for maize.

The impact is mixed on private sector participation. More than 1,000 agrodealers have been trained and currently supply is mainly a private sector activity with government oversight. However, the bidding by region implies that distributors can lose their previous zone where they have already built a network. MINAGRI has now substantially scaled back its budgetary allocation to subsidies, thus meeting its objectives of cutting costs.

APPENDIX C. REFERENCES FOR TABLES 4.1, 4.3, AND 4.4 AND BASIC INFORMATION ON DATA SOURCES AND METHODS

(Note: Below, the term "IV" is used to generically refer to instrumental variables and two-stage least squares.)

Ethiopia

[E1] Gilligan, D.O., J. Hoddinott, and A.S. Taffesse. 2009. The Impact of Ethiopia's Productive Safety Net Programme and its Linkages. *The Journal of Development Studies* 45.10: 1684-1706. Sample of 3,700 households representing the four regions principally served by PSNP (Tigray, Amhara, Oromiya, Southern Nations, Nationalities, and People's Region.

[E2] Rashid, S., N. Tefera, N. Minot, and G. Ayele. 2013. Can Modern Input Use Be Promoted without Subsidies? An Analysis of Fertilizer in Ethiopia. *Agricultural Economics* 44.6: 595-611. (Estimates based on 2008 EDRI-IFPRI household survey)

Ghana

[G1] Vondolia, G.K., H. Eggert, and J. Stage. 2012. *Nudging Boserup? The Impact of Fertilizer Subsidies on Investment in Soil and Water Conservation* Discussion Paper No. 12-08. Washington, DC: Environment for Development and Resources for the Future. (Cross sectional data from 460 rice farmers in the Afife irrigation project in Ghana's Volta region).

[G2] Banful, A.B. 2011. Old Problems in the New Solutions? Politically Motivated Allocation of Program Benefits and the 'New' Fertilizer Subsidies. *World Development* 39.7: 1166-1176.

[G3] Resnick, D. and D. Mather. 2015. *Agricultural Inputs Policy under Macroeconomic Uncertainty: Applying the Kaleidoscope Model to Ghana's Fertilizer Subsidy Program (2008-2015).* IFPRI/MSU draft working paper. Washington DC and East Lansing: IFPRI and MSU.

Kenya

[K1] Sheahan, M., J. Olwande, L. Kirimi, and T.S. Jayne. 2014. *Targeting of Subsidized Fertilizer Under Kenya's National Accelerated Agricultural Input Access Program* (NAAIAP). Tegemeo Institute of Agricultural Policy and Development Working Paper No. 52. Nairobi, Kenya: Tegemeo Institute. (2 waves of nationwide household panel survey data; NAAIAP receipt only captured in 2nd (2010) wave; probit models using NAAIAP receipt as of 2nd wave as dependent variable, and HH/village characteristics as of 1st (2007) wave.)

[K2] Mather, D. and T.S. Jayne. 2015. Fertilizer Subsidies and the Role of Targeting in Crowding Out: An Assessment of Smallholder Fertilizer Demand in Kenya. Selected paper prepared for the International Conference of Agricultural Economics, 9-14 August. Milan, Italy. (4 waves of nationwide household panel survey data; NAAIAP/NCPB receipt only captured in 4th (2010) wave; targeting results based on CRE Tobit regressions; crowding out/total fertilizer use effects based on truncated normal hurdle model with CRE and CF.)

[K3] Mason, N.M., A. Wineman, L. Kirimi, and D. Mather. 2015. *The Effects of Kenya's 'Smarter' Input Subsidy Program on Smallholder Behavior and Incomes: Do Different Quasi-Experimental Approaches Lead to the Same Conclusions?* Working Paper No. 56. Nairobi, Kenya: Tegemeo Institute of Agricultural Policy and Development. (3 waves of nationwide household panel survey data; NAAIAP receipt only captured in 3rd (2010) wave; range of impact estimates due to range of

econometric approaches used – i.e., difference-in-differences (DID), FE, propensity score weighting-DID, and propensity score matching-DID with associated Rosenbaum bounds. *Maize yield* is kg of maize harvested per acre planted with maize, be it mono- or inter-cropped. Not feasible to apportion inter-cropped area to constituent crops with these data.)

[K4] Jayne, T.S., D. Mather, N.M. Mason, et al. 2015. Rejoinder to the Comment by Andrew Dorward and Ephraim Chirwa on Jayne, T.S, D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. 'How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion, and Benefit/Cost Assessments'. *Agricultural Economics* in press. DOI: 10.1111/agec.12190.

[K5] Jayne, T.S., D. Mather, N.M. Mason, and J. Ricker-Gilbert. 2013. How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion, and Benefit/Cost Assessments. *Agricultural Economics* 44.6: 687-703 (Kenya analysis same as [K2] above.)

[K6] Ochola, R.O. and F. Nie. 2015. Evaluating the Effects of Fertilizer Subsidy Programmes on Vulnerable Farmers in Kenya. *Journal of Agricultural Extension and Rural Development* 7.6: 192-201. (Despite the article's title and although it focuses on NAAIAP, it does not estimate the *ceteris paribus* effects of NAAIAP participation on household incomes or other outcomes; only NAAIAP beneficiaries are included in the sample.)

Malawi

[M1] Jayne, T.S., D. Mather, N.M. Mason, J. Ricker-Gilbert, and E. Crawford. 2015. Rejoinder to the Comment by Andrew Dorward and Ephraim Chirwa on Jayne, T.S, D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. 'How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion, and Benefit/Cost Assessments'. *Agricultural Economics* in press. DOI: 10.1111/agec.12190.

[M2] Jayne, T.S., D. Mather, N.M. Mason, and J. Ricker-Gilbert. 2013. How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion, and Benefit/Cost Assessments. *Agricultural Economics* 44.6: 687-703 (Three waves of nationally-representative HH survey data (IHS2, AISS1, AISS2); truncated normal hurdle model with CRE and control function approach.).

[M3] Ricker-Gilbert, J., T.S. Jayne, and E. Chirwa. 2011. Subsidies and Crowding Out: A Double-Hurdle Model of Fertilizer Demand in Malawi. *American Journal of Agricultural Economics* 93.1: 26-42. (Two waves of nationally-representative household survey data (Integrated Household Survey II (IHS2) covers 2002/03 and 2003/04, and Agricultural Input Subsidy Survey (AISS1) covers 2006/07); truncated normal hurdle model with CRE and control function approach.)

[M4] Ricker-Gilbert, J., N. Mason, F. Darko, and S. Tembo. 2013. What Are the Effects of Input Subsidy Programs on Maize Prices? Evidence from Malawi and Zambia. *Agricultural Economics* 44.6: 671-686. (Malawi analysis based on 12 years of biannual data from 72 markets in 26 districts; Arellano-Bond dynamic panel data models.)

[M5] Dionne, K.Y. and J. Horowitz. 2013. The Political Effects of Anti-Poverty Initiatives: An Analysis of Malawi's Agricultural Input Subsidy Program. Paper presented at the Midwest Group in African Political Economy meeting, 17-18 October. Bloomington IN: Indiana University. (Data from 3 districts on FISP participation in 2009, and respondent-level panel data from 2008 and 2010 on partisan leanings, and other respondent and HH characteristics; logit models for receipt of FISP; logit, matching, and Rosenbaum bounds sensitivity analysis for effects of FISP receipt in 2009 on partisanship in 2010.)

[M6] Brazys, S., P. Heaney, and P.P. Walsh. 2015. Fertilizer and Votes: Does Strategic Economic Policy Explain the 2009 Malawi Election? *Electoral Studies* 39: 39-55. (Various data sources including the 2008 Malawian Welfare Monitoring Survey, the 2004/05 Malawi Integrated Household Survey, AidData, Afrobarometer Round 3 (2005), Malawi Electoral Commission and others – please see the article for details; constituency and district-level data and two-step procedure/IV approach (district-level regressions) to correct for endogeneity of FISP to election outcomes.)

[M7] Chibwana, C., G. Shively, M. Fisher, and C. Jumbe. 2014. Measuring the Impacts of Malawi's Farm Input Subsidy Programme. *African Journal of Agriculture and Resource Economics* 9.2: 132-147. (Two- and three-year household panel survey dataset from 375 and 176 total smallholder households, respectively, in two districts – Kasungu and Machinga; IV approach; panel data used to create lagged variables but panel data methods not used.)

[M8] Chibwana, C., M. Fisher, and G. Shively. 2012a. Cropland Allocation Effects of Agricultural Input Subsidies in Malawi. *World Development* 40.1: 124-133. (Same data as [M7] but only use most recent wave – 2008/09 – as cross-section; multinomial logit and probit regressions for targeting; Tobit regressions for share of land devoted to various crops; two-step/IV approach.)

[M9] Chibwana, C., C. Jumbe, and G. Shively. 2012b. Agricultural Subsidies and Forest Clearing in Malawi. *Environmental Conservation* 40.1: 60-70. (Cross-sectional data from 380 HHs near forest reserves in two districts in Malawi; two-step/IV approach with multinomial logit regression for targeting, and Tobit regression for the extent of forest clearing.)

[M10] Chirwa, T.G. 2010. Program Evaluation of Agricultural Input Subsidies in Malawi Using Treatment Effects: Methods and Practicability Based on Propensity Scores. Munich Personal RePEc Archive Paper No. 21236. Munich, Germany: Ludwig-Maximilians-Universität München. Retrieved from http://mpra.ub.uni-muenchen.de/21236/1/MPRA_paper_21236.pdf (Panel data from the nationally-representative IHS2 and AISS1; PSM and IV approaches; panel data methods not employed.)

[M11] Chirwa, E.W., P.M. Mvula, A. Dorward, and M. Matita. 2011. *Gender and Intra-Household Use of Fertilizers in the Malawi Farm Input Subsidy Programme.* Future Agricultures Working Paper No. 028. Brighton: Future Agricultures Consortium. (Cross-sectional data from the nationally-representative AISS2 survey, which covers the 2008/09 agricultural season; probit regressions; no correction for endogeneity of FISP participation.)

[M12] Fisher, M. and V. Kandiwa. 2014. Can Agricultural Input Subsidies Reduce the Gender Gap in Modern Maize Adoption? Evidence from Malawi. *Food Policy* 45.May: 101-111. (Cross-sectional data from the nationally-representative IHS3, which covers the 2008/09 agricultural season; multinomial logit for targeting analysis, and logit model for factors affecting adoption of modern maize varieties; two-step/IV approach.)

[M13] Holden, S., and R. Lunduka. 2010a. Too Poor to Be Efficient? Impacts of the Targeted Fertilizer Subsidy Programme in Malawi on Farm Plot Level Input Use, Crop Choice and Land Productivity. NORAGRIC Report No. 55. Ås, Norway: Department of International Environment and Development Studies, Norwegian University of Life Sciences. (Three-wave panel survey of 450 HHs (378 in balanced panel) in six districts in Malawi; random effects, fixed effects, panel probit, and bivariate probit models; IV approach also tried but authors note that "no good instruments were available for predicting each of the input variables" (p. 5).)

[M14] Holden, S.T. and R.W. Lunduka. 2013. Who Benefit from Malawi's Targeted Farm Input Subsidy Program? *Forum for Development Studies* 40.1: 1-25. (Data same as last two waves in [M13]; ordered probit for maize market position (net buyer, autarkic, net seller), OLS for maize production; lagged dependent variables included in regressions; panel data methods and instrumental variables not employed.)

[M15] Holden, S. and R. Lunduka. 2012. Do Fertilizer Subsidies Crowd Out Organic Manures? The Case of Malawi. *Agricultural Economics* 43.3: 303-314. (Same data as [M13]; probit and Tobit models with CRE and control function approach.)

[M16] Mason, N.M. and J. Ricker-Gilbert. 2013. Disrupting Demand for Commercial Seed: Input Subsidies in Malawi and Zambia. *World Development* 45(May): 75-91. (2 waves of nationally-representative household panel survey data – AISSI and AISS2; Tobit models with CRE and CF.)

[M17] Ricker-Gilbert, J. and T.S. Jayne. 2011. What Are the Enduring Effects of Fertilizer Subsidy Programs on Recipient Farm Households: Evidence from Malaw? MSU Staff Paper No. 2011-09. E. Lansing, MI: Michigan State University. (Three-waves of nationally-representative HH panel survey data – IHS2, AISS1, AISS2; first-difference estimator and log-normal hurdle model with CRE, both with control function approach.)

[M18] Ricker-Gilbert, J. and T.S. Jayne. 2012. Do Fertilizer Subsidies Boost Staple Crop Production and Reduce Poverty across the Distribution of Smallholders in Africa? Quantile Regression Results from Malawi. Selected Paper for the Triennial Meeting of the International Association of Agricultural Economists. August 18-24, 2012. Foz Do Iguacu, Brazil. (Same data as [M17]; quantile regression model with CRE.)

[M19] Ricker-Gilbert, J. 2014. Wage and Employment Effects of Malawi's Fertilizer Subsidy Program. *Agricultural Economics* 45.3: 337-353. (Same as [M17]; fixed effects and CRE Tobit regressions.)

[M20] Karamba, R.W. and P.C. Winters. 2015. Gender and Agricultural Productivity: Implications of the Farm Input Subsidy Program in Malawi. *Agricultural Economics* 46.3: 357-374. (Same data as [M12]; probit model for FISP participation, and OLS, propensity score weighting (PSW), and PSW with spatial fixed effects for yield effects of FISP.)

[M21] Karamba, R.W. 2013. Input Subsidies and Their Effect on Cropland Allocation, Agricultural Productivity, and Child Nutrition: Evidence from Malawi. Ph.D. dissertation, American University. (Same data as [M12]; probit and IV models for if used fertilizer on plot, OLS and IV for kg and kg/ha of fertilizer applied, and crop diversity, OLS and three stage least squares for cropland allocation decisions, OLS and IV for per capita value of food consumption, non-food consumption, and health expenditures, dietary diversity, and weight-for-height Z-score for preschool children (6-59 months).)

[M22] Arndt, C., K. Pauw, and J. Thurlow. 2014. *The Economywide Impacts and Risks of Malawi's Farm Input Subsidy Programme.* WIDER Working Paper No. 99/2014. Helsinki, Finland: United Nations University, World Institute for Development Economics Research. (Study the 2006/07 FISP, which aimed to distribute 150,000 MT of fertilizer for use on maize, along with improved

seed (60% of which was hybrid, and 40% of which was composite); assumed these inputs were used on 500,000 ha of land; computable general equilibrium (CGE) model of the Malawian economy based on 2003 Social Accounting Matrix; CGE model linked to a poverty module based on household survey data (IHS2) to estimate impacts of FISP on consumption poverty. "Observed consumption changes in the model are then applied proportionally to survey households, each with a unique consumption pattern. A post-simulation consumption value can then be calculated and compared against an absolute poverty threshold to determine if a household's poverty status has changed from the base." (p. 5).)

[M23] Westberg, N.B. 2015. *Exchanging Fertilizer for Votes?* NORAGRIC Working Paper No. 12/2015, Ås, Norway: Department of International Environment and Development Studies, Norwegian University of Life Sciences. (Main data sources are district-level FISP allocations from the Malawi Logistics Unit, population data from the National Statistical Office, and election data from the Sustainable Development Network Programme and Malawi Electoral Commission; 6 years of district-level panel data covering all 28 districts in Malawi; district-level fixed effects model of number of FISP vouchers allocated to district regressed on past election results and other controls.)

[M24] Chirwa, E.W., M. Matita, M., and A. Dorward. 2010. *Targeting Agricultural Input Subsidy Coupons in Malawi.* Working Paper. London: Centre for Development, Environment and Policy, SOAS, University of London, and Wadonda Consultants. (Cross-sectional data from the nationally-representative AISS2 survey, which covers the 2008/09 agricultural season; probit and Tobit models for factors affecting receipt of FISP fertilizer coupons and kg of subsidized fertilizer acquired, respectively.)

[M25] Holden, S. 2013. *Input Subsidies and Demand for Improved Maize: Relative Prices and Household Heterogeneity Matter!* Centre for Land Tenure Studies Working Paper No. 06/13. Ås, Norway: Norwegian University of Life Sciences. (Simulations based on non-separable agricultural household models, with rural Malawian households classified into six households groups based on region (South vs. Central), sex of the household head, and land availability ("land-poor" vs. "land-rich"). Models calibrated to 2005/06 survey data from six districts.)

[M26] Mkwara, B. and D. Marsh. 2011. *Effects of Maize Fertilizer Subsidies on Food Security in Malawi.* University of Waikato Working Paper in Economics No. 14/11. Hamilton, New Zealand: University of Waikato. (Cross-sectional, nationwide administrative area data from the 2008/09 Annual National Census of Agriculture. OLS and OLS controlling for spatial autocorrelation regressions of administrative area maize yield on the percentage of HHs receiving FISP and other controls. No correction for potential endogeneity of FISP to maize yields.)

[M27] Dorward, A., and E. Chirwa. 2013. *Impacts of the Farm Input Subsidy Programme in Malawi: Informal Rural Modeling.* Working Paper No. 067. Brighton: Future Agricultures Consortium. (Partial equilibrium model of the impacts of FISP on smallholder livelihoods in two livelihood zones for 2005/06 through 2010/11. IHS2 data used to develop household/livelihood zone classification scheme. Household livelihood models developed for Kasungu Lilongwe Plain and Shire Highlands for each household type per the classification scheme (see the paper itself for details); model results then aggregated by livelihood zone to obtain an 'informal rural economy' model. 'With subsidy' scenario modeled in two ways: (i) universal 50 kg fertilizer + 2 kg hybrid maize seed, and (ii) targeted distribution of 100 kg of fertilizer + 2 kg hybrid maize seed to their 'poor male-headed household' and 'poor female-headed household' types. Per the authors, "an average taken across [the two scenarios] is likely to be closer to distribution patterns actually achieved. However, it should be recognized that this is likely to over-estimate access by poorer households" (p. 7).

[M28] Kilic, T., E. Whitney, and P. Winters. 2015. Decentralised Beneficiary Targeting in Large-Scale Development Programmes: Insights from the Malawi Farm Input Subsidy Programme. *Journal of African Economies* 24.1: 26-56. (Cross-sectional, nationally-representative HH survey data from IHS3 used to analyze the decentralized targeting of FISP during the 2009/10 agricultural season. Decomposes targeting coefficients into inter-district, intra-district inter-community, and intra-district intra community components. IHS3 rural HHs classified as poor (FISP eligible) or not based on annual rural household consumption per capita predicted as a function of non-monetary explanatory variables, the IHS2 2004/05 poverty line, and a survey-to-survey imputation approach using the IHS2 data to estimate the relationship between these explanatory variables and per capita consumption. 'Poor' defined in this way used as a proxy for 'resource poor', a key FISP eligibility criterion. Household assets and landholding size used as alternative proxies for 'resource poor'. Probit (order probit) model for factors affecting household-level participation in FISP (number of FISP coupons received), with controls for district and agro-ecological zone fixed effects.

[M29] Ricker-Gilbert, J. and T.S. Jayne. 2015. What Are the Dynamic Effects of Fertilizer Subsidies on Commercial Fertilizer Demand and Maize Production? Panel Evidence from Malawi. Paper prepared for presentation at the symposium on Using Smart Subsidies to Support Small Scale Farmers in Africa, International Conference of Agricultural Economists, August 18. Milan, Italy. (4 waves of panel data on 462 farm households in Malawi; panel data techniques to correct for the potential endogeneity of subsidized fertilizer to household commercial fertilizer demand and maize production.)

Nigeria

[N1] Takeshima, H. and E. Nkonya. 2014. Government Fertilizer Subsidy and Commercial Sector Fertilizer Demand: Evidence from the Federal Market Stabilization Program (FMSP) in Nigeria. *Food Policy* 47(August): 1-12. (Two different datasets analyzed: a two-year, nationwide Local Government Area (LGA)-level pseudo-panel dataset of export-crop growers, and a nationally-representative cross-sectional survey of agricultural households (LSMS); double-hurdle version of Nelson and Olson's (1978) simultaneous Tobit model with IV (and LGA-level CRE for pseudo-panel analysis).[51]

[N2] Liverpool-Tasie, L.S.O. 2014. Fertilizer Subsidies and Private Market Participation: The Case of Kano State, Nigeria. *Agricultural Economics* 45.6: 663-678. (Cross-sectional dataset from Kano State; truncated normal hurdle model with CF approach.)

[N3] Liverpool-Tasie, L.S., and S. Salau. 2013. *Spillover Effects of Targeted Subsidies: An Assessment of Fertilizer and Improved Seed Use in Nigeria.* IFPRI Discussion Paper No. 01260, Washington, DC: International Food Policy Research Institute, Development Strategy and Governance Division. (Same dataset and approach as [N2], except probit model instead of truncated normal hurdle model.)

[N4] Liverpool-Tasie, L.S.O. 2014. Do Vouchers Improve Government Fertilizer Distribution? Evidence from Nigeria. *Agricultural Economics* 45.4: 393-407. (Same data as [N2] and [N3] plus cross-sectional dataset from Taraba State; PSM and Rosenbaum bounds.)

[51] Nelson, F., and L. Olson, L. 1978. "Specification and Estimation of a Simultaneous-Equation Model with Limited Dependent Variables." *Int. Econ. Rev.* 19(3):695-709.

[N5] Liverpool-Tasie, L.S.O. 2014. Farmer Groups and Input Access: When Membership is Not Enough. *Food Policy* 46(June): 37-49. (Same data as N4; generalized Tobit and lognormal hurdle models.)

[N6] Takeshima, H., and L.S.O. Liverpool-Tasie. 2015. Fertilizer Subsidies, Political Influence and Local Food Prices in Sub-Saharan Africa: Evidence from Nigeria. *Food Policy* 54(July): 11-24. (Enumeration area (EA) local rice, maize, and sorghum prices for 187 EAs, and LGA-level subsidized fertilizer quantities; multiple EAs per LGA; prices measured at post-harvest and post-planting in one year; EA-level, 2-season panel; three-stage least squares models for growth rate in crop price.

[N7] Takeshima, H., E. Nkonya, and S. Deb. 2012. Impact of Fertilizer Subsidies on the Commercial Fertilizer Sector in Nigeria: Evidence from Previous Fertilizer Subsidy Schemes. IFPRI Working Paper No. 23 Abuja, Nigeria: IFPRI Nigeria Strategy Support Program II, (Same data as [N1], endogenous Tobit model with both datasets, and combined with CRE in analysis of the pseudo-panel data.)

Zambia

[Z1] Mason, N.M., and T.S. Jayne. 2013. Fertiliser Subsidies and Smallholder Commercial Fertiliser Purchases: Crowding Out, Leakage and Policy Implications for Zambia. *Journal of Agricultural Economics* 64.3: 558-582. (3 waves of nationally-representative household panel survey data; Tobit and truncated normal hurdle models with correlated random effects (CRE) and control function (CF) approach.)

[Z2] Mason, N.M., and J. Ricker-Gilbert. 2013. Disrupting Demand for Commercial Seed: Input Subsidies in Malawi and Zambia. *World Development* 45(May): 75-91. (2 waves of nationally-representative household panel survey data; Tobit models with CRE and CF.)

[Z3] Mason, N.M., T.S. Jayne, and R. Mofya-Mukuka. 2013. Zambia's Input Subsidy Programs. *Agricultural Economics* 44.6: 613-628. (Most results based on 3 waves of nationally-representative household panel survey data; targeting results also reported from a more recent nationally-representative cross-section; various econometric models combined with CRE and CF.)

[Z4] Mason, N. M., and M. Smale. 2013. Impacts of Subsidized Hybrid Seed on Indicators of Economic Well-Being Among Smallholder Maize Growers in Zambia. *Agricultural Economics* 44.6: 659-670. (2 waves of nationally-representative household panel survey data; various econometric models with CRE and CF.)

[Z5] Mason, N.M., T.S. Jayne, and R.J. Myers. 2015. Smallholder Supply Response to Marketing Board Activities in a Dual Channel Marketing System: The Case of Zambia. *Journal of Agricultural Economics* 66.1: 36-65. (3 waves of nationally-representative household panel survey data; various econometric models with CRE and CF.)

[Z6] Mason, N.M., T.S. Jayne, and N. van de Walle. 2013. Fertilizer Subsidies and Voting Patterns: Political Economy Dimensions of Input Subsidy Programs. Selected paper presented at the Agricultural and Applied Economics Association's AAEA and CAES Joint Annual Meeting, 4-6 August. Washington, DC. (3 waves of nationally-representative household panel survey data and Tobit models with CRE for targeting analysis; 2 waves of district-level panel data and fractional response models with CRE and CF for impacts of ISP on voting patterns.)

[Z7] Xu, Z., W.J. Burke, T.S. Jayne, and J. Govereh. 2009. Do Input Subsidy Programs "Crowd In" or "Crowd Out" Commercial Market Development? Modeling Fertilizer Demand in a Two-Channel Marketing System. *Agricultural Economics* 40.1: 79-94. (2 waves of nationally-representative household panel survey data with truncated normal hurdle models and CRE.)

[Z8] Zulu, P., T. Kalinda, and G. Tembo. 2014. Effects of the Maize Input Subsidy Program on Groundnuts Production in Zambia. *Journal of Agricultural Science* 6.7: 253-264. (3 waves of nationally-representative household panel survey data; truncated normal hurdle model with CRE and CF.)

[Z9] Sianjase, A., and V. Seshamani. 2013. Impacts of Farmers Inputs Support Program on Beneficiaries in Gwembe District in Zambia. *Journal of Environmental Issues and Agriculture in Developing Countries* 50.1: 40-50. (4 waves of panel data from Gwembe district; quantile regression with CRE.)

[Z10] Smale, M., E. Birol, and D. Asare-Marfo, D. 2014. Smallholder Demand for Maize Hybrids in Zambia: How Far do Seed Subsidies Reach? *Journal of Agricultural Economics* 65.2: 349-367. (Cross-sectional data from Central, Copperbelt, Eastern, Lusaka, Northern, and Southern provinces; instrumental variables (IV) and CF approaches.)

[Z11] Namonje-Kapembwa, T., T.S. Jayne, and R. Black. 2015. Does Late Delivery of Subsidized Fertilizer Affect Smallholder Maize Productivity and Production? Selected paper presented at the Agricultural and Applied Economics Association and Western Agricultural Economics Association Annual Meeting, 26-28 July. San Francisco, CA. (Nationally-representative cross-section; stochastic frontier model with CF.)

[Z12] Goeb, J. 2011. Impacts of Government Maize Supports on Smallholder Cotton Production in Zambia. MS thesis, Michigan State University. (3 waves of nationally-representative household panel survey data and 2 waves of enumeration area-level panel data; CRE Tobit and truncated normal hurdle models.)

[Z13] Mason, N.M., and S.T. Tembo. 2015. *Do Input Subsidy Programs Raise Incomes and Reduce Poverty Among Smallholder Farm Households? Evidence from Zambia.* IAPRI Working Paper No. 92. Lusaka, Zambia: Indaba Agricultural Policy Research Institute, (2 waves of nationally-representative household panel survey data; various econometric models with CRE and CF.)

[Z14] Levine, N.K. 2015. Do Input Subsidies Crowd In or Crowd Out Other Soil Fertility Management Practices? Evidence from Zambia. MS Plan B Paper, Michigan State University. (2 waves of nationally-representative household panel survey data; fixed effects (FE) and FE-IV models.)

[Z15] Jayne, T.S., D. Mather, N.M. Mason, J. Ricker-Gilbert, and E. Crawford. 2015. Rejoinder to the Comment by Andrew Dorward and Ephraim Chirwa on Jayne, T.S, D. Mather, N. Mason, and J. Ricker-Gilbert. 2013. 'How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion, and Benefit/Cost Assessments'. *Agricultural Economics* 44.6: 687-703. DOI: 10.1111/agec.12190.

[Z16] Jayne, T. S., D. Mather, N.M. Mason, and J. Ricker-Gilbert. 2013. How Do Fertilizer Subsidy Programs Affect Total Fertilizer Use in Sub-Saharan Africa? Crowding Out, Diversion, and Benefit/Cost Assessments. *Agricultural Economics* 44.6: 687-703. (Zambia analysis based on 3 waves of nationally-representative household panel survey data; truncated normal hurdle models with CRE and CF.)

[Z17] Ricker-Gilbert, J., N.M. Mason, F.A. Darko, and S.T. Tembo. 2013. What Are the Effects of Input Subsidy Programs on Maize Prices? Evidence from Malawi and Zambia. *Agricultural Economics* 44.6: 671-686. (Zambia analysis based on 12 years of biannual data from 50 districts; Arellano-Bond dynamic panel data models.)

Tanzania

[T1] Pan, L. and L. Christiaensen. 2012. Who is Vouching for the Input Voucher? Decentralized Targeting and Elite Capture in Tanzania. *World Development* 40.8: 1619-1633.

[T2] Msolla, M.M. 2014. Effects of the Subsidy Voucher Program on Fertilizer Markets: Example from Tanzania. Paper presented at the IFDC Training on Fertilizer Value Chain-Supply System Management and Servicing Farmers' Needs, 14-18 April. Accra, Ghana.

[T3] Mather, David, B. Waized, D.Ndyetabula, A. Temu, I. Minde and D. Nyange. 2015. The Role of Relative Prices, Agro-Ecological Factors, and Household Soil and Crop Management Practices in Explaining Smallholder Profitability of Fertilizer Use on Maize in Tanzania. Forthcoming MSU working paper.

[T4] World Bank. 2014. Tanzania Public Expenditure Review: National Agricultural Input Voucher Scheme (NAIVS). Strengthening National Comprehensive Agricultural Public Expenditure in Sub-Saharan Africa Washington, DC: World Bank. www.worldbank.org/afr/agperprogram

APPENDIX D

A Review of Two Studies on Returns to Public Agricultural Investments

Many parts of Asia have achieved impressive gains in agricultural productivity and poverty reduction over the past half-century. By contrast, sustained agricultural development remains elusive in most of Africa. Can African policy makers learn from Asia's green revolution? Conditions differ in many respects between Africa and Asia, as well as across countries within Africa, and the impacts of various investments and policies in Asia may not necessarily produce the same impacts in Africa. However, it is instructive to understand the mix of public investments and policies that helped many Asian countries achieve their smallholder-led green revolutions and to consider the potential lessons for Africa.

Two studies are especially insightful to provide guidance. The first study, carried out by the Economist Intelligence Unit (EIU 2008), estimated the contribution of various types of public investments and strategies to agricultural growth and poverty reduction in six Asian countries: China, India, Indonesia, South Korea, Taiwan, and Vietnam. The second study, carried out by IFPRI (Fan, Gulati, and Thorat 2008) provides an in-depth analysis of India to identify the returns to various types of public expenditures over a 40-year period.

Main Findings

The EIU study highlights the primacy of policy and enabling environment in driving both agricultural growth and poverty reduction in most of Asia (Table D1). As stated by the report:

"In places such as Korea and Taiwan, land-to-the tiller reforms created a broad-based agrarian population with ownership over land and strong incentives to increase output. In China and Vietnam, increasing individual farmers' rights over their land and output, combined with agricultural market liberalization, substantially improved farmers' incentives and stimulated rapid growth in output and private investment. Indeed, policy and institutional reforms have been central to (arguably, the main sources of) agricultural growth in China and Vietnam because those countries had to overcome complete state control of the entire economy. But getting institutions and policies right also mattered a great deal in the other four Asian economies as well" (p. 7-8).

"Appropriate policy reforms not only bring about one-off efficiency gains…more importantly they improve incentives for private investment in resource conservation, technology adoption, innovation, and increased modern inputs application, all of which lead to higher steady-state rates of output growth" (p. 8).

"Policy and institutional improvements can also improve equity since administrative power over farmer behavior tended to favor the wealthiest and those with the best political connections, rarely poorer individuals or communities" (p. 8).

The EIU (2008) study contends that policy and institutional reform in Africa may not produce the same magnitude of benefits as in Asia because of its view that African nations have already undertaken most of the major sectoral reforms enacted in Asia. However, food and input markets in Africa continue to be hampered by unpredictable state operations, trade barriers, and sudden entry and retreat from markets. If anything, state intervention in food and input markets appears to be on the rise. The high degree of policy uncertainty creates major market risks and impedes private investment from flowing into the agricultural sector to support smallholder farmers. In these ways, there is still a great deal to be gained from sectoral reform in Africa, not necessarily to liberalize private trade *per se* but to reduce the risks and costs imposed on private trade arising from unpredictable government actions. The policy environment will clearly influence the impact of public investments on agricultural growth and poverty reduction.

Table D1. Summary of Analysis of Six Asian Economies' Agricultural Growth Boom Periods

	Agricultural growth effects			Poverty-reduction effects		
	Median share of agricultural growth attributable to:	Median rank by total effect	Median rank by benefit/cost ratio	Median share of poverty reduction attributable to:	Median rank by total effect	Median rank by benefit/cost ratio
Policy / institutional reform	40%	1	1	30%	1	1
Infrastructure						
Rural roads	10%	3.5	3	15%	3	3
Irrigation	9%	4.5	4	8%	5	4
Electricity/health/ education	9%	4	7	18%	2	4
Agricultural inputs delivery						
Fertilizer/seed/chemicals	10%	5	6	7%	6 (tied)	6
Agricultural credit/ insurance	2%	6 (tied)	8	5%	6 (tied)	2.5
Agricultural/ natural resource management research/extension						
Ag./NRM research	15%	2	2	10%	4	2
Ag/NRM extension	2%	6 (tied)	4	5%	6 (tied)	2.5

Source: The Economist Intelligence Unit (2008).

As shown in Table D1, other investments found by the EIU study to have high payoffs were: crop science R&D and investments in rural roads, electricity, health, and education. These investments helped smallholders produce more food while also improving their access to markets and services. Resources invested in input subsidies and direct distribution of fertilizers and other agri-chemicals showed modest returns on average. Input subsidies played a greater role in irrigated areas where the combination of water control, improved seed varieties and fertilizer raised yields dramatically. Returns to subsidies were lower under rainfed conditions, especially in semi-arid areas.

The IFPRI study of India estimates the return to various types of government expenditures in terms of agricultural growth and poverty reduction. Moreover, this study estimates impacts at different periods in India's development path from the 1960s to 2000.

Table D2. Returns in Agricultural Growth and Poverty Reduction to Investments and Subsidies, India, 1960-2000

	1960s Returns	Rank	1970s Returns	Rank	1980s Returns	Rank	1990s Returns	Rank
Returns in Agricultural GDP (Rs produced per Rs spent)								
Road investment	8.79	1	3.80	3	3.03	5	3.17	2
Educational investment	5.97	2	7.88	1	3.88	3	1.53	3
Irrigation investment	2.65	5	2.10	5	3.61	4	1.41	4
Irrigation subsidies	2.24	7	1.22	7	2.28	6	na	8
Fertilizer subsidies	2.41	6	3.03	4	0.88	8	0.53	7
Power subsidies	1.18	8	0.95	8	1.66	7	0.58	6
Credit subsidies	3.86	3	1.68	6	5.20	2	0.89	5
Agricultural R&D	3.12	4	5.90	2	6.95	1	6.93	1
Returns in Rural Poverty Reduction (decrease in number of poor per million Rs spent)								
Road investment	1272	1	1346	1	295	3	335	1
Educational investment	411	2	469	2	447	1	109	3
Irrigation investment	182	5	125	5	197	5	67	4
Irrigation subsidies	149	7	68	7	113	6	na	8
Fertilizer subsidies	166	6	181	4	48	8	24	7
Power subsidies	79	8	52	8	83	7	27	6
Credit subsidies	257	3	93	6	259	4	42	5
Agricultural R&D	207	4	326	3	345	2	323	2

Source: Fan, Gulati, and Thorat 2008.

As shown in Table D2, most public expenditures to agriculture in the 1960s generated very high returns to both agricultural growth and poverty reduction. During this period, India's green revolution was just starting to take hold, which might make this period particularly relevant for many African countries. Particularly high returns were generated from public investments in roads and education, which had estimated benefit-cost ratios of 6 to 9. Agricultural research investments and credit subsidies yielded benefits that were 3 to 4 times the amount spent. This was the period when improved seed varieties, fertilizer, and credit were being promoted as a high payoff technology package. Irrigation and power subsidies yielded the lowest returns in this period, though returns to these subsidies were more than double spending. In the 1970s and 1980s, the returns to most of the subsidy programs declined though they began to account for a growing share of national budgets. Meanwhile, investments in agricultural R&D, roads, and education provided the greatest payoffs in terms of agricultural growth. By the 1990s only agricultural R&D and road investments continued to yield estimated returns of more than 300%. Estimated net returns to irrigation investments and education were low but still positive, whereas credit, power, and fertilizer subsidies had negative net returns, i.e., a Rupee invested generated less than one Rupee of benefits (Fan, Gulati, and Thorat 2008). These findings are similar to those of Rashid et al. (2007) who concluded that state subsidies in input and output markets played an important role in supporting the initial uptake of improved farm technologies in Asia, but that their return fell over time and that the subsidies have now become a major drain on the treasury while crowding out other public investments that could produce higher payoffs.

The ranking of public investments in terms of poverty reduction follow the same broad pattern as that for agricultural GDP growth. Spending on roads, agricultural R&D, and education provided the greatest poverty reduction impacts. These findings are consistent with evidence from Africa showing returns to investment in agricultural R&D over 20% per year (Oehmke and Crawford 1996; Masters, Bedingar, and Oehmke 1998). The economic assessment evidence strongly indicates that if the resources that were spent on crop science had been spent on something else, African economies would now be poorer, government finances would be in worse shape, food import bills would be higher, and more Africans would suffer from food insecurity.

Fertilizer subsidies are estimated to have been effective at reducing poverty in the 1960s and 1970s, but subsequently appear to have been highly ineffective (Table D2). Credit subsidies were effective in the 1960s and 1980s. As stated by Fan, Gulati, and Thorat (2008), "These results have significant policy implications: most importantly, they show that spending government money on investments is surely better than spending on input subsidies. And within different types of investments, spending on agricultural R&D and roads is much more effective at reducing poverty than putting money in, say, irrigation" (p. 18-19).

The findings of these two studies from Asia provide potentially important implications for promoting agricultural growth and poverty reduction in Africa. Although the regions differ in important respects, there are strong reasons to believe that the policy reforms and investments in R&D and infrastructure that generated high payoffs in Asia are likely to be crucial drivers of growth in most of Africa as well. The payoffs to most types of public investments will be greater in a policy environment conducive to private investment. As concluded by EIU (2008): "Our assessment is that the interventions that proved most effective in Asia—policy and institutional reforms, an agricultural research revolution, major expansion of rural roads and irrigation, and improved rural financial services delivery—must likewise be the primary targets for new investments…..The specifics of the strategies will vary among countries and even among agro-ecologies within countries, and must be developed internally, albeit with external financial and technical assistance. But the broader patterns are clear" (p. 18).

The main caveat to these studies is that they are based on the period 1960-2000. Much has changed since then. Global climate change, constraints and costs associated with bringing new land into production, higher energy prices, the evolving structure of the global food system, the concentration of agricultural R&D research and increasing intellectual property right protection barriers to public R&D, Africa's increasingly urban complexion, and the possible slow-down of crop productivity growth in the world's breadbasket zones are several of the most important developments that would need to be carefully considered which might alter, perhaps fundamentally, the way relative payoffs to public sector investments in the future and the nature of the CG research priorities.