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Abstract:

Input subsidy programs have once again become a major plank of agricultural development strategies in Africa. Ten African governments spend roughly US$1 billion annually on ISPs, amounting to 28.6 percent of their public expenditures on agriculture. This article reviews the micro-level evidence on input subsidy programs undertaken since the mid-2000s. We examine the characteristics of subsidy beneficiaries, maize response rates to fertilizer application and their influence on the performance of subsidy programs, the impacts of subsidy programs on national fertilizer use, the development of commercial input distribution systems, food price levels, and poverty rates. The weight of the evidence indicates that the costs of the programs generally outweigh their benefits. Findings from other developing areas with a higher proportion of crop area under irrigation and with lower fertilizer prices -- factors that should provide higher returns to fertilizer subsidies than in Africa -- indicate that at least a partial reallocation of expenditures from fertilizer subsidies to R&D and infrastructure would provide higher returns to agricultural growth and poverty reduction. However, because input subsidy programs enable governments to demonstrate tangible support to constituents, they are likely to remain on the African landscape for the foreseeable future. Hence, the study identifies ways in which benefits can be enhanced through changes in implementation modalities and complementary investments within a holistic agricultural intensification strategy. Among the most important of these are efforts to reduce the crowding out of commercial fertilizer distribution systems and programs to improve soil fertility to enable farmers to use fertilizer more efficiently. The challenges associated with achieving these gains are likely to be formidable.

Keywords: input subsidies, agricultural productivity, fertilizer markets, crop response rates, Africa

JEL classification: O2, O13, Q12, Q18

1. Introduction

The resurgence of input subsidy programs in Africa has arguably been the region's most important agricultural policy development in recent years. At the turn of the millennium, input subsidy programs (ISPs) had been phased out in all but a small number of African countries. In 2011, the latest year for which data are available, ten African countries spent roughly US$1.05 billion on ISPs, amounting to 28.6 percent of their public expenditures on agriculture (Table 1).

In spite of the resurgence of ISPs, there has been limited rigorous assessment of their impacts to date. The last major synthesis of input subsidy programs in Sub-Saharan Africa was in 2007 by Morris *et al* (2007).[1] At that time in 2007, Africa was on the cusp of a major tidal change ushering in a new wave of "smart subsidy" programs, based on the apparent success of Malawi's Agricultural Inputs Subsidy Programme. Initial but somewhat superficial assessments of that program (e.g., New York Times 2007; AGRA 2009) reported how Malawi's program had turned the country from a food basket case into a grain exporter and was dramatically reducing rural poverty rates.[2] While more recent analyses have shown these assertions to be highly debatable in some respects and factually incorrect in others,[3] the Malawi case had an important "primacy effect" on policy discourse on the continent, convincing numerous governments to undertake similar targeted input subsidy programs. By 2010, at least nine other countries accounting for over 60% of sub-Saharan Africa's population[4] had re-instituted input subsidy programs.

Fortunately, there has been a recent proliferation of farm household panel surveys and other data in many African countries that have implemented input subsidy programs (ISPs). The availability of such data has provided great scope for improving the empirical foundation to better understand the complex impacts and distributional effects of ISPs.[5]

This article synthesizes studies undertaken since the mid-2000s on input subsidy programs in Africa. The collection of studies in this special issue of *Agricultural Economics* shed light on longstanding knowledge gaps about ISPs. This article also incorporates views expressed by participants at an authors' workshop (April 16-17, 2013) and subsequent policy conference (April 18, 2013) on ISPs at the International Food Policy Research Institute in Washington, DC. Some of the most important and poorly understood policy questions include: (1) How do ISPs affect overall fertilizer use and agricultural output? (2) Are the

[1] Druilhe and Barreiro-Hurlé (2012) has also published a recent review since the undertaking of this special issue, which is synthesized here.
[2] 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".
[3] For evidence of this, see Lunduka *et al* (this issue).
[4] This study excludes South Africa because of its fundamentally different agricultural system.
[5] Input subsidy programs were widely studied in the 1970s-80s when they were commonly implemented at this time, yet analysis was confined to market-level supply, demand and price data due to the lack of household survey data at that time. Therefore, there has been little research evidence prior to 200 to understand the effects of ISPs on household behavior, income distribution, and poverty.

subsidies targeted to particular types of households, e.g., the poor? (3) Do the subsidy programs affect the price of food and wages and thus produce important indirect effects on income distribution? And (4) how do targeted input subsidy programs affect the development of commercial input distribution systems? This special issue provides multiple-country evidence on each of these questions.

The review is organized as follows: Section 2 identifies some of the political and value-laden dimensions of input subsidy programs that have made it so difficult to gain consensus about ISP impacts. Section 3 briefly reviews the history of input subsidy programs in Sub-Saharan Africa, identifies the factors leading from the near absence of such programs at the turn of the millennium to once again constituting a major share of many governments' agricultural budgets. Section 4 reviews the recent evidence on ISPs in Africa using farm survey data. Section 5 summarizes the main findings, discusses the policy implications of the recent evidence, and identifies directions for future research.

2. Why has achieving consensus on input subsidy programs been so elusive?

Even while the evidence base on input subsidy programs (ISPs) is improving rapidly, reaching consensus on the effectiveness of ISPs in achieving national policy objectives seems as elusive as ever. Fertilizer subsidy programs remain one of the most contentious policy debates in Africa, and the literature on these programs has been sharply divided (e.g., Morris *et al* 2007; World Bank 2007; Denning *et al* 2009; Dorward and Chirwa 2011; Sachs 2012; Druilhe and Barreiro-Hurlé 2012).

Views about ISPs can be partly informed by technical analysis, but they have fundamentally political dimensions. Input subsidy programs appear to be vastly more popular among African politicians, analysts, and citizens than outside the continent. Several factors appear to be responsible for this.

First, ISPs are a highly demonstrable way for politicians to show their support to constituents. The beneficiaries of ISPs are clearly identifiable but the losers are not. The distribution of input vouchers has made the beneficiaries even more aware of government support compared to universal subsidy programs where the subsidies were conferred through price of inputs on the market. By contrast, the losers of ISPs are much less visible. The main costs of ISPs would occur if foregone public expenditures on investments could have provided greater payoffs to agricultural growth and poverty reduction (e.g., as found by Fan *et al* 2008; and Economist Intelligence Unit 2008). If such were the case, the losers are the general public, and while such losses could be quite large over time, they tend to be dispersed across the general population and do not directly feel resources being taken away from them. Domestic opponents of ISPs have generally been confined to Ministries of Finance. Not coincidentally, many African countries having long histories of grain and/or input subsidy policies, such as Malawi, Kenya, Zambia, and Zimbabwe, have powerful farm lobbies. Lopez (2003) also attributes much of the staying power of agricultural subsidy programs in Latin America to elites' learning that they are capable of capturing a large part of the benefits of such programs. Mancur Olsen (1971) and others have shown how conditions where beneficiaries are organized and losers are dispersed can lead to great staying power of particular programs, regardless of their merits on technical grounds.

A second important political dimension of ISPs concerns the timing of benefits. ISPs can be a powerful tool for raising food production within one crop season. By contrast, while public expenditures on crop R&D and physical infrastructure have been repeatedly found to generate massive benefits to society (e.g., Masters *et al* 1998; EIU 2008; Fan *et al* 2008), these benefits accrue only over a number of years. Because politicians throughout the world tend to prioritize programs that provide visible payoffs from which they can benefit while still in office (Nordhaus 1975; Clague *et al* 1996; Bueno de Mesquita *et al* 2003), public investments with long-term payoffs tend not to attract the impassioned advocates that ISPs do.

A third political dimension concerns the possibility that ISPs may be used by the ruling party as a tool to consolidate their control over the political process. There is growing evidence that the allocation of input subsidies to localized areas are influenced by prior election outcomes (Banful 2011; Mason *et al* this volume). And lastly, there is the "geopolitical" dimension. African policy-makers often note that high income countries routinely subsidize their farmers and might in some instances view outside criticism, no matter how well intentioned, as hypocritical meddling influenced by perceived aims of foreign governments. By contrast, some African analysts quietly express reluctance to present evidence unfavorable to ISPs for fear of appearing critical or arousing retribution from their governments. Especially in light of development agencies' laudable efforts to promote indigenous African policy research institutes to inform and guide governments, even mild forms of self-censorship could be a disturbing development that reduces the ability of such institutes to serve their intended roles.

In short, reaching a common understanding regarding the value and impacts of input subsidy programs in Africa has been hindered by differences in beliefs, values, worldviews, and interests. As a result, the debate over the effectiveness of large-scale input subsidy programs has taken on a range of political and ideological overtones that characterize the broader class of policy issues known as "wicked problems" (Ricker-Gilbert *et al* 2013).[6] While applied research alone is certainly not sufficient for the effective resolution of a wicked problem, it is nevertheless likely to be necessary for finding reasonable and workable solutions. Policy discourse about the welfare effects of ISPs remains unresolved partly because the empirical evidence on the range of these complex effects has been so spotty. ISPs may produce complex outcomes, including partial, multi-market and general equilibrium effects on employment, wage rates, food prices, nutritional status, and poverty rates, to name a few. Against this backdrop, a major motivation of this special issue of *Agricultural Economics* is to contribute evidence and understanding to these debated issues. Many issues of course remain unresolved, and our concluding section identifies what we believe to be salient issues for future research.

[6] A central feature of wicked problems (see Rittel 1972; Conklin 2006) is indeterminancy, i.e., there are no definitive conditions or tests to resolve problems, and even a lack of basic agreement about what constitutes the real problem. Every wicked problem is a symptom of another, "higher level" problem—for example, poverty and underdevelopment in the case of input subsidies. For every wicked problem there is always more than one possible explanation or pathway to resolution, with each depending on the "core beliefs" of those involved. Wicked problems resist resolution through appeals to facts.

3. Historical evolution of ISPs in SSA

Input subsidy programs have been a cornerstone of agricultural policy in many African countries since their independence (Kherallah *et al* 2002). In the 1960s and 1970s, international donors largely supported the use of universal input subsidies to overcome market failures in input and finance markets. However, there is wide consensus that universal input subsidies in Africa were generally ineffective in achieving their stated objectives (Morris et al 2007). Evaluations pointed to high costs, mismanagement of funds, elite capture, and ineffectiveness in reaching resource-poor smallholder farmers. In many cases, the costs of the programs exceeded the value of output produced (e.g., Howard and Mungoma 1997; World Bank 2007) and contributed to governments' budget deficits and macroeconomic imbalances. As many African governments' deficits became unsustainable during the 1980s and early 1990s, international lenders gained leverage over national agricultural policies. During this high tide of liberalization and structural adjustment, African governments were forced under duress to discontinue ISPs with a few exceptions such as Malawi and Zambia. While such forms of structural adjustment (which also included the curtailing of agricultural marketing board operations) were deeply resented by many African governments, some form of budget realignment was indeed necessary to avoid loan default and the specter of macroeconomic instability. However, the range of other agricultural sector investments necessary to accelerate African agriculture, including crop science research, extension programs, infrastructural investments, and policies to provide a hospitable environment for private investment in food value chains remained underfunded by both donors and African governments through the 1990s (World Bank 2009b).

The intended response to liberalization up to at least to the mid-1990s appeared disappointing. Fertilizer use and agricultural productivity were stagnant in most countries (Kherallah et al 2002) and rural poverty rates remained stubbornly high. The stagnation of African agriculture in the 1980s and early 1990s led many to argue that the liberalization reforms were a failed experiment and that the re-introduction of direct government participation in markets was necessary (e.g., Dorward *et al* 2004). Other studies showed that in specific instances where governments supported the input market liberalization process, as in Kenya, the results were quite impressive (Freeman and Kaguongo 2003; Ariga and Jayne 2009). Political economy problems were identified as being at the heart of ineffective donor funding to the agricultural sector and ineffective implementation of agricultural sector reforms (Lancaster 1999; World Bank 2007; van de Walle 2001). However, in hindsight, the painful macroeconomic and structural adjustment policy changes in the 1980s and 1990s appear to have, with a lag, contributed to economic growth since the late 1990s (e.g., UNECA 2012). Recent studies suggest that African poverty rates also started declining steadily since the mid-1990s, with improved macroeconomic performance and stability associated with structural adjustment being one of the major factors attributed to this trend (Sala-i-Martin and Pinkovskiy 2010).

The greater macroeconomic stability enjoyed by most African governments by the late 1990s led most donors to shift from agricultural sector conditionality to general budget support, which was based on the idea that the donor-government relationship would work better and be more sustainable as a cooperative one rather than conflict-laden one. The shift to general budget support started to alleviate the budget constraint on African governments' spending, which was relieved further by the process of debt forgiveness initiated in the early 2000s through the World Bank/IMF Heavily Indebted Poor Countries (HIPC) initiative.[7] These factors sowed the seeds for a revival of direct government programs to support agriculture.

With conditionality and external leverage over agricultural policy in decline, and with a growing recognition of the role of agriculture in overall economic development, African governments in 2003 made a public commitment to increase their support for agriculture through the Maputo Declaration of the Africa Union. This was followed by the Abuja Declaration in 2006, stressing a commitment to increased fertilizer use in general and "smart" input subsidy programs in particular.

Morris et al (2007) and the World Bank (2007) 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.

After well-publicized initial reports about the success of the first such targeted input voucher program in Malawi and after the President of Malawi was awarded several prizes for allegedly turning the country from a food basket case to a food exporter, at least 9 other African governments quickly followed suit.[8] The global commodity price boom of 2008/09 created additional impetus for ISPs, by increasing the treasury resources of countries with mineral resources and most importantly, by raising food import costs and creating strong incentives to promote domestic food production. By the late 2000s, 10 countries were spending over US$800 million annually on input subsidy programs (Table 1).

In summary, the resurgence of input subsidy programs on the continent was driven by five principal forces: (i) HIPC debt reduction; (ii) a shift in donor support from aid conditionality to direct budget support; (iii) higher world food prices since 2008; (iv) a shift in the World Bank's position on ISPs, which prior to 2000 worked hard to limit or end them (World Bank 2007) and in recent years has co-financed

[7] Debt relief under the initiatives to the 36 post-decision point countries represented almost 35 percent of their 2010 GDP and has been estimated to reduce the debt burden for these countries by about 90 percent relative to pre-decision point levels. The World Bank contends that spending by governments on poverty reduction increased by more than three percentage points of GDP, on average, between 2001 and 2010 (IDA/IMF 2011).

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

them in countries like Tanzania, Malawi, and Ethiopia;[9] and (v) the continued maturation of African democracies, whereby leaders quickly discovered that ISPs were politically popular among voters and could help win elections.[10]

4. Recent Micro-level Evidence of ISP Impacts

This section reviews recent evidence on six main aspects of ISPs. We first review studies identifying the characteristics of subsidy recipients. We then review the survey evidence on maize response rates to fertilizer application, why they appear to be lower than commonly expected, and how this affects the performance of ISPs. We then review studies estimating the influence of ISPs on total fertilizer use, the development of commercial input distribution systems, and agricultural growth and poverty rates. We finally examine the evidence to date on multi-market and general equilibrium effects of ISPs. [11]

4.1 Targeting of ISPs

One of the main tenets of smart subsidy programs is that they be targeted to households meeting certain criteria, and hence be more cost-effective in meeting their objectives than the universal (untargeted) subsidies of the past (Morris *et al* 2007; Banful 2010). Targeting is believed to make it possible to (i) promote economic efficiency; (ii) be pro-poor and promote equity; and (iii) promote the development of the private sector. However, these three criteria have presented trade-offs (Pan and Christiaensen 2012). For example, if the goal is to increase agricultural productivity and incomes among poor smallholders, input vouchers should be aimed at poorer farmers who cannot afford to buy fertilizer at commercial prices. Targeting poor farmers would also minimize crowding out of commercial input systems. By contrast, the objective of boosting aggregate output would warrant targeting farmers who could utilize fertilizer most efficiently. These groups may not coincide. Consequently, governments have articulated the objectives of input subsidy programs in various ways.

Table 2 summarizes the results of econometric analysis on the characteristics of households receiving ISP in Malawi, Zambia, and Kenya. Targeted beneficiaries in all three countries tended to be wealthier than non-beneficiaries. In Zambia, although 73% of smallholder households cultivate less than 2 hectares of land, and these households constitute 78% of the smallholder farms below the US$1.25/capita/day poverty line, 55% of ISP fertilizer has been allocated to the 23% of households

[9] Informal discussions with World Bank representatives indicate that the Bank felt that it would have more influence over the design of subsidy program implementation if it were helping to finance them. However, much of the Bank's criteria for smart subsidy programs mentioned above were not adhered to, suggesting that it may have had less influence than anticipated.

[10] Commentators on Malawi argue that ISPs figured prominently in President Muluzi's reelection in 1999 and in President Mutharika's reelection in 2009. By contrast, recent analysis from Zambia indicate that while voting patterns influenced subsequent allocation of fertilizer subsidies in Zambia's 2006 and 2011 elections, the reverse was not true (Mason et al, this volume).

[11] Parts of this section draw on Ricker-Gilbert, Jayne, and Shively (2013).

cultivating larger areas.[12] Households with 10–20 hectares of land were significantly more likely to receive subsidized fertilizer, and received seven times more subsidized fertilizer on average than households controlling 2 hectares of land or less. In their review of numerous studies in Malawi, Lunduka *et al* conclude that the most vulnerable households are not sufficiently included in the subsidy program, and that the targeting system is not particularly effective (see also Holden and Lunduka 2012; Chibwana *et al*. 2010; Ricker-Gilbert *et al*. 2011). Dorward *et al* (2008) also find that farms with greater landholdings and asset wealth were significantly more likely to receive fertilizer vouchers. Although targeting poor and female-headed households is a stated program objective in Malawi, female-headed households were less likely to be targeted in practice (Dorward *et al* 2008; Chibwana *et al* 2010; Ricker-Gilbert *et al* 2011), and wealthier households acquired significantly more subsidized fertilizer. Holden and Lunduka (2012) found that vouchers tend to be sold by smaller farms and purchased by larger farms. Consistent with Banful (2011), the three studies summarized in Table 2 show significant influence of political considerations in the targeting of fertilizer subsidies to particular areas.

In their recent study of targeting of recent input subsidy programs in Tanzania, Pan and Christiaensen (2012) find that decentralized targeting in the Kilimanjaro region leads to distribution that favors political elites and relatively wealthy households. In an exception to these studies, Liverpool-Tasie (2012), using data from the Kano District of Nigeria, finds that farmers who participate in the subsidy voucher program tend to be poorer than non-participants.

The finding that fertilizer subsidies are generally targeted to better off households, while foregoing potential poverty reducing benefits, may promote the achievement of other objectives such as increasing food supplies if farmers with larger farms and asset holdings are indeed more efficient users of fertilizer. The evidence is rather mixed on this point. Ricker-Gilbert and Jayne (2012) found that larger producers of maize tend to obtain higher crop response rates to fertilizer. Burke (2012) found no such pattern among Zambian farmers; in fact, the marginal and average products of fertilizer use on maize are relatively constant with respect to farm size between zero and 20 hectares. This is an important point for future research, as it can inform policy makers as to the trade-offs (or not) between promoting the efficient use of fertilizer to raise national food supplies vs. reducing rural poverty.

4.2 Crop response to fertilizer

A fundamental determinant of ISPs' direct effects on recipient households and indirect effects on the economy is the rate at which farmers convert fertilizer into food, i.e., crop response rates. Crop response rates can be measured as the average or marginal product of nitrogen nutrient in yield response functions. Table 3 presents estimates of maize response to fertilizer application and value cost

[12] Ministry of Agriculture targeting guidelines were modified in the late 2000s to clarify that the targeting of non-poor farmers was deliberate because the program's primary aim was to increase food supplies (Mason *et al* this volume).

ratios (VCRs)[13] based on studies found in the literature. Most studies reported in Table 3 utilize farm panel survey data; while such data can control for unobserved time-invariant factors in the estimation of crop response rates to fertilizer application, they typically suffer from significant respondent measurement error and must be interpreted cautiously.

Estimated crop response rates vary considerably, which is unsurprising given the wide variations in soil, rainfall and market conditions found in the region. However, recent estimates using farm panel survey data consistently find relatively low crop responses, 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. Given prevailing commercial input and output price ratios, many of the VCR estimates shown in Table 3 indicate marginal profitability or in some cases unprofitability of fertilizer use. Achieving greater response rates will be crucial to raise the contribution of ISPs to productivity growth and poverty reduction. Cereal output/fertilizer price ratios from the region show a fairly constant trend over the past 20 years (see Appendix Figure 1 for several illustrative markets in west, east, and southern Africa), indicating that shifts over time in fertilizer profitability may be primarily driven by changes in response rates.

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 2-3 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).[14] By contrast, 96% of SSA'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 (Table 4, see also 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).

For these reasons, the economics of fertilizer use in SSA 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 11% over the next 50 years (p. 781), which would remain substantially lower than in Asia and Latin America.

[13] VCRs are defined as the value of output produced per value of fertilizer applied. It is commonly found that VCRs at least 1.5 or higher are necessary before farmers in low-income countries use fertilizer on a regular basis.
[14] 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* (this issue).

Another massive challenge that African farmers face in raising crop response to fertilizer application is soil quality. Research in the fields of agronomy, soil science, and farming systems ecology are pointing the way to how sustainable intensification will need to occur in rainfed SSA and the role of fertilizer in these systems. 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 2003; Tittonell and Giller 2012). 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 are utilized by crops is strongly reduced by soil degradation. 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. Tittonell and Giller (2012) 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 category (i) to (ii) and (iii), where crop response to fertilizer is poor.

In a similar vein, Marenya and Barrett (2009) highlight the importance of soil organic matter, which is an important indicator of soil degradation, and which strongly affects response rates to fertilizer application. 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 economics literature on fertilizer promotion policy in SSA. Perhaps not surprisingly, three studies studying the profitability of fertilizer use in Kenya all found that official use rates published by the Kenya Plant Health Inspectorate Service (KEPHIS) to far be in excess of the optimal level for most farmers (Duflo *et al* 2008; Marenya and Barrett 2009; Sheahan *et al* 2013).

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 to 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 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 in a profitable and sustainable way.

Another branch of research documents the degree to which soil acidity limits crop response to basal fertilizer application. While the Brazilian *Cerrado* region is heralded as modern agricultural success story, its naturally highly acidic soils required liming for many years before farmers could productively utilize these lands and achieve a profitable response to fertilizer application (World Bank 2009a; see also 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 between <4.3 (on which 51% of Zambian farms are located) achieved an average of 2.1 kgs maize/kg basal fertilizer, rising to 3.7 on fields with pH between 4.4-5.4 (47% of farms), rising to 7.8 on fields with pH>5.5 (2% of farms).

For these reasons, facile comparisons of average fertilizer application rates between Africa and Asia 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 indicate 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, 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 and acidity constraints.

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 more favorable soil pH, 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). 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% in Malawi. Clearly, the foundation for increased fertilizer use in SSA will depend on a more holistic approach to sustainable agricultural intensification.

4.3 Effects of ISPs on total fertilizer use

The issue of how ISPs affect total fertilizer use is only briefly treated here. A companion article in this issue synthesizes the evidence in depth (Jayne *et al*, this issue).

It is commonly assumed that an ISP distributing, for example, 100,000 tons of fertilizer to recipient farmers will raise total fertilizer use by 100,000 tons. Unfortunately, evidence suggests this is typically far from the case. The receipt of subsidized fertilizer induces some farmers to buy less fertilizer from commercial retailers than they otherwise would have in the absence of the subsidy program. The "crowding out" of commercial fertilizer tends to be less when subsidy programs are targeted to relatively poor farmers and areas where the commercial demand for fertilizer is low (Xu *et al* 2009a; Ricker-Gilbert *et al* 2011; Mason and Jayne 2013). By contrast, Liverpool-Tasie (2012) found evidence of crowding-*in* of commercial fertilizer demand in a pilot subsidy scheme in one district of Nigeria, the success of which appears to be related to the fact that fertilizer vouchers were mainly targeted to areas where private commercial markets were relatively weak and to households that were relatively poor.

Jayne *et al* (2013, this issue) show how earlier estimates of crowding out may be been seriously underestimated by not taking account of diversion of program fertilizer by authorities. Comparisons of subsidy fertilizer obtained by farmers through nationally-representative farm survey data in Malawi and Zambia against official government figures indicate that as much as 30-40% of the fertilizer imported for distribution under government subsidy programs appears to have been diverted and resold to intermediaries before reaching intended beneficiaries (even more in Nigeria in recent years). While most of the diverted program fertilizer is ultimately resold to and used by farmers, farmers may believe that they are purchasing commercial fertilizer and refer to it as such when responding to surveys when in fact they purchased diverted government fertilizer intended for distribution under the subsidy program. This means that the quantity of fertilizer procured by fertilizer wholesalers and retailers for commercial distribution is actually less than the total amount of fertilizer purchased by farmers through commercial channels according to farm survey data. After accounting for program diversion, every additional ton of fertilizer distributed through the subsidy programs is estimated to have raised total fertilizer use by 490kgs in Malawi, by 536kgs in Zambia, and by 239kgs in Kenya. The failure to account for program diversion is shown to overestimate the contribution of the subsidy programs to national fertilizer use by 67.3% in the case of Malawi, by 61.6% for Zambia and by 138.0% for Kenya. These estimates of the contribution of subsidy programs to total fertilizer use all pertain to the recent generation of "smart subsidy" programs, that were intended to overcome the targeting and diversion problems of universal subsidy programs commonly implemented in the 1970s and 1980s in Africa.

Obviously, these findings generate dramatically different impacts on aggregate crop output than if the full quantity of government program fertilizer were assumed to be utilized on farmers' fields. Crowding out estimates of this magnitude have not been used in prior estimates of benefit-cost ratios (e.g., Dorward and Chirwa 2011). Jayne *et al* (2013, this issue) conclude that the incorporation of these findings turns the benefit-cost ratios of input subsidy programs decidedly below 1 in Malawi and Zambia and on average below 1 in Kenya.[15]

4.4 Effects of ISPs on commercial distribution systems

One of the main attributes of the new wave of smart subsidy programs was that they would promote the development of commercial input distribution systems. The estimates of crowding out and diversion in the previous section underscore the extent to which commercially imports have been depressed in countries where survey data has permitted such analysis.

However, some private firms have indeed benefited greatly from ISPs. We feel it is useful to differentiate between changes in private distributors' sales of program fertilizer and sales of commercial fertilizer. Dorward *et al* (2008) report that importer/distributors that were allowed to distribute fertilizer on behalf of the government experienced increased sales of fertilizer resulting from the Malawi subsidy program. Anecdotal evidence from Kenya indicates that many private retailers have experienced increased business resulting from farmers' redeeming subsidy vouchers at their stores. Liverpool and Takashima (this issue) also report that retailers have experienced increased sales resulting from the new subsidy program in Nigeria. In contrast, fertilizer distributors who were excluded from participating in the programs were generally worse off. Retail agro-dealers have been excluded from the Malawi and Zambia programs and evidence from Zambia indicates that many retailers have folded operations in areas where the subsidy program was active (Xu *et al* 2009a). Vouchers distributed under the Malawi program for most years were redeemable only at certified government and cooperative retail centers (Dorward and Chirwa, 2011; Lunduka *et al* this issue). The evidence of ISP impacts on commercial distribution systems therefore seems to vary greatly by the way the programs were implemented, with the main variables being whether authorities allowed vouchers to be redeemable at private dealers' shops, and in the case of importers and wholesalers, whether they were chosen to distribute government fertilizer.

4.5 Evidence on agricultural growth and poverty reduction

Before reviewing recent evidence from SSA, we first review the empirical record of input subsidy programs on growth and poverty reduction in Asia. Because much analysis has been carried out over the decades in Asia, it would be 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.

We draw from two studies analyzing the returns to public expenditures and policies. The first study, carried out by the Economist Intelligence Unit (Economist Intelligence Unit 2008), estimated the contribution of various types of public investments and strategies to agricultural growth and poverty

[15] These benefit/cost ratios also explicitly incorporate the effects of the programs on maize price levels.

reduction in six Asian countries: China, India, Indonesia, South Korea, Taiwan, and Vietnam. The second study, carried out by IFPRI (Fan *et al* 2009) provides an in-depth analysis of India to identify the returns to various types of public expenditures over a 40-year period.

The EIU study highlights the primacy of policy and enabling environment in driving both agricultural growth and poverty reduction in most of Asia (Appendix Table A1). The types of policies emphasized are reforms increasing individual farmers' rights over their land and output, combined with agricultural market liberalization, which were found to substantially improved farmers' incentives and stimulated rapid growth in output and private investment (p. 7-8). Other investments found by the EIU study to have a high return in terms of agricultural growth and poverty reduction were: crop science R&D, investments in rural roads, electricity, health and education. 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. Appendix Table A2 shows that 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. Particularly high returns at this time were generated from public investments in roads and education, which had estimated benefit-cost ratios of 6 to 9. Agricultural research investments, investment in irrigation, and fertilizer and credit subsidies yielded benefits that were 2 to 4 times the amount spent. Subsidies on irrigation and power generated 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 began to decline, though they began to account for a growing share of national budgets. Meanwhile, investments in agricultural R&D, roads, irrigation, 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 percent. 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.[16] 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.

[16] Fan *et al* conclude that "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). Other studies of India also found very low returns to credit and input subsidies, e.g., Binswanger and Khandker (1995) and Gulati and Narayanan (2003).

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 *et al* 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.

Returning to Africa, our review of the micro-level evidence shows unequivocally that input subsidy programs have raised national food production (e.g., Liverpool and Takashima, this issue; Dorward and Chirwa 2011; Mason, Jayne and Mofya this issue; Lunduka *et al* this issue). In some cases, such as Malawi, the officially stated production increases have most likely been overstated (Jerven 2012; Dorward *et al* 2011).

However, the effects of ISPs are highly asymmetric across the distributions of farm size and wealth. The general pattern derives from the fact that resource-poor households tended to receive proportionately less of the subsidy than wealthier farmers as shown earlier. Using nationally representative survey data from Zambia, Jayne *et al* (2011) show that farms in the 10-20 hectare category received 7 times more subsidized fertilizer than farms below 2 hectares (accounting for 77% of all farms) and generated 23 times more maize production after the input subsidy program and output marketing supports were ramped up in the late 2000s. Ricker-Gilbert and Jayne (2012) use quantile regression to measure the returns to subsidized fertilizer in Malawi, and find that households at the 10th percentile of the maize production distribution obtain 0.75 kg additional per kg fertilizer received, while farmers at the 75th percentile of the maize production distribution gain 2.61 kg. Many households at the bottom of the income distribution seem to be unable to generate a substantial response from the subsidized fertilizer that they acquire (Marenya and Barrett 2009; Tittonell and Giller 2012).

The concentration of the food production response in the hands of a small proportion of the relatively better-off farm households may explain why rural poverty rates have not declined in either Malawi or Zambia between the early 2000s and 2010.[17] While early assessments of the Malawian program argued that it has had favorable effects on poverty rates, this has yet to be rigorously shown. Official rural headcount poverty rates have actually increased from 52% in 2004 to 53% in 2010 (Ricker-Gilbert *et al*, this issue). Rural headcount poverty rates in Zambia have consistently hovered around 80% throughout the 10-year period of the implementation of the Farm Inputs Support Programme (Mason *et al,* this issue).

[17] See Lunduka et al (this issue) and Jayne et al (2011). The phenomenon of economic growth occurring without poverty reduction has also been found in Tanzania by Pauw and Thurlow (2010).

Evidence also indicates that Malawi's input subsidy program may induce some reallocation of cultivated area to maize at the expense of area devoted to other crops,[18] put less pressure on land expansion onto surrounding forests (Fisher and Shively 2005), and caused other off-site effects, both positive and negative (Ricker-Gilbert *et al* 2013).

4.6 Multi-market and general equilibrium effects:

It is sometimes argued that the most powerful effects of ISPs are through their multi-market and general equilibrium effects on output market prices and wage rates (e.g., Minten and Barrett 2008). Dorward and Chirwa (2011) argue that ISPs may reduce food prices and raise agricultural wage rates, both of which may be powerful processes for kick-starting dynamic growth processes. They also argue that such effects should be incorporated into estimates of ISP benefits, and that by doing so, their benefit/cost ratios rise considerably. While these are plausible hypotheses, there has been a paucity of research evidence to support them. To address this evidence gap, Ricker-Gilbert *et al* (2013, this issue) used a combination of market price data, farm survey data, and official district-level data on quantities of fertilizer distributed under government subsidy programs in Malawi and Zambia to econometrically estimate the effects of the programs on maize price levels. In both countries, they found significant but quite small effects. Their simulations indicate that eliminating the subsidy programs would raise maize prices by at most 2.5% in Malawi and by 1.8% at most in Zambia. Because Malawi has remained an importer of maize for most of the period of its subsidy program (but its quantities of imported maize have indeed declined), it appears that the production increase from the program effectively substituted local production for imports but not sufficiently to move the country from its typical position of being at import parity. Ricker-Gilbert *et al* find that the Zambia input subsidy program also had little effect on maize prices, as surplus production was either stored by the government (much of which spoiled and did not reach local markets) or was absorbed into the import markets of Zimbabwe and DRC Congo. The fact that both countries are part of a vibrant regional trading network appears to have largely dissipated the price effects of the programs. Even for Nigeria, which has an expansive internal market, Takeshima and Liverpool-Tasie (2013) found small and statistically insignificant effects of Nigeria's input subsidy program on domestic maize, rice and sorghum prices.

Regarding effects of the programs on agricultural wage rates, Ricker-Gilbert (2012) examines the impact of the fertilizer subsidy program on agricultural labor supply, labor demand, and wage rates in Malawi. He finds that the subsidy program had a small negative effect on household labor supply, and a small positive effect on labor demand. In addition, he found that a 10kg increase in the average amount of subsidized fertilizer acquired per household in a community raised that community's median agricultural wage rate by 1.4%. The study provides evidence that non-recipients of subsidized fertilizer may have gained some small spillover benefit from the subsidy program in the form of slightly higher agricultural wage rates. However, more evaluation needs to be conducted that quantifies the indirect

[18] Chibwana *et al*. (2011) calculate that these reductions in the value of output of other crops may be as much as 50% of the value of the additional maize produced.

benefits from input subsidy programs to provide a complete picture of their benefits.

5. Conclusions

Input subsidy policies (ISPs) have once again re-emerged as a favored policy tool of many African governments. Some international development partners have joined to co-finance these programs, under the view that problems with ISPs in prior decades could be addressed and that their co-funding would give them some influence over the design and implementation of the programs. This study synthesizes the recent literature on the recent wave of input subsidy programs in Sub-Saharan Africa.

The following summarizes the arguments commonly made in support of input subsidy programs in Africa, followed by a brief summary of recent evidence:

1. ISPs can raise food production within one growing season. Several articles in this special issue confirm that this this is certainly the case (Awotide et al; Mason et al; Lunduka et al). ISPs provide a highly visible and demonstrative show of governments' support to constituents and it is therefore understandable why many African governments find them appealing. However, expanded food production is not a sufficient economic justification for such programs. The criteria used by economists require that for a program to be considered worthy of major public funding, it must generate benefits that exceed its costs – and to a greater extent than alternative uses of public funds. The weight of recent evidence indicates that, even after accounting for multi-market effects on food prices, the benefits of targeted input subsidy programs in the region have seldom exceeded their costs. The food production response to ISPs is generally significantly lower than commonly understood, due to crowding out of commercial fertilizer demand, and due to low crop response rates to fertilizer borne of chronically late delivery of program fertilizer, non-responsive soil conditions, poor management practices, and insufficient use of complementary inputs that are necessary to enable farmers to obtain higher rates of fertilizer use efficiency. There may be specific conditions where the benefits of ISPs would exceed their costs, but studies of Malawi, Kenya, and Zambia during the post-2008 era of high food prices indicates that such conditions have rarely been met.
2. ISPs can substitute local production for imports and thereby reduce dependence on world markets for strategically important food commodities. Food self-sufficiency could be seen as a prudent strategy for poor countries during volatile times. However, global food prices have typically been less volatile than domestic food prices in Africa (Minot 2011) and there is no evidence that programs to achieve food self-sufficiency either through ISPs or output market interventions has led to either lower or more stable food prices (Chapoto and Jayne 2009; Mason et al this issue; Lunduka et al this issue). Because input subsidy programs do expand food production, the output response has typically created political pressures to support farm prices through marketing board operations and discretionary trade policies. The combination of shifting input subsidy, price support levels, and trade policy tools has created major policy uncertainty in much of the region (Jayne 2012), which has in turn not clearly led to more stable

food markets and prices than in the absence of these policies. Therefore, it is not clear that programs aiming to achieve national food self-sufficiency lead to improved stability and access to food for consumers, a point demonstrated by Sen (1981) after the volatile food price episodes of the 1970s and perhaps better understood three decades ago than now.

3. The new wave of targeted input voucher programs can support the development of private sector input markets. The evidence on this point is mixed. Private firms selected to distribute program fertilizer on behalf of government have benefited the most from such programs, often at the expense of firms that were excluded. The Malawi and Zambia governments have steadfastly refused to allow private retailers to be included in the program as a source of subsidized fertilizer for farmers. In Kenya and Nigeria, by contrast, it is reported that many retailers are enjoying increased sales from participation in the voucher program. The evidence of voucher program impacts on commercial distribution systems therefore seems to vary greatly according to the way the programs were implemented. “Smart subsidy” principles laid out after the Abuja Declaration in 2006 were in many cases not adhered to.
4. ISPs can reduce food prices and thereby benefit the majority of Africa’s population who are buyers or net buyers of staple foods. The few rigorous applied studies devoted to measuring the effects of ISPs on food prices in Malawi, Nigeria, and Zambia have found very weak and small effects (Takeshima and Liverpool 2013, Ricker-Gilbert et al., this issue, Ricker-Gilbert, 2013). Small price effects mainly result from a lower production impact than commonly imagined after accounting for low fertilizer use efficiency, crowding out and illicit diversion of program fertilizer.

ISPs suffer from several additional downsides:

1. A major risk with ISPs is that they may crowd out other much needed uses of public funds. The ten countries presented in Table 1 spent in 2011 roughly 28.6 percent of their public expenditures on agriculture. Some countries spent substantially greater proportions than this, especially after accounting for marketing board operations, which have often accompanied input subsidy programs to mitigate their production expansion effect on market prices.
2. ISPs appear to provide low “bang for the buck”. The research evidence from Asia generally concludes that fertilizer subsidies played an important role in the first decade of jump-starting agricultural growth processes, but became ineffective in later decades. Several other types of investments, such as crop R&D and infrastructure provided greater returns to both agricultural growth and poverty reduction. The evidence from Africa also points to generally unimpressive benefit/cost ratios of ISPs. Achieving greater impacts from ISPs will also require more serious political attention to the apparently widespread problem of illicit diversion of program fertilizer and associated crowding out of commercial fertilizer distribution systems.
3. Finally, given that subsidy programs are highly political in nature, once implemented they have proven difficult to remove.

There are many reasons for low fertilizer use in Africa: low crop response rates, yield risk and low returns in rainfed semi-arid conditions, financial market failures, high marketing costs contributing to low output prices and high fertilizer prices, instability in output markets, and market concentration in fertilizer production (Hernandez and Torero, this volume). ISPs can address some of these constraints as long as they remain in place. They cannot address problems of low crop response, declining soil fertility driven by rural population growth and continuous cultivation, production risk, and instability in output markets. Once farmers no longer have access to subsidized inputs, most of these constraints on fertilizer use re-emerge. The risk of devoting a large portion of public agricultural budgets to input subsidy programs is that they may crowd out the broader range of public expenditures required to support agricultural intensification in a sustainable manner.

Despite the general weight of the evidence, it appears that fertilizer subsidy programs will remain on the African agricultural landscape for some time to come. Though we believe it is incumbent on technical analysis to speak truth to power regarding the costs and benefits of such programs, the usefulness of technical analysts to policy makers may involve, for some time, shifting from debating "whether or not" governments ought to have input subsidy programs to "how to improve the effectiveness" of such programs, and identifying the complementary types of public expenditures that will enable ISPs to be more effective.

The way forward

It is commonly argued that in every region of the world, the intensification of agriculture has been associated with major increases in the use of chemical fertilizers, that fertilizer use must increase rapidly in SSA in order for agricultural growth to occur, and that for these reasons fertilizer promotion policies and programs are imperative.

There is little disagreement on this issue, but it is increasingly apparent that this line of argument is often taken out of context and too narrowly defined to achieve sustained increases in fertilizer use by African farmers. Sustainable agricultural intensification may need to take place differently in much of SSA compared to S. and E. Asia. SSA 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. 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 commodity 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 would otherwise not purchase fertilizer; (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), (e) supporting reliable and competitive output markets through policies that promote new investment and competition in food commodity 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., Dreshcel et al 2001; Tittonell and Giller 2012). 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 phosphorus, deep placement application, appropriate plant populations for farmers' specific micro-locations, and restoring soil organic matter through various conservation farming practices, including minimum tillage, use of green manures, and intercropping with shrubby legumes, among others.

Implications for future research

We believe that there is an urgent need for detailed analyses based on data from farmers' fields to establish optimal fertilizer use rates for the heterogeneous farming systems, soils, and levels of management found in Africa. While it is commonly assumed that African farmers grossly underuse fertilizer, this is based on comparisons with other regions of the world with vastly different degrees of water control, soil and moisture conditions, market infrastructure, and crop science and extension systems. Official recommended fertilizer use rates are commonly uniform throughout the country, higher than application rates that farmers themselves use, and -- most importantly – likely to be inappropriately high and contribute to unprofitable use given the limited use of complementary inputs, soil and management challenges that most African farmers face. A very limited number of studies have been undertaken in recent years to assess the gap between actual fertilizer use and optimal rates taking into account the crop response rates that farmers actually achieve given the constraints they face. Several such studies indicate a relatively small gap between use rates found to maximize profitability and actual fertilizer use rates in most areas, and in some cases apparent overuse of fertilizer (e.g., Sheahan *et al* 2013; Matsumono and Yamano 2012). African farmers would clearly benefit from the release of extension messages regarding fertilizer types and application rates that are more accurately based on assessments of profit maximization taking into account changes in relative fertilizer and crop prices, soil types, and management practices. Effective extension messages will in turn require greater agronomic research based on the different types of conditions and resource constraints faced by heterogenous smallholder farmers.

Another major knowledge gap concerns multi-market impacts of input subsidy programs. While some research on this topic has been reported in this study, the literature is thin. Much of verdict regarding ISPs' benefits relative to their costs depend on the magnitude of multi-market and general equilibrium effects, e.g., on wage rates, prices of a broad range of food items, production impacts on other crops.

Lastly, we believe there is a need to empirically resolve the competing hypotheses that (i) farmers receiving input subsidies for four or five years in a row can jump to a higher income trajectory and pull themselves out of poverty, and (ii) farmers will tend to revert back to pre-subsidy behaviors and levels of welfare after graduating from multiple years of participation in subsidy programs. On this issue as well, the empirical record is scant at best, but the increasing availability of long-term multi-wave panel data should make it increasingly possible to analyze these issues.

References

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

Ariga, J. and T.S. Jayne. 2009. *Private Sector Responses to Public Investments and Policy Reforms: The Case of Fertilizer and Maize Market Development in Kenya*. International Food Policy Research Institute Discussion Paper 00921. Washington, D.C.: IFPRI.

Awotide, B., A. Karimov, A. Diagne, T. Nakelse. 2013. Impact of Seed Voucher on Poverty Reduction among Smallholder Rice Farmers in Nigeria. Agricultural Economics, 44(6), this issue.

Banful, Afua. 2011. Old Problems in the New Solutions? Politically Motivated Allocation of Program Benefits and the “New” Fertilizer Subsidies. *World Development*, 39:(7): 1166–176.

Binswanger, H. and S.R. Khandker. 1995. The Impact of Formal Finance on the Rural Economy of India. *The Journal of Development Studies*, 32(2): 234-262.

Bueno de Mesquita, B., Smith, A., Siverson, R.M., Morrow, J.D. 2003. *The Logic of Political Survival*. Cambridge, MA: MIT Press.

Burke, W. 2012. Determinants of Maize Yield Response to Fertilizer Application in Zambia: Implications for Strategies to Promote Smallholder Productivity. PhD dissertation, Michigan State University, East Lansing, MI.

Chibwana, C., Fisher, M., Jumbe, C., Masters, W., Shively, G., 2010. Measuring the impacts of Malawi’s Farm Input Subsidy Program. Paper presented at the 2010 meeting of the African Agricultural Economics Association, September 20-23, 2010.

Chibwana, C., M. Fisher, and G. Shively. 2011. Cropland Allocation Effects of Agricultural Input Subsidies in Malawi. *World Development* 40(1):124–133.

Clague, C., Keefer, P., Knack, S., & Olson, M. (1996). Property and contract rights in autocracies and democracies. *Journal of Economic Growth 1(2)*, 243–276.

Conklin, J. 2006. Wicked Problems & Social Complexity. Chapter 1 of Dialogue Mapping: Building Shared Understanding of Wicked Problems. Chichester, UK: Wiley.

Denning, G., P. Kabambe, P. Sanchez, A. Malik, R. Flor, R. Harawa, P. Nkhoma, C. Zamba, C. Banda, C. Magombo, M. Keating, J. Wangila, J. Sachs. 2009. Input Subsidies to Improve Smallholder Maize Productivity in Malawi: Toward an African Green Revolution. *Plos Biology,* 7(1):0002-0010.

Dorward, A., Kydd, J., Morrison, J. and Urey, I. 2004. A Policy Agenda for Pro-poor Agricultural Growth, *World Development* 32 (1): 73–89.

Dorward, A., and E. Chirwa. 2011. The Malawi Agricultural Input Subsidy Programme: 2005/06 to 2008/09. *International Journal of Agricultural Sustainability,* 16:232–247.

Dorward, A., E. Chirwa, V. Kelly, T.S. Jayne, R. Slater, and D. Boughton. 2008. Evaluation of the 2006/07 Agricultural Input Subsidy Programme, Malawi. Final Report. Lilongwe: Overseas Development Institute.

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 (2001) 251–258

Druilhe, Z. and J. Barreiro-Hurlé 2012. Fertilizer subsidies in sub-Saharan Africa. SA Working Paper No. 12-04. Food and Agriculture Organization of the United Nations, Rome.

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,* 98 (2): 482–488.

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

Ekasingh, B., P. Gypmantasiri, K. Thong-ngam, and P. Grudloyma. 2004. Maize in Thailand: Production Systems, Constraints, and Research Priorities. Mexico, D.F.: CIMMYT.

Fan, S., A. Gulati, and S. Thorat. 2008. Investment, Subsidies, and Pro-poor Growth in Rural India. *Agricultural Economics,* 39(2): 163–170.

Freeman, Ade, and W. Kaguongo. 2003. Fertilizer market liberalization and private retail trade in Kenya. *Food Policy,* 28(5-6): 505-518.

Giller, K.E., Cadisch, G., 1995. Future benefits from biological nitrogen fixation: An ecological approach to agriculture. *Plant Soil* 174: 255-277.

Giller, K., E. Rowe, N. de Ridder, H. van Keulen. 2006. Resource use dynamics and interactions in the tropics: scaling up in space and time. *Agricultural Systems,* 88: 8-27.

Gulati, A. and S. Narayanan. 2003. The Subsidy Syndrome in Indian Agriculture. Oxford, Oxford University Press.

Holden, S. T., Lunduka, R.W., 2012. Who benefit from Malawi's targeted farm input subsidy program? Forum for Development Studies 39(3), 290-314. http://dx.doi.org/10.1080/08039410.2012.688858.

Howard, J. and C. Mungoma. 1997. Zambia's Stop-and-Go Maize Revolution. In *Africa's Emerging Maize Revolution*, eds. D. Byerlee and C. Eicher. Colorado: Lynn Rienner Publishers.

IDA/IMF. 2011. Heavily Indebted Poor Countries (HIPC) Initiative and Multilateral Debt Relief Initiative (MDRI)--Status of Implementation and Proposals for the Future of the HIPC Initiative, International Development Association/International Monetary Fund. http://siteresources.worldbank.org/INTDEBTDEPT/ProgressReports/23063134/HIPC_MDRI_StatusOfImplementation2011.pdf

IFPRI. 2011. Global Food Policy Report - 2011. International Food Policy Research Institute, Washington, DC.

Jayne, T.S. 2012. Managing food price instability in East and Southern Africa, *Global Food Security,* 1 (2): 143–149. http://www.sciencedirect.com/science/article/pii/S221191241200017X

Jayne, T.S., J. Govereh, M. Wanzala, and M. Demeke. 2003. Fertilizer Market Development: A Comparative Analysis of Ethiopia, Kenya, and Zambia. *Food Policy,* 28(4): 293-316.

Jayne, T., N. Mason, W. Burke, A. Shipekesa, A. Chapoto, and C. Kabaghe. 2011. Mountains of Maize, Persistent Poverty. *The Zambian Economist*, October, pp. 20–22.

Jayne, T., D. Mather, N. Mason, 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): this issue.

Jerven, M. 2012. The Political Economy of Agricultural Statistics: Evidence from India, Nigeria and Malawi. Simons Papers in Security and Development, No. 18/2012, Simon Fraser University, Vancouver, Canada.

Kherallah, M., Delgado, C., Gabre-Madhin, E., Minot, N., and Johnson, M. (2002). *Reforming Agricultural Markets in Africa,* Baltimore: Johns Hopkins University Press.

Lal, R. 2011. Sequestering carbon in soils of agro-ecosystems. *Food Policy* 36 (2011): S33-S39.

Lopez, R. 2003. Under-investing in public goods: evidence, causes, and consequences for agricultural development, equity, and the environment. *Agricultural Economics, 32*(1): 211–224.

Liverpool-Tasie, L.S. 2012. Moving Forward with Fertilizer in Nigeria: Fertilizer Promotion Strategies within a Complex Fertilizer Subsector. *Agricultural Economics,* this issue.

Lunduka, R., J. Ricker-Gilbert, and M. Fisher. 2013. What are the farm-level impacts of Malawi's Farm Input Support Program? A critical review. *Agricultural Economics,* this issue.

Marenya, P. and C. Barrett. 2009. State-conditional fertilizer yield response on western Kenyan farms. *Amer. J. Agr. Econ.* 91(4) (November 2009): 991–1006.

Mason, N. and T. Jayne. 2013. Fertilizer subsidies & smallholder commercial fertilizer purchases: Crowding out, leakage, & policy implications for Zambia. *Journal of Agricultural Economics,* in press.

Mason, N. M., Jayne, T. S., Mofya-Mukuka, R. 2013. Zambia's input subsidy programs. *Agricultural Economics,* this issue.

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

Masters, W., Bedingar, T., & Oehmke, J. 1998. The Impact of Agricultural Research in Africa: Aggregate and Case Study Evidence. *Agricultural Economics, 19*(1-2): 81-86.

Mather, D., and T.S. Jayne. Forthcoming. How Much do Fertilizer Subsidy Programs Contribute to Total Fertilizer use? Evidence from Kenya. Staff Paper, Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing.

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.

Minot, N. 2011. Transmission of world food price changes to markets in Sub-Saharan Africa, IFPRI discussion papers 1059, Washington DC, International Food Policy Research Institute.

Minten, B. and. C. Barrett. (2008). Agricultural Technology, Productivity, and Poverty in Madagascar. *World Development 36*(5): 797–822.

Minten, B., B. Koru, and D. Stifel. 2013. The Last Mile(s) in modern input distribution: Pricing, profitability, and adoption. *Agricultural Economics,* 44(6): this issue.

Morris, M., V. Kelly, R. Kopicki, and D. Byerlee. 2007. *Fertilizer use in African agriculture: Lessons learned and good practice guidelines*. Washington, D.C.: World Bank.

National Farmers Information Service (NAFIS). 2013. Broad Fertilizer Recommendations for Maize Growing Areas in Kenya. Accessed January 2. Retrieved from http://www.nafis.go.ke/agriculture/maize/field-management-practices/.

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

Nordhaus, W.D. (1975). The Political Business Cycle. *The Review of Economic Studies 42(2)*, 169–190.

Oehmke, J. and E. Crawford, 1996. The Impact of Agricultural Technology in Sub-Saharan Africa. *Journal of African Economies,* 5: 271-92.

Olson, M. 1965. The Logic of Collective Action: Public Goods and the Theory of Groups. Cambridge, MA, Harvard University Press.

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.

Powlson, D., P. Gregory, W. Whalley, J. Quinton, D. Hopkins, A. Whitmore, P. Hirsch, and K. Goulding. 2011. Soil management in regional to sustainable agriculture and ecosystem services. *Food Policy,* 36(2011): S72-S87.

Rada, N. 2013. Assessing Brazil's *Cerrado* agricultural miracle. *Food Policy*, 38(2013): 146-155.

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, A. 2010. Agro-economic feasibility of fertilizer use for wheat cultivation in rainfed regions of Pakistan. *Journal of Agricultural Research,* 48(3): 353-359.

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. 2013. "Wage and Employment Effects of Malawi's Fertilizer Subsidy Program." *Agricultural Economics* (*Forthcoming*).

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. Foz Do Iguacu, Brazil, August 18-24, 2012.

Ricker-Gilbert, J., T.S. Jayne, and J. Shively. 2013. Addressing the "Wicked Problem" of Input Subsidy Programs in Africa. *Applied Economic Perspectives and Policy,* 35(2): 322–340.

Rittel, H. 1972. On the Planning Crisis: Systems Analysis of the "First and Second Generations." Bedrifts Økonomen 8:390–396.

Sachs, J. 2012. How Malawi Fed Its Own People. New York Times Op-Ed piece, April 19, 2012.

Sali-i-Martin, X. and M. Pinkovskiy. 2010. African Poverty is Falling… Faster than You Think. NBER Working Paper 15775.

Sen, A. 1981. *Poverty and Famines: An Essay on Entitlement and Deprivation,* Oxford, Clarendon Press.

Sheahan, M., R. Black, and T. Jayne. 2013. Are Kenyan farmers under-utilizing fertilizer? Implications for input intensification strategies and research. *Food Policy,* 41(August): 39-52.

Shively, G., C. Chibwana, M. Fisher, C. Jumbe, and W. Masters. 2012. Measuring Impacts of Malawi's Farm Input Subsidy Program. Paper presented at the International Conference of Agricultural Economists. Foz du Iguac¸u, Brazil, 20 August 2012.

Stoorvogel, J.J., Smaling, E., 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. Winand Staring Center, Wageningen, The Netherlands.

Takeshima, H. and S. Liverpool-Tasie. 2013. Fertilizer Subsidy, Political Influence and Local Food Price in Sub-Saharan Africa: Evidence from Nigeria. Paper presented at the 2013 Agricultural and Applied Economics Association Annual Meetings, August 4-6, 2013, Washington DC.

Tittonell, P. and K. Giller. 2012. When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. *Field Crops Research* 143 (2013): 76–90

Tittonell, P., B. Vanlauwe, N. de Ridder, K. Giller. 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: 348-368.

UNECA (United Nations Economic Cooperation for Africa). 2012. Economic Report on Africa, 2012: Unleashing Africa's Potential as a Pole of Global Growth, UNECA, Addis Ababa.

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

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

World Bank. 2007a. World Development Report 2008: Agriculture for Development. Washington, DC: World Bank.

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

World Bank 2009a. *Awakening Africa's Sleeping Giant. Prospects for Commercial Agriculture in the Guinea Savannah Zone and Beyond*. Washington DC, World Bank

World Bank, 2009b. *Accelerated Food Security Program of the United Republic of Tanzania Under the Global Food Crisis Response Program*, Report No. 48549-TZ, Washington DC: The World Bank.

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*. International Development Working Paper No. 70, Michigan State University, East Lansing, Mich., U.S.A.

You, L., Ringler, C., Wood-Sichra, U., Robertson, R., Wood, S., Zhou, T., Nelson, G., 2012. What Is the Irrigation Potential for Africa? A Combined Biophysical and Socioeconomic Approach. *Food Policy* 36, 770-782.

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 Use Decisions in a Two-Channel Marketing System. *Agricultural Economics* 40(1):79–94.

Xu, Z., Z. Guan, T.S. Jayne, and R. Black. 2009. Profitability of Applying Fertilizer on Maize for Smallholder Farmers in Zambia. *Agricultural Economics,* November 2009.

Table 1: Fertilizer subsidy and public expenditure in selected African countries, 2008 to 2011

Country	Year	Program Cost (million US$)		Program Cost per Mt of program fertilizer distributed (USD per Mt)	Public Expenditure on Agriculture (million US$)	ISP as % share of public agricultural spending [b]
		Official Source [a]	Computed using secondary data [b]			
Universal subsidy programs						
Mali	2009	na	15.5	878	159	9.7
	2010	na	10.5	873	177	5.9
	2011	na	38.6	890	213	18.1
Burkina Faso	2008	na	14.4	947	158	9.1
	2009	na	27.3	938	189	14.4
	2010	na	21.7	867	259	8.4
Ghana	2009	na	52.5	719	275	19.1
	2010	na	55.5	631	279	19.9
	2011	na	111.7	634	374	29.9
Senegal	2008	na	42.4	731	137	30.9
	2009	na	36.0	720	136	26.6
	2010	na	42.4	785	163	26.1
Nigeria	2008	na	159	625	662	24.1
	2009	na	108	648	677	16.0
	2010	na	190	719	729	26.0
Targeted subsidy programs						
Kenya	2009	na	80.9	696	194	22.2
	2010	na	21.6	911	262	9.1
	2011	na	61.1	1072	318	25.7
Malawi	2009	275	184.2	1000	258	71.3
	2010	115	152.0	1070	323	47.1
	2011	127	179.2	1200	308	58.3
Tanzania	2009	92	96.4	683	250	38.5
	2010	114	135.0	894	252	53.5
	2011	94	134.1	1056	291	46.0
Zambia	2009	119	104.9	935	214	21.0
	2010	101	99.8	971	270	26.9
	2011	109	134.8	1310	438	39.9
Other subsidy programs						
Ethiopia	2009	na	49.0	132	410	12.0
	2010	na	43.0	117	483	8.9
	2011	na	55.0	130	530	10.4

Source notes: [a] Official program costs are obtained from Ministry of Agriculture reports (Tanzania figures are from the World Bank (2009b). [b] Computed program costs are the product of weighted average price of fertilizer, the quantity of subsidized fertilizer distributed, and the percentage of the fertilizer price paid by government. Our computed prices add 12% to account for costs typically not counted in official program cost estimates, such as program administration costs, involvement of extension agents at various stages of the program, fertilizer storage costs, spoilage and transit losses, and government contracts for transport of fertilizer. Fertilizer prices for all countries except Ethiopia are obtained from the IFDC, available at: (http://213.193.193.214/IFDC_ReportServer/Pages/ReportViewer.aspx?/IFDC_Reports/Monthly+National+Prices&rs:Command=Render). Druilhe and Barreiro-Hurlé (2012) point out that in some countries, the full cost of government-imported fertilizer was significantly higher than the price at which farmers were purchasing fertilizer from commercial retailers, indicating that Table 1 may understate the costs of ISPs borne by governments by 10% or more. Quantities of subsidized fertilizer are obtained from Ministry of Agriculture reports for Ethiopia, Mali, Malawi, Kenya, and Zambia; and, for the remaining countries, from

Wanzala-Mlobela *et al* (2013) available at: (http://www.ifdc.org/Documents/NEPAD-fertilizer-study-EN-web/) [b] Public expenditure data are from IFPRI's Public Expenditure for Economic Development (SPEED) database. Available at: (http://www.ifpri.org/book-39/ourwork/programs/priorities-public-investment/speed-database).

Table 2: Characteristics of recipient households acquiring subsidized fertilizer

Household (HH)) or village characteristic	Malawi	Zambia	Kenya
HH total landholding	HHs with larger landholding and asset wealth get more. Less of an issue in recent years.	HHs with larger landholding get more.	HHs with larger landholding get more
Gender of HH head	Female headed HHs less likely to receive subsidized fertilizer; not the case in the most recent survey	Female headed HHs equally likely to receive subsidized fertilizer	Female headed HHs equally likely to receive subsidized fertilizer
Market access	Households farther from main district market get more	HHs farther from main district market and/or feeder road get less	HHs farther from motorable road get more
Political Economy factors (electoral results)	Districts where ruling party won last presidential election get more	Constituencies where ruling party won last presidential election get more (and more so the larger the ruling party's margin of victory)	Constituencies with more electoral support for challenger in the last presidential election get more

Sources: Lunduka *et al* (this issue); Mason *et al* (this issue); Mather and Jayne (forthcoming).

Table 3. Recent estimates of fertilizer application rates, crop response rates, and value cost ratios in sub-Saharan Africa and Asia

African study areas	***Geographic focus***	***% maize fields receiving commercial fertilizer application***	***Application rate for users***	***Response rate (kgs output per kg nitrogen)***	***VCR***
Sheahan *et al* (2013)	20 districts of Kenya where maize is commonly grown, 5 years of data between 1997 and 2010.	Maize and maize/bean intercrop. Ranges from 64% (1997) to 83% (2007)	26 kg N/ha (1997) rising to 40kg 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=17.6kg maize/kg N	MVCR=1.76 (but fertilizer was <1.0 on 30% of plots).
Matsumono and Yamano (2012)	100 locations in Western and Central Kenya (2004, 2007)	74%	94.7 kgs fertilizer product/ha maize	MP=14.1 to 19.8kg hybrid maize/kg N	MVCR=ranging from 1.05 to 1.24 for hybrid maize
Matsumono and Yamano (2012)	Nationwide sample in Uganda (2003, 2005)	3%	2.4 kg maize/kg N	MP=23.4 to 25.2kg maize/kg N	MVCR=0.75 to 1.05
Morris *et al* (2007)	W/E/S Africa			E/S Africa: 14 kgs maize/kg N (median) W. Africa: 10kg maize/kg N (median)	E/S Africa: 2.8 W.Africa: 2.8
Minten, Koru, Stifel (2013)	Northwestern Ethiopia	69.1% of maize plots fertilized	65.3 kg N/ha	MP=12kg 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	Kilimanjaro District, Tanzania			11.7 kg maize/kg N	
Xu *et al* (2009b)	AEZ IIa in Zambia (relatively good quality soils and 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 and within relevant price ranges.
Ricker-Gilbert *et al* (2013)	Malawi, national panel data	59% of maize fields	47.1 N/ha maize	8.1kg maize/kg N	0.6 to 1.6

Table 4: Fertilizer use in India by variety and irrigation status, 2006/07

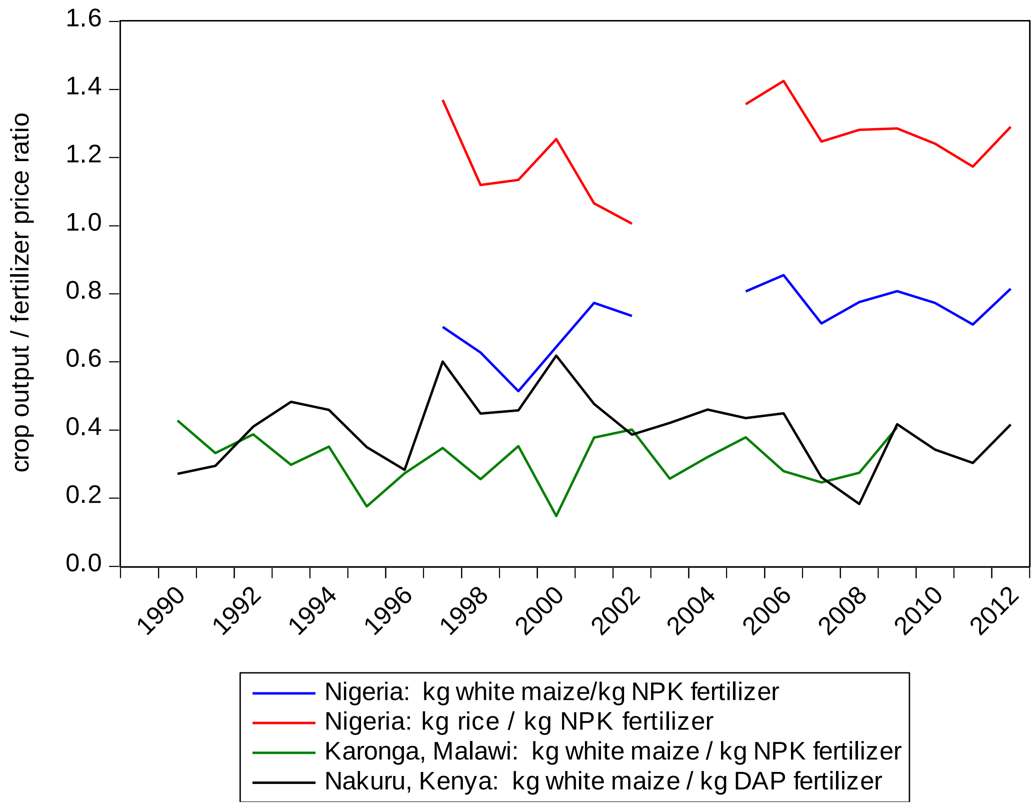
Farm Size	**% share of total cultivated land**			**Fertilizer use rates on all fields (kgs N/ha)**			**Fertilizer dose rates on fertilized fields (kgs N/ha)**		
	HYV	OV	Total	HYV	OV	Total	HYV	OV	Total
Marginal (Below 1.0)									
Irrigated	16	3	12	208	11.9	200	215	168	212
Un-irrigated	10	15	12	98	5.1	78	149	148	149
Total	26	18	23	166	6.3	140	196	154	190
Small (1.0 - 1.99)									
Irrigated	13	3	10	205	9.5	192	213	133	206
Un-irrigated	8	16	11	96	3.8	68	119	97	112
Total	22	19	21	163	4.9	128	181	107	167
Semi-medium (2.0 - 3.99)									
Irrigated	14	5	11	176	8.2	163	186	114	178
Un-irrigated	9	18	12	86	3.5	61	105	84	98
Total	23	23	23	140	4.4	108	157	93	143
Medium (4.0 - 9.99)	0	0	0						
Irrigated	13	5	11	165	7.0	149	177	97	166
Un-irrigated	8	19	12	71	2.4	46	90	71	84
Total	21	25	22	130	3.4	95	147	81	133
Large (10 and above)									
Irrigated	5	3	4	140	5.8	124	152	81	141
Un-irrigated	3	12	6	56	1.1	25	77	59	70
Total	8	15	10	112	1.9	68	131	69	116
All groups									
Irrigated	62	19	48	185	8.4	172	195	117	187
Un-irrigated	38	81	52	86	3.2	59	113	93	107
Total	100	100	100	147	4.2	113	168	101	155

Source: Input survey, 2006/07, Government of India

Notes: 1) HYV = High Yielding Variety; OV = Other Variety

Appendix

Figure A1. Cereal-to-fertilizer price ratios, Kenya, Malawi, and Nigeria.



Sources: Nigeria crop prices from National Bureau of Statistics data files; fertilizer prices from National Programme on Food Security and National Agricultural Input Marketing Information Services. Malawi and Kenya from respective Ministry of Agriculture data files.

Appendix Table A1. 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 managmt 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).

Appendix Table A2. 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 *et al*., 2009