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147- The Economywide Impacts and Risks of Malawi's Farm Input Subsidy Program

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ABSTRACT

Program evaluations often overlook economywide spillovers and constraints. We estimate the impact of Malawi's Farm Input Subsidy Program using a computable general equilibrium model informed by household-level studies. We find that indirect benefits account for about two-fifths of total benefits, underscoring the complementarity between economywide and survey-based program evaluations. Benefit-cost ratios fall when domestic taxes finance the program or when real fertilizer prices rise. Abstracting from very strong weather events, we find that Malawi's program potentially generates double-dividends in the form of higher and more drought-resilient yields. Overall, using parameters similar to survey-based evaluations, we identify mostly positive economywide returns over a range of program designs and risks. However, similar to earlier evaluations, benefit-cost ratios depend strongly on assumptions about fertilizer dose-response rates; and the dose-response rates from *ex post* survey-based studies generate benefit-cost ratios less than one even when indirect program benefits are included.

JEL codes: C68, O13, O22, Q18

Keywords: Program evaluation, risk assessment, economywide model, farm input subsidies, Malawi.

I. INTRODUCTION

A growing number of household-level programs are implemented each year, particularly in Sub-Saharan Africa (Nino-Zarazua 2012). They span a wide range of interventions, including food aid, fertilizer subsidies and cash transfers, and are often coupled with detailed household-level evaluations (see Duflo et al. 2011; Gilligan et al. 2009). Malawi's Farm Input Subsidy Program (FISP) is a prime example of a large scale, national program aimed at enhancing household food security. The program's evaluation approach was designed in advance and surveys have been conducted each year since implementation began in 2005.

The debate over program evaluations typically focuses on the merits of alternative survey-based techniques in attributing outcomes (Bamberger et al. 2010). However, even when a program's evaluation is well designed and executed, there are at least three program "design elements" that are difficult to capture using household surveys. First, programs may generate *spillovers* that benefit non-recipients, or conversely, may compete for resources (e.g., land, labor and water) and so indirectly affect non-recipients and other programs. Second, *scaling-up* a program may influence spillovers and resource constraints, leading to positive threshold effects or diminishing returns. Third, national-level programs may have *macroeconomic effects*, especially when external balances are affected or when financing a program alters fiscal policy. Evaluations that do not to account for these design elements may reach incorrect conclusions about a program's desirability, sustainability and overall impacts.

Risk is another aspect that is difficult to evaluate using surveys. "External risks" can bias estimates of benefits and costs irrespective of how well a program evaluation is designed and implemented. There are two examples of external risk that are particularly relevant for evaluations of programs like Malawi's FISP. First, it is difficult to control for weather patterns, which make evaluations susceptible to the timing of surveys and complicate program comparisons. Secondly, shifts in world commodity prices, such as for fertilizer, can strongly influence a program's overall cost and exacerbate macroeconomic constraints. Ignoring these external risks can lead to misleading assessments, especially concerning program sustainability.

This paper evaluates Malawi's FISP and demonstrates how the above design elements and risks can be incorporated within a comprehensive program evaluation. We adopt a "mixed methods" approach that uses a detailed economywide model calibrated to empirical evidence from household-level evaluations. The model is linked to a survey-based micro-simulation module for poverty analysis, and to results from a stochastic hydro-meteorological crop-loss model for weather risk analysis.

Economywide models are most often used for *ex ante* analysis of policies or economic shocks; however, they are increasingly used for *ex post* evaluation (see Arndt et al. 2012; Dyer and Taylor 2011; Horridge et al. 2005). Here, we employ a mixed methods approach that allows us to harness the strengths of *ex post* evaluation data; triangulate this information with other sources; and address the inherently *ex ante* design elements and risks required for a comprehensive and, to our knowledge, unique method of program evaluation. Furthermore, when used in conjunction with micro-level evaluation data, a carefully calibrated economywide model allows us to experiment in advance with alternative program designs and risks. At least two household-level studies of FISP, including the official evaluation, identified aspects of the program that require economywide analysis (see Dorward et al. 2008; Ricker-Gilbert et al. 2011). This paper responds to this need and so complements standard survey-based techniques.

In the next section, we describe Malawi's FISP and review the existing evaluation studies. We then specify the economywide model, describe its calibration to survey and other data, and outline our evaluation approach. Our findings are then presented, where we consider three program design elements (i.e., spillovers, financing and scale) and two external risks (i.e., weather and world prices). The final section summarizes the additional insights provided by our economywide assessment.

II. MALAWI'S FARM INPUT SUBSIDY PROGRAM

Like most low income countries, agriculture is Malawi's main sector, generating one-third of gross domestic product (GDP), half of total export earnings and two-thirds of employment (Douillet et al. 2012a). The sector is dominated by rain-fed maize and tobacco grown by smallholders. Maize is particularly vulnerable to frequent droughts (Pauw et al. 2011). As such, improving maize yields, as well as the robustness of maize yields to adverse climatic conditions, is a priority for poverty reduction and food security (Benin et al. 2012). After severe droughts and famine in the early 2000s, the government decided to implement FISP.

Program Design

FISP was first implemented during the 2005/06 cropping season and has continued in subsequent years. The program targets 1.5 million rural smallholders or about half of all farmers in Malawi. FISP is designed to provide each farmer with two coupons, which are redeemable for two 50kg bags of fertilizer. Beneficiaries pay a small redemption fee, equating to a subsidy of two-thirds or more of the commercial fertilizer price. Recipients are supposed to be the "productive poor", meaning smallholders who cannot afford fertilizer at commercial prices but have sufficient land and human resources to make effective use of subsidized inputs (Chibwana et al. 2010). Overall, planned fertilizer distribution has been between 150,000 and 170,000 metric tons each year, although actual distribution peaked at 216,000 tons in 2007/08.

Farmers are also provided with free improved seeds: starting at 2-3 kilograms per farmer in 2005/06 and rising to 5-10 kilograms in 2009/10, with the size of the seed packet depending on the seed type chosen. Farmers can, in principle, choose between composite and hybrid seed varieties. Composites are lower-yielding and require a higher seeding rate but can be recycled at the end of the season, whereas higher-yielding hybrids cannot be recycled. Initially, about 60 percent of the seeds under FISP were hybrids, but this rose to almost 90 percent in 2009/10. Finally, FISP has at times included tobacco and legumes, although these are relatively small components compared to maize. Tobacco subsidies were discontinued in 2008/09.

Program Implementation

Identifying the "productive poor" presents a challenge. In practice, farmers' eligibility has been determined by local leaders who do not always apply the same criteria, leading to inconsistent targeting across districts or over time. Evaluation studies consistently show that resource-poor farmers are less likely to receive subsidies (Dorward et al. 2008; Chibwana et al. 2010; Ricker-Gilbert et al. 2011); moreover, there is evidence that subsidized fertilizers have been targeted towards less efficient households (Holden and Lunduka 2010). On average, beneficiaries receive less than the intended 100 kilograms of fertilizer (Dorward et al. 2008), probably because local leaders allocate fertilizer more broadly across communities (Holden and Lunduka 2010).

Some of the fertilizer provided under FISP displaced the fertilizer used in Malawi before the program was implemented. This is indicative of a program that targets farmers that would have purchased fertilizer even in the absence of the subsidy. Ricker-Gilbert et al. (2011) estimate a 22 percent fertilizer displacement rate, implying that each kilogram of subsidized fertilizer provided under FISP increased final fertilizer use by 0.78 kilograms. Higher maize yields achieved under the program might also prompt farmers to diversify into other crops; for example, Holden and Lunduka (2010) use panel data and find that farmers' average share of land allocated to maize declined significantly during 2006-2009. This may also partly explain the displacement of commercial fertilizer. Finally, Ricker-Gilbert (2012) finds that, while FISP did not influence farmers' decision to hire out their own labor, it did raise average wages for hired workers in rural areas.

Program Financing

FISP's main cost components are fertilizer, seeds, transport and logistics. Donors have typically made direct contributions towards FISP for seeds and logistics, amounting to 10-15 percent of FISP's total annual costs (Dorward and Chirwa 2010). The government has paid for all other costs, including fertilizers, which are by far the largest expenditure item. Farmers' redemption prices have not been fixed to world prices and so government payments for fertilizers ballooned in 2008/09 when the world price tripled. This accounts for most of the wide gap between planned and actual costs. The range of planned costs was US$51-139 million per year during 2005/06-2009/10, whereas the range of actual costs was US$81-228 million.

FISP has accounted for about nine percent of the national budget, except in 2008/09 when this share doubled. This has prompted large cuts to other agricultural programs, such as irrigation, research and extension, and to other economic sectors, including roads, industry and the environment. While FISP may benefit the maize sector, it has potentially substantial opportunity costs with economywide implications. In the next section, we describe an economywide model that captures many of the above design, implementation and financing aspects of FISP.

III. Measuring Economywide Impacts

Economywide Model

Computable general equilibrium (CGE) models have a number of features that make them suitable for program evaluations. They simulate the functioning of a market economy, including markets for land, labor, capital and products, and offer insights into how a program's impacts are mediated through prices and resource reallocations. They ensure all resource and macroeconomic constraints are respected, which is essential for large-scale programs. Finally, they provide a detailed "simulation laboratory" for quantitatively examining the interaction of impact channels and spillovers. The model employed follows Lofgren et al. (2002) in its basic structure. The model is briefly summarized below.

Malawi's economy is divided into 58 producer and 30 household groups, who act as individual economic agents. Producers maximize profits subject to input and output prices. Output is supplied to national markets, where it may be exported and/or combined with imports. There is imperfect substitution between domestic and foreign goods. A constant elasticity of transformation function determines the quantity of domestically-produced goods supplied to export markets. Similarly, a constant elasticity of substitution function determines the quantity of imported goods and combines these with domestic production for sale in domestic markets. The model includes domestic and foreign transfers, which are exogenous in real terms.

The government is a separate agent in the model. Government revenues are used to purchase services such as public administration, health and education. Added to revenues is the portion of FISP's cost covered by additional foreign aid. Donors pay a share of the total cost of the subsidies for seeds and fertilizers. To balance the government budget, we assume that indirect tax rates adjust, through additive increases in sales tax rates across commodities, to ensure that revenues equal total spending and borrowing. This captures the macroeconomic effects of FISP when foreign aid does not fully finance program costs.

Our model assumes that the exchange rate adjusts to clear the external account. Thus, if the price of imported fertilizer increases and this additional cost is not covered by foreign aid, the exchange rate is expected to depreciate to encourage exports and discourage imports. Labor is fully employed due to seasonal labor constraints in Malawi (Wodon and Beegle 2006). The total supply of capital is also fixed. In equilibrium, factor returns adjust such that, for each factor, total factor supply equals the sum of factor demands. Product market equilibrium requires that the composite supply of each good equals total private and public consumption and investment demand and the sum of intermediate demands. Market prices for commodities adjust to maintain equilibrium. Finally, we adopt a "balanced" closure in which private and public consumption and investment spending are fixed shares of total nominal absorption (see Lofgren et al. 2002). This closure spreads macroeconomic adjustments across the components of absorption. The national consumer price index is the numéraire.

To estimate impacts on consumption poverty, we use a top-down "macro-micro" approach to measuring poverty changes (see Arndt et al. 2012). In this poverty module, individual households in the underlying survey dataset are linked to their corresponding representative household groups in the CGE model. Observed consumption changes in the model are then applied proportionally to survey households, each with a unique consumption pattern. A post-simulation consumption value can then be calculated and compared against an absolute poverty threshold to determine if a household's poverty status has changed from the base.

Data Sources

The model's parameters are given values from survey and other data. A social accounting matrix (SAM) was estimated for 2003,[1] which is the closest "normal" weather year prior to FISP's implementation in 2005, and is the baseline used by Dorward et al. (2008). The SAM reconciles data from national and government accounts; customs and revenue services; and industrial and household surveys. An input-output table for the model's 58 sectors was estimated using farm budgets from the Ministry of Agriculture and Food Security (MOAFS) and Annual Economic Surveys from the National Statistical Office. The 2004/05 Integrated Household Survey (IHS2) was used to divide labor into five education categories and households into 30 groups.[2] Households earn incomes based on reported wages and profits from farm and nonfarm enterprises. IHS2 includes detailed household expenditure patterns, which are used to calibrate the poverty module.

Agricultural sectors are divided into estate farms and smallholders using production data from MOAFS. Crop land is separated from agricultural capital and includes farm profits and the implicit returns to unpaid family labor. Smallholders are separated by farm size, i.e., small (≤0.5 hectares), medium (≤2.5 hectares) and large (>2.5 hectares). Farmers can reallocate their land and labor in response to relative price changes. Smallholders can also choose between producing local, composite and hybrid maize varieties, but the maize they produce is perfectly substitutable once supplied to the commodity market. Table 1 summarizes the maize technologies derived from surveys by Dorward et al. (2008) and Ricker-Gilbert et al. (2012) and value-chain analysis by Tchale and Keyser (2010). Farm-level input use is consistent with national seed production and fertilizer imports, both in the pre- and post-FISP periods. Finally, household income elasticities are econometrically estimated by rural and urban quintiles using IHS2, and trade and factor substitution elasticities are from Dimaranan (2006).

[Insert Table 1]

[1] The 2003 SAM was constructed following the approach described in Douillet et al. (2012a).
[2] Groups include farm and nonfarm households in rural and urban areas. Rural farm households are further separated by farm size, i.e., small, medium and large. Each group is disaggregated by national expenditure quintiles.

Evaluation Approach

We evaluate the maize component of FISP and ignore the subsidies given to tobacco and legume farmers. Table 1 shows the new maize technologies adopted by FISP recipients (i.e., COM+ and HYB+). Prior to FISP, these new technologies produce negligible amounts, such that all maize is effectively produced using existing technologies (i.e., ALL in Table 1).

To simulate FISP, we exogenously increase the land allocated to COM+ and HYB+ technologies. Producing this new maize requires resources that must be drawn from existing crops, including traditional maize, and from non-farm activities. Final land allocations for all other crops are determined endogenously by technologies, resource constraints and relative prices. Given that FISP's targeting criteria were vague and inconsistently applied, we implicitly distribute FISP vouchers across all smallholder maize farmers irrespective of whether they are poor. Household outcomes will vary depending on their cropping patterns and diversification options as well as the contribution of farm earnings to their total income. Non-farm households are affected through changes in consumer prices and wages. Taxes may also change depending on the fertilizer import price and the share of FISP's cost financed by foreign aid.

To evaluate weather effects, we draw on the hydro-meteorological crop-loss models in Pauw et al. (2011). The loss-exceedance curves (LEC) in Figure 1 show estimated production losses during droughts of different return periods (RPs), which are measures of both the likelihood of occurrence and severity of drought events.[3] For example, local variety maize production is 33.8 percent lower in a one-in-twenty year drought (RP20) than it would have been in a "normal" year (represented by RP1). Composite and hybrid varieties not only have higher yields (see Table 1), but they are also more drought-resistant, with losses of 12.8 and 18.2 percent, respectively, in an RP20 year. The crop losses in the figure are econometrically-estimated using historical district-level production and weather data, and then extrapolated across unobserved drought events using a stochastic weather model.

[Insert Figure 1]

For the weather risk scenarios, we select an RP event from the LECs and apply the productivity losses to each maize variety. To reflect farmers' decision-making and difficulty in predicting weather, we assume that farmers allocate land to crops at the start of the season and cannot reallocate land in response to weather-induced production losses (i.e., droughts are considered unexpected and "rapid-onset" events). To evaluate the full distribution of outcomes, we simulate the effects of FISP under RP1 to RP25 events. We restrict our weather analysis to a maximum RP25 event. This is similar to the most severe nationwide drought recorded in Malawi's historical weather data (Pauw et al. 2011). Estimating crop losses

[3] A weather "hazard" is defined by the severity of an event and the probability of that event occurring within a given year (Pauw et al. 2011). An event's "return period" is the expected length of time between the reoccurrence of two events with similar characteristics. An event with a higher RP is more severe but less frequent than a low RP event.

beyond RP25 is speculative, although we expect that the LECs in Figure 1 would eventually converge at a threshold event greater than RP25. At this threshold, production would be similar regardless of which seed variety (or how much fertilizer) is used, implying that, for a sufficiently severe drought, the FISP would provide zero returns.

IV. EVALUATION RESULTS

Program Impacts and Spillovers

We use the model to replicate the maize component of Malawi's 2006/07 FISP, i.e., 150,000 tons of fertilizer distributed to smallholders together with improved seeds, of which 60 percent are hybrid varieties. In order to simulate FISP in the model, we must determine how much maize land was affected by the program. If we assume the recommended application rate of six 50kg bags of fertilizer per hectare (see Benson 1999), then FISP provided fertilizer to 500,000 hectares (i.e., 150,000mt/300kg). This fertilizer application rate generates yields of 2.2 and 2.8 tons per hectare for composite and hybrid maize, respectively (see Table 1), under normal climate conditions. Note that the same amount of fertilizer is applied to composite and hybrid seeds, but fertilizer dose-response rates differ across varieties. The yield effect is largest for hybrids.[4]

Dorward and Chirwa (2011) report that, in 2006/07, 54 percent of 2.47 million eligible farmers received subsidized fertilizer. This implies that 1.32 million farmers were given 2.3 vouchers each (113kg of fertilizer). Using IHS2, Benin et al. (2012) estimate that poor farmers planted an average of 0.38 hectares of maize in 2004/05. If we maintain this land allocation, then FISP affected 507,500 hectares (i.e., 1.32 million × 0.38). This is very similar to our own estimate. However, Dorward and Chirwa (2011) identify discrepancies in population estimates and suggest that there may be as many as 3.48 million farmers. This means that FISP gave farmers only 1.6 vouchers each (80kg of fertilizer) and affected 715,500 hectares (i.e., 54 percent × 3.48 million × 0.38). In this case, subsidized fertilizer was spread over a larger land area, but obtained lower yields than are shown in Table 1.

Table 2 reports our simulation results. In this section, we focus on Simulation A, which replicates the scale and composition of the 2006/07 FISP, but, unlike the actual program, assumes that all costs are financed by additional foreign aid from donors. We maintain baseline fertilizer dose-response rates and import prices, and assume a "normal" year without weather-related production losses (i.e., RP1 in Figure 1).

[Insert Table 2]

The immediate or direct effect of FISP is an increase in maize yields and production and a decline in maize prices due to marketing and demand constraints. Farmers respond to

[4] The seed planting rates in Table 1 are based on the 2009/10 program, which distributed 8,500 tons of subsidized seed. This is almost twice the amount of seed distributed in 2006/07, but ensures consistency between the seed and fertilizer components of our modeled program as far as land coverage is concerned.

falling maize prices by reallocating land to non-maize crops that earn better returns. This spillover from maize to other crops causes the crop diversification index to rise, which is consistent with the findings of Holden and Lunduka (2010). Taking into account this land reallocation, FISP's net effect is an increase in maize production of 307,300 tons. This is smaller than the production gains reported in Dorward and Chirwa (2011). One reason for this difference is that those authors assume that only ten percent of pre-FISP fertilizer is displaced, which is below the 24.6 percent displacement rate determined endogenously by our model and the 22 percent estimated by Ricker-Gilbert et al. (2012) using survey data.

Unlike survey-based studies, our model captures how FISP affects Malawi's current account. About 80 percent of the cost of the program is payment for imported fertilizer, while the remainder consists of domestically produced improved seed and transport and logistics costs. Hence, in our donor-funded scenario most of the additional foreign aid brought into the country to cover the program cost leaves the country again to pay for fertilizer and has little effect on external balances. Overall, there is a slight appreciation (increase) in the real exchange rate and a decline in total exports, even though maize exports increase.[5] The effect of FISP on non-maize exports via the exchange rate is an important spillover and macroeconomic effect of the program.

FISP increases land productivity and releases agricultural land to other crops, many of which are of higher value than maize. This is a major source of indirect benefits from FISP and causes agricultural GDP to expand. Farm employment, wages and the returns to crop land all increase. This leads to higher welfare for farm households (measured using equivalent variation). Nonagricultural GDP falls slightly as resources are drawn into agriculture. However, nonfarm households' welfare still improves due to lower food prices and higher real wages for less-skilled workers. The national poverty rate falls by 2.7 percentage points as a result of the 2006/07 FISP. Our simulation does not attempt to target the vouchers, and so poor and non-poor maize farmers benefit equally from the subsidy. Poor urban households are typically net food consumers, and so the urban poverty rate is affected more due to the fall in maize prices.

The total cost of the FISP, as modeled here, is US$65.9 million (measured in 2002/03 prices), which is comparable in real terms to the actual program cost in 2006/07.[6] One approach to measuring program benefits is to value the increase in maize production at base year prices. This produces a "production-based" benefit-cost ratio (P-BCR) of 0.99, implying that FISP's benefits effectively equal its costs. This is broadly consistent with Dorward and Chirwa's (2011) average P-BCR of 1.06. These results suggest that FISP generated fairly modest returns. However, a production-based approach captures only the *direct* impact of FISP and ignores *indirect* benefits, such as diversification into higher value crops and positive spillovers from rising incomes and consumer spending.

[5] We do not simulate the 225,000 ton net maize exports after the 2006/07 season, since this was a once-off arrangement with neighboring Zimbabwe.
[6] This is net of the fertilizer redemption price paid by farmers to the government.

To account for FISP's indirect impacts, we measure economywide benefits using total real absorption, which is a measure of national welfare (i.e., private and public consumption and investment). This produces an "economywide" BCR (E-BCR) of 1.62, which means that each dollar spent on FISP generated US$1.62 dollars in national welfare improvements. This result indicates that, under the assumptions imposed, FISP should generate positive returns once indirect effects are included. By not including indirect benefits, survey-based evaluations fail to capture as much as two-fifths of FISP's total benefits. It should be highlighted that these BCRs are upper-bound estimates, since we have so far assumed that FISP was entirely paid for by foreign aid. This was not the case and this assumption is dropped in the next section.

Domestic Financing Options

Foreign aid has only covered a small portion of FISP's total cost. In Simulations B and C, we again model a 500,000 hectare program distributing 150,000 tons of fertilizer, but we now assume that the government, rather than donors, pays for the fertilizer component. This is similar to FISP's actual financing arrangement. To pay for its own share of costs (mainly fertilizer), the government must raise tax revenues. In Simulation B, the government uniformly raises all sales tax rates. This is a relatively distribution-neutral option since the same percentage point increase in tax rates is imposed on all products. In Simulation C, the government proportionally increases *direct* tax rates. This is a progressive option since wealthier households, who have higher initial tax rates, experience larger percentage point increases.

In reality, Malawi's government financed FISP through a reorganization of its economic services budget, and further attempted to contain rising fertilizer costs by fixing the exchange rate and rationing foreign exchange (see Douillet et al. 2012b). This policy contributed to a shortage of foreign currency, which prompted a macroeconomic crisis and the eventual removal of the rationing system. Since we are concerned with evaluating the impact of FISP, and not exchange rationing, we shall restrict our analysis to financing options involving domestic taxes.

The results of the financing scenarios are shown in the final two columns of Table 2. Without foreign aid, Malawi must generate the foreign exchange needed to pay for imported fertilizer. This is achieved by encouraging the production of tradeables via a depreciation of the real exchange rate. This differs sharply from the real appreciation in the donor-funded scenario. Despite more maize exports, there is still a reallocation of land to non-maize sectors. However, while diversification under donor funding was into food crops, the depreciation now shifts resources into export crops. The choice of financing option therefore has implications for program spillovers.

Agriculture is Malawi's main export sector and so the need to generate foreign exchange prompts a larger shift out of nonfarm activities and a rise in farm employment. Unskilled wages do not increase by as much as they did under donor funding. This is particularly true when FISP is paid for through higher indirect taxes, which lower consumer demand for farm products and depress land and labor returns. This means smaller gains in household welfare. Distributional outcomes vary, however, depending on the tax instrument. The burden of higher *indirect* taxes falls fairly evenly across all households since the increase in tax rates is uniform across products. Conversely, urban and non-poor households form the bulk of the *direct* tax base and so are the worst affected when these taxes increase proportionally. This result highlights how domestically-financed programs like FISP can adversely affect households that are not direct beneficiaries. Accounting for these effects is important for comprehensive program evaluations when the programs have macroeconomic implications.

Switching to domestic financing has little effect on the size of the GDP gain, since maize productivity gains are of the same magnitude. As such there is only a small decline in FISP's P-BCR, which falls from 0.99 to between 0.92 and 0.96 depending on the tax instrument. This is still higher than the 0.70 lower-bound estimated by Dorward and Chirwa (2011) and is within the 0.90-1.05 range estimated by Ricker-Gilbert et al. (2012).

It is the composition of GDP, rather than its level, that changes under domestic financing. As fertilizer costs are now paid for by domestic taxes rather than foreign aid, this portion of total program costs is now "internalized" by Malawi. As a result, the absorption gains are smaller than in the purely donor funded scenario. Internalizing fertilizer costs requires that more foreign exchange is generated locally to pay for imported fertilizers. This is achieved by increasing exports and reducing non-fertilizer imports. Thus, while absorption falls, there is little change in final GDP relative the donor funded scenario.

The formula for the E-BCR accounts for the fact that some costs are internalized. Total cost is equal to the cost borne by foreign donors and the internalized cost borne by domestic tax payers. Total benefit is equal to the real absorption gain as well as the internalized cost. This is shown below:

$$BCR = \frac{Total\ benefit}{Total\ cost} = \frac{Absorption\ gain + Internalized\ cost}{Foreign\ aid\ cost + Internalized\ cost}$$

In the purely donor funded scenario there are no internalized costs and so the BCR is simply the absorption gain divided by the foreign aid inflow.[7] When costs are internalized, the absorption gain in the model is net of the cost to domestic taxpayers. Since we add the latter to the total cost of the program, we must also add it to the measure of total benefits. When all costs are internalized, then the absorption gain is the full net benefit of the program. Based on this formula, there is little change in the E-BCR when FISP is partly financed using domestic taxes, even though the P-BCR has fallen.

[7] There is an opportunity cost to using the foreign aid given to Malawi to finance FISP. A correct assessment should compare FISP to the returns generated by other program options. We simulated a universal cash transfer program and found that it produced an E-BCR close to one. This means our E-BCR results can interpreted as being relative to a universal cash transfer program.

Rescaling the Program

We next examine how outcomes vary with the scale of FISP and how sensitive the estimated returns are to changes in fertilizer dose-response rates. Previously we simulated 150,000 tons of fertilizer spread over 500,000 hectares. We now vary the scale from 100,000 hectares (30,000 tons of fertilizer) to 700,000 hectares (210,000 tons). Results are shown in Table 3, which reports E-BCRs with P-BCRs in parentheses. We select the joint-funding option with distribution-neutral indirect tax rate increases as basis for the comparison. As such, a 500,000 hectare program without any changes to fertilizer dose-response rates produces the same 1.62 E-BCR reported for Simulation B in Table 2.

[Insert Table 3]

Changing the scale of FISP has little effect on the P-BCRs, since the value of maize production, measured in base year prices, rises proportionally with the amount of subsidized fertilizer. In other words, fertilizer and land displacement rates remain fairly constant across programs of different scales. In contrast, E-BCRs fall as FISP is scaled-up. This is because marketing and macroeconomic constraints are more pronounced for larger programs (e.g., it becomes more difficult for Malawi to find the export opportunities and foreign exchange needed to pay for imported fertilizers; in addition, the larger sales taxes required to finance the program result in a higher marginal cost of public funds). Although these scale effects complicate program comparisons, the E-BCRs do not change dramatically, thus suggesting fairly stable returns from scaling up.

Outcomes are far more sensitive to changes in fertilizer dose-response rates. As shown in Table 1, our baseline assumption is 15 and 18 kilograms of maize produced for each kilogram of nitrogen applied to composite and hybrid seeds, respectively. With 60 percent hybrid seeds, the average fertilizer response rate for FISP sectors (COM+ and HYB+) is 16.8 kilograms of maize per kilogram of nitrogen, which is similar to the base response rates used in the official FISP evaluation (Dorward et al. 2008). Table 3 shows that if response rates are 30 percent lower (i.e., 11.8 kilograms), then the E-BCR falls to around 0.50, regardless of program scale. This response rate is closer to the survey-based estimates of 12.3 kilograms in Ricker-Gilbert and Jayne (2011) and 9.6 kilograms in Chibwana et al. (2010). Conversely, if response rates are 10 percent higher (i.e., 18.5 kilograms), then even the P-BCR rises above one, indicating positive direct returns to FISP. Finally, the scale of FISP has a greater effect on the E-BCR when response rates are high. This is because more maize is produced per hectare and so marketing constraints are more binding, even for smaller-scaled programs.

Fertilizer Price Risks

The previous sections considered various program design elements, including program scale and financing options. We next consider two external risks. We start with fertilizer prices and then move onto weather shocks in the next section. Table 4 presents the results from the fertilizer price scenarios. Starting from Simulation B, we impose 10, 20 and 50 percent increases in world fuel and fertilizer prices, which generate Simulations D, E and F, respectively.[8]

[Insert Table 4]

Fertilizer is the main cost component of FISP and so higher world fertilizer prices inflates program costs considerably. At higher fertilizer prices, more foreign exchange is required, which in turn necessitates larger real exchange rate depreciations. This encourages a further reallocation of resources towards export agriculture, leading to lower maize production levels and smaller P-BCRs. Results indicate that a 50 percent increase in real fertilizer prices virtually eliminates any increase in maize production (i.e., the P-BCR is only 0.07). This is due to increased pressure to reallocate resources towards export crops like tobacco in order to generate foreign exchange. The E-BCRs also decline as fertilizer prices rise, since it becomes more difficult to generate additional foreign exchange from non-maize exports. Higher fertilizer prices also reduce FISP's welfare gains and poverty reduction.

These results indicate that FISP's returns are exposed to the risk of higher world fertilizer prices. This makes the timing of surveys crucial for impact evaluations. For example, programs implemented in 2006/07 and 2008/09 would produce different E-BCRs even if they shared the same program design and implementation. This is because global fertilizer prices were almost three times larger in 2008 than they were in 2006. Studies that rely on P-BCRs for their final assessments are even more likely to produce incomparable results. This is because higher fertilizer prices lead to greater diversification into export agriculture and lower maize production. Increasing returns to export agriculture may offset some of the decline in total absorption on which E-BCRs are based. Ultimately, being able to control for and experiment with external risks is a major advantage of using economywide models.

Weather Risks

Weather shocks affect program benefits by reducing maize production. As was shown in Figure 1, production losses caused by non-normal weather events vary according to maize variety. The top panel of Figure 2 reports maize production losses for the baseline and FISP scenarios. In 2002/03, 21 and 48 percent of maize was produced using composites and hybrids, respectively – the rest were local varieties. The baseline production losses in Figure 2 are therefore a weighted combination of the exogenous production losses from Figure 1, and the endogenous adaptation to weather events within the model. To illustrate, a severe RP20 drought will likely lead to baseline maize production losses of 31.2 percent.

[Insert Figure 2]

[8] Maize prices may be correlated with world fertilizer prices (Baffes 2007). Higher world maize prices would increase the value of Malawi's maize exports thereby alleviating some of the foreign exchange constraints caused by higher fertilizer prices. We do not, however, simulate higher maize prices, but note that this might reduce Malawi's exposure to higher fertilizer prices, albeit only partially.

As shown in Figure 1, improved seeds are more drought-tolerant than local varieties within the range of our analysis, i.e., RP1 to RP25. By expanding the use of these seeds, FISP improves the drought tolerance of Malawi's maize sector. We again model the 2006/07 program in which 60 percent of the seeds were hybrids. Production losses during an RP20 event now fall to 22.5 percent or about two-thirds of baseline losses. We also experiment with programs providing only composite or hybrid seeds. Production losses are smaller for composite-only programs since this is the more drought-resistant of the two seed varieties. These results suggest that FISP generates "double dividends", i.e., higher maize yields generally as well as a maize system that is more resilient during droughts.

Program benefits fall but costs remain virtually unchanged as weather shocks become more severe, causing the E-BCR to decline. This is shown by the "unadjusted" curves in the lower panel of Figure 2. Composite-only programs generate lower E-BCRs than hybrid-only programs, because the former's yield gains are smaller and so less additional maize is produced per dollar spent. Overall, the E-BCR for the 2006/07 program would have fallen below 1.00 (from a baseline 1.62) under an RP14 or worse event. Every year the country faces roughly an eight percent probability of experiencing an RP14 or worse event. Weather patterns therefore greatly influence E-BCR estimates.

The strong influence of weather on returns to the FISP complicates the task of identifying an appropriate counterfactual. For the weather-risk scenarios, the appropriate baseline is not the stationary 2002/03 season, which was a normal to favorable weather year (i.e., RP1). The correct counterfactual is the outcomes that would have been achieved if the pre-FISP maize system was subjected to the same weather shock as the post-FISP system. In other words, the incremental benefit of the program is defined as domestic absorption with FISP and a given weather outcome less domestic absorption without FISP and the same weather outcome. This differential is shown by the gap between absorption in the baseline and FISP scenarios in the middle panel of Figure 2. If we impose weather-related losses on the baseline and compare the FISP scenarios to this adjusted counterfactual, then the E-BCRs *increase* under more severe weather events (see the lower panel). This is because the E-BCR includes FISP's added benefit of greater drought-tolerance. The adjusted E-BCRs suggest that the average annual returns to FISP are higher than the baseline E-BCR of 1.62 once weather risks are accounted for. This emphasizes the need to disentangle external risks from observed program outcomes, and to include changes in risk when calculating program benefits and costs.

V. CONCLUSION

Household surveys are often used to evaluate government and donor programs. However, this approach usually overlooks economywide program design elements, such as spillovers, scaling and macroeconomic effects, and risk factors, such as weather and world price shocks, all of which can be important particularly for large-scale programs. These elements may prove to be crucial in deciding whether a program is desirable and/or sustainable. In this paper, we showed that this is true for Malawi's Farm Input Subsidy Program, which is a large-scale and costly program exposed to droughts and rising fertilizer prices. To conduct our economywide impact assessment, we developed a computable general equilibrium model that combined empirical evidence from survey-based studies with detailed macro-structural information about the Malawian economy and its behavior.

We find that, under baseline assumptions, FISP generates modest *direct* returns in the form of higher maize productivity and production, which is modulated by increased crop diversification. These findings are consistent with those from survey-based studies. However, our economywide analysis indicates that FISP also generates *indirect* benefits that are either not captured by small-scale “farm” surveys or extremely hard to identify in more comprehensive ones (e.g., nationally representative household surveys). Indirect benefits equal two-fifths of FISP’s total benefits. These arise mainly from falling food prices and higher wages.

Benefits decline when FISP is financed using domestic taxes rather than donor funding, as has been the case since the program was first implemented. Without a large supply-response from exporters, Malawi finds it difficult to import fertilizers using taxes collected in local currency. This problem compounds itself for larger-scale programs. Moreover, financing FISP influences distributional outcomes, potentially making some households worse off after the program due to higher taxes. Our findings suggest that overcoming macroeconomic constraints is essential for the future returns and sustainability of FISP and is at least as important as efforts to improve the targeting and distribution of farm inputs.

Fertilizer dose-response rates, droughts and fertilizer prices are key determinants of FISP’s benefits and costs. A lower fertilizer response rate substantially reduces both direct and indirect returns and drives the economywide benefit-cost ratio to less than one when the response rate declines by slightly more than 20 percent of the value used in official FISP evaluations. Similarly, higher fertilizer prices increase program costs and foreign exchange pressures. We find that FISP’s economywide benefit-cost ratio falls below one when real fertilizer prices rise by 50 percent from 2002/03 levels, which is well below what occurred in 2008/09. FISP’s total benefits also decline during drought years. When economywide outcomes are compared with a baseline that reflects a normal weather year without droughts, we find that FISP’s benefit-cost ratio falls below one during a one-in-fourteen year or worse drought. However, it is more appropriate to compare economywide outcomes with and without the FISP under the same set of weather events. When this is done, economywide benefits of FISP rise with worsening weather outcomes because the improved seeds distributed under the FISP program are more drought-tolerant than local varieties. By expanding the use of these seeds, FISP has the potential to generate “double-dividends” in the form of higher yields and a more drought-resilient maize sector.

This study has shown how a comprehensive program evaluation must measure both direct and indirect benefits and costs. Our economywide approach not only captures indirect effects, but also complements survey-based studies by allowing us to experiment with alternative program design elements and risks. It is therefore an important part of the evaluation toolkit. Accounting for indirect benefits of the FISP potentially allows for much greater benefits. Under assumptions similar to those imposed in other evaluations, we find an economywide benefit-cost ratio of about 1.62. However, similar to other evaluations, this result is shown to depend critically upon fertilizer dose-response rates and fertilizer prices. Under response rates near the survey-based estimates of Ricker-Gilbert and Jayne (2011) and Chibwana et al. (2010), economywide benefit-cost ratios decline to less than one.

Beyond more accurate estimation of fertilizer response rates, there are still areas requiring further research. First, our analysis of financing options is incomplete. We did not, for example, consider additional foreign borrowing or the fixed exchange rate policy that Malawi adopted to curb program costs, at least until 2012 (see Douillet et al. 2012b). Second, we did not evaluate the opportunity cost of using taxes to finance farm subsidies. Ideally, FISP's returns should be compared to those from other interventions, such as cash transfers (see Filipski and Taylor 2012). Third, we did not consider how farm subsidies could be phased out over time or packaged with other interventions, such as investments in rural roads and export opportunities. Better packaging and sequencing of interventions could improve FISP's long-term sustainability. Finally, we did not consider the cost savings that could arise over time from recycling composite seed varieties over multiple seasons.

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TABLE 1. Maize production technologies (inputs and output per hectare)

	Existing maize crops, 2002/03				FISP maize crops	
	LOC	COM	HYB	ALL	COM+	HYB+
Fertilizer (50kg bags)	0.7	2.5	3.3	1.8	6.0	6.0
Traditional seeds (kg)	23.7	0	0	12.1	0	0
Improved seeds (kg)	0	20.0	15.0	8.3	20.0	15.0
Hired labor (days)	35.0	47.0	58.4	44.3	56.8	60.8
Family labor (days)	44.0	44.0	44.0	44.0	44.0	44.0
Revenues (USD)	152	273	388	246	446	551
Seed and fertilizer costs (USD)	23	80	93	55	41	41
Value-added (USD)	83	125	220	133	324	421
Hired labor costs	50	66	76	61	92	106
Capital (hand equipment rental)	14	14	14	14	14	14
Profits (attributed to land)	20	45	130	58	218	300
Maize yield (tons/hectare)	0.76	1.37	1.94	1.23	2.23	2.76
From fertilizer use	0.14	0.63	0.97	0.44	1.49	1.78
From improved seed use	0.00	0.12	0.35	0.18	0.13	0.36
Base yield for local maize	0.62	0.62	0.62	0.62	0.62	0.62
Fertilizer dose-response rate (kg/Nkg)	12.0	15.0	18.0	14.4	15.0	18.0

Source: Own calculations using evaluation data from Dorward and Chirwa (2010) and value-chain data from Tchale and Keyser (2011).

Notes: LOC, COM and HYB are local, composite and hybrid maize varieties, respectively, and ALL is an average weighted according to land area. 'Fertilizer dose-response rate' is the quantity of maize produced per kilogram of fertilizer applied, assuming a fertilizer nitrogen content factor of 0.33.

TABLE 2. Results from the FISP impact and financing scenarios

	Baseline value, 2003	Deviation from baseline without FISP		
		Donor funded	Jointly funded	
			Indirect tax	Direct tax
		(A)	(B)	(C)
Maize production (1000mt)	1,982.8	307.3	289.2	306.1
Maize land (1000ha)	1,501.9	-236.8	-248.9	-237.3
Maize yield (average mt/ha)	1.32	0.49	0.49	0.49
Net maize exports (1000mt)	65.0	86.0	122.5	114.1
Crop diversification index	0.613	0.036	0.040	0.039
Real maize price index (%)	100	-4.26	-3.15	-2.60
Real food prices index (%)	100	-3.32	-2.71	-2.02
Real exchange rate index (%)	100	-2.74	0.72	0.85
Tobacco production (1000mt)	94.3	12.8	12.8	11.1
GDP at factor cost (%)	187.7	4.65	4.69	4.63
Agriculture	61.8	14.96	15.37	15.39
Non-agriculture	125.8	-0.41	-0.57	-0.65
GDP market prices (%)	199.9	1.93	1.89	1.84
Absorption	226.0	3.89	2.07	2.00
Exports	51.2	-0.87	4.64	4.41
Imports	77.3	5.82	3.81	3.67
Farm employment share (%)	65.6	0.13	0.26	0.31
Average farm wage (%)	86.1	7.02	4.42	7.07
Average land return (%)	84.4	8.47	7.39	11.44
Household welfare (%)	177.8	5.00	2.79	2.67
Farm	151.7	6.00	4.16	4.91
Non-farm	352.9	2.17	-1.10	-3.68
Poverty headcount rate (%)	52.4	-2.72	-1.78	-2.93
Rural	55.9	-2.69	-1.82	-2.98
Urban	25.4	-2.90	-1.45	-2.51
FISP benefit-cost ratio	-	1.62	1.62	1.60
Production-based approach	-	0.99	0.92	0.96
Total cost (mil. USD)	-	65.9	67.2	68.0
Financed by foreign aid (%)	-	100.0	16.4	16.2

Source: Economywide model results.

Notes: Assumes a 60 percent hybrid FISP as in 2006/07. Base year GDP values are in USD per capita. Crop diversification index is a modified entropy measure ranging from zero to one, where one is greater diversification of land use. Total benefit is the undiscounted value of total absorption and includes economywide spillovers. Welfare is measured using equivalent variation – reported base year values are average per capita consumption (in unadjusted USD).

TABLE 3. Results from rescaling and fertilizer dose-response scenarios

	Economywide BCR (production-based BCR)					
Program	Deviation from baseline fertilizer dose-response factor					
scale (ha)	-30%	-20%	-10%	0%	+10%	+20%
100,000	0.53	1.11	1.41	1.70	1.99	2.28
	(0.35)	(0.64)	(0.78)	(0.92)	(1.06)	(1.20)
200,000	0.52	1.10	1.39	1.68	1.97	2.25
	(0.35)	(0.63)	(0.78)	(0.92)	(1.06)	(1.20)
300,000	0.51	1.09	1.37	1.66	1.94	2.23
	(0.35)	(0.63)	(0.77)	(0.92)	(1.06)	(1.20)
400,000	0.50	1.07	1.36	1.64	1.92	2.20
	(0.35)	(0.63)	(0.77)	(0.92)	(1.06)	(1.20)
500,000	0.50	1.06	1.34	1.62	1.90	2.18
	(0.35)	(0.63)	(0.77)	(0.92)	(1.06)	(1.20)
600,000	0.49	1.05	1.33	1.60	1.88	2.16
	(0.35)	(0.63)	(0.77)	(0.91)	(1.06)	(1.20)
700,000	0.48	1.03	1.31	1.59	1.86	2.13
	(0.35)	(0.63)	(0.77)	(0.91)	(1.06)	(1.20)

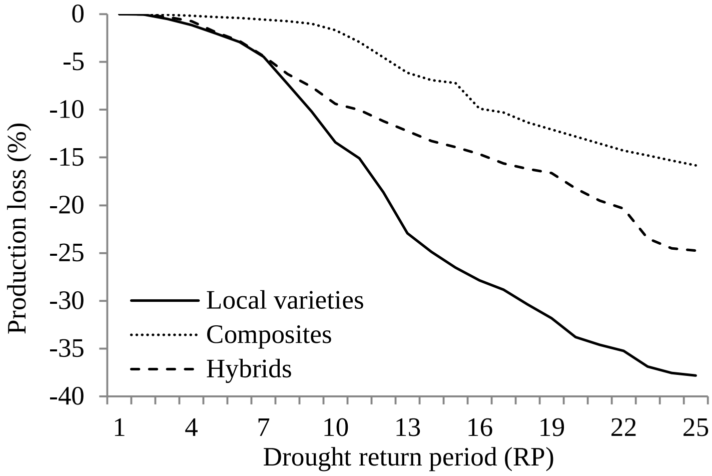
Source: Economywide model results.
Notes: Baseline average dose-response is 16.8 kilograms of maize produced per kilogram of fertilizer, assuming a nitrogen content factor of 0.33 (see Table 1) and a 60 percent hybrid FISP with joint-funding as in 2006/07.

TABLE 4. Results of the fertilizer price risk scenarios.

	Deviation from baseline without FISP			
Real world fertilizer prices	+0% (B)	+10% (D)	+20% (E)	+50% (F)
FISP benefit-cost ratio	1.62	1.51	1.41	1.22
Production-based approach	0.92	0.68	0.49	0.07
Total costs (mil. USD)	67.2	74.7	82.3	105.3
Public funding share (%)	83.6	85.3	86.6	89.6
Real exchange rate index	0.72	0.93	1.12	1.67
Tobacco production (1000mt)	12.8	14.3	15.8	20.3
Household welfare (%)	2.79	2.63	2.47	2.00
Farm	4.16	4.07	3.99	3.75
Non-farm	-1.10	-1.46	-1.82	-2.98
Poverty headcount	-1.78	-1.51	-1.37	-0.90
Rural	-1.82	-1.54	-1.42	-1.02
Urban	-1.45	-1.24	-0.98	-0.01

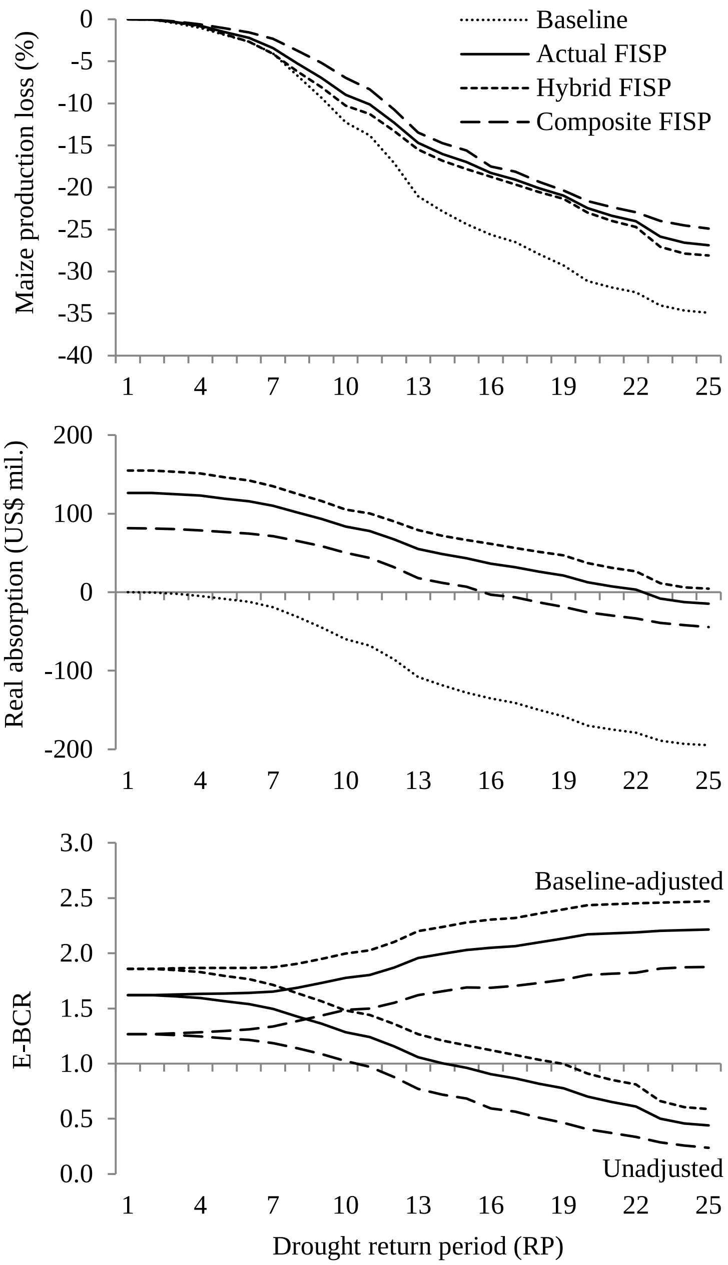
Source: Economywide model results.
Notes: Assumes a jointly-funded 60 percent hybrid FISP scenario (i.e., 2006/07 program). Total benefit is the nominal undiscounted value of total absorption and includes economywide spillovers.

FIGURE 1. Drought loss exceedance curves for maize varieties



Source: Own calculations using the stochastic weather and crop model from Pauw et al. (2011).
Notes: Return period is the expected length of time between the reoccurrence of two events with similar magnitude and severity.

FIGURE 2. Results from the weather risk scenarios



Source: Economywide model results.
Notes: "E-BCR" is the economywide benefit-cost ratio. Composite and Hybrid FISP scenarios use entirely composite and hybrid maize varieties, respectively, while Actual FISP is the 60 percent hybrid 2006/07 program. Total benefit is the undiscounted value of total absorption.