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**The Impact of Alternative Input Subsidy
Exit Strategies on Malawi's Maize Commodity Market**

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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ABSTRACT

This study has been conducted in order to generate evidence of the visibility of exit from farm input subsidies in an African context. The study simulates the impact of alternative exit strategies from Malawi's farm input subsidy program on maize markets. The simulation is conducted using a multiequation partial equilibrium model of the national maize market, which is sequentially linked via a price-linkage equation to local rural maize markets. The model accounts for market imperfections prevailing in the country that arise from government price interventions. Findings show that some alternative exit strategies have negative and sustained impacts on maize yields, production, and acreage allocated to maize over the simulation period. Market prices rise steadily as a result of the implementation of different exit strategies. Despite higher maize prices, domestic maize consumption remains fairly stable, with a slow but increasing trend over the simulation period. Results further suggest that exit strategies that are coupled with improvements in agricultural extension services have the potential to offset the negative impacts of the removal or scaling down of agricultural input subsidies. The study findings demonstrate the difficulty of feasibly removing farm input subsidies. Study recommendations are therefore relevant for policymakers and development partners debating removal or implementation of farm input subsidies.

Keywords: fertilizer subsidies, farm input policy, fertilizer subsidy removal, partial equilibrium model, Africa

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1. INTRODUCTION

Fertilizer subsidies have re-emerged in recent years due mainly to persistent food insecurity and low agricultural productivity (Harrigan 2008; Denning et al. 2009). In addition, volatility in both global and domestic food commodity markets (Dorward 2009) has contributed to the revival of fertilizer subsidies. One such program that has dominated global policy dialogue is the Malawi Farm Input Subsidy Programme (FISP). First implemented in the 2005/06 cropping season, Malawi's FISP has been hailed as one of the most successful *smart subsidies* of the day.. However, the program lacks a clear exit strategy to ensure financial manageability and easy political adjustment (World Bank 2009).

Despite these concerns, the Malawi FISP continues to influence policy across the African continent because rigorous evidence supports its claims of success, with many studies showing improved livelihoods for the majority of people as a result of increased staple food production (Dorward et al. 2008; Dorward and Chirwa 2011). Other studies show that substantive livelihood improvements—in terms of income, plot-level nutrients, and maize self-sufficiency—have been achieved at the household level (Chibwana, Fisher and Shively et al. 2011; Ricker-Gilbert, Jayne, and Chirwa 2011; Holden and Lunduka 2013). On the other hand, evidence of the feasibility of exit from FISP is far less readily available. Gladwin (1992) evaluated the gendered impacts of the removal of farm input subsidies for Malawi and Cameroon, finding that removal of the subsidy for maize had adverse effects on women as compared with men because the former engage mainly in food production. However, the rapid changes in global and national food systems and policy of the new century render Gladwin's findings, though insightful, less applicable for current agricultural policymaking. Other robust studies of the impacts of fertilizer subsidy removal that have been conducted in non-African contexts (Chaudhry and Sahibzada 1995; Acharya 1997; Bradshaw and Smit 1997), though equally insightful, are less relevant for African policymakers due to differences in the social, economic, and political conditions between Africa and the developed or emerging economies in which these studies were conducted.

Studies that specifically focus on exit from the prevailing farm input subsidy in Malawi are mainly qualitative in nature. Chinsinga (2012) suggested different exit strategies for Malawi using a political economy perspective. Proposed strategies included scaling down of the FISP to a few geographic areas that have high maize production potential, or subsidizing smaller amounts of fertilizer in combination with improved seeds. Chirwa, Dorward, and Matita (2011) proposed that beneficiaries graduate from FISP in Malawi when it is determined that their removal from the program would not reduce their households' land and labor productivity. Although both studies provide insight into the formulation of exit strategies for Malawi, they do not rigorously assess the potential welfare gains and losses, nor do they quantify the potential or actual impacts of exit from the farm subsidy program on commodity and input markets or on beneficiaries and nonbeneficiaries.

Understanding the impact of an exit from farm input subsidies is essential for policymakers—those currently implementing subsidies as well as those contemplating future use—because generally there is strong resistance to scaling down or terminating farm input subsidies (Dorward, Hazell, and Poulton 2007). Thus, countries using subsidies as well as those planning to emulate Malawi's farm input policy need to plan effectively in order to ensure the establishment of a clear exit strategy. Such planning can be facilitated only by robust evidence. This study fills this gap by analyzing *ex ante* the impact of alternative exit strategies from farm input subsidy programs on the national maize commodity market. Malawi is used as a case study because its FISP has dominated policy dialogue. Studies of the impact of the removal of farm input subsidies on beneficiaries and nonbeneficiaries, the wider macroeconomy, and input supply networks are also essential; however, these topics are outside the scope of this study.

2. METHODOLOGY

The study uses a multi-equation partial equilibrium model of the Malawi maize market that is recursive in nature. The model, developed by Mapila (2011) and adapted by Mapila et al. (2013), estimates a set of single equations based on economic theory as well as an understanding of the economic and production dynamics of the maize subsector in Malawi. Time series data from the 1989/90 agricultural season to the 2010/11 agricultural season were used to estimate single equations, which were in turn used to build the partial equilibrium framework. A key weakness of data in Malawi is the lack of a single, comprehensive source. Therefore data were obtained from various sources, including the World Bank; FAO, the United Nations Conference on Trade and Development; and the Malawi Ministry of Agriculture and Food Security, National Statistical Office, and Department of Meteorological Services and Climate Change. Data from international databases were validated with industry players and government experts to ensure accuracy.

A summary of the model is presented below:

Domestic Maize Supply Block

$$\text{Production} \quad QP_t = AM_t \times YM_t \quad (1)$$

$$\text{Area} \quad \log AM_t = a_0 + a_1 \log AM_{t-1} + a_2 \log NPM_{t-1} + a_3 DAG_1 \quad (2)$$

$$\text{Yield} \quad \log YM_t = a_0 + a_1 \log Rn_t - a_2 \log PF_t - a_3 DAG_2 + a_4 S06 \quad (3)$$

$$\text{Beginning stock} \quad BS_t = ES_{t-1} \quad (4)$$

Domestic Maize Demand Block

$$\text{Consumption} \quad QC_t = PCC_t \times PP_t \quad (5)$$

Per capita consumption

$$\log PCC_t = a_0 - \log NPM_t + a_2 \log pGDP_t - a_3 TN_t + a_4 DR - a_5 DXP \quad (6)$$

$$\text{Ending stock} \quad ES_t = a_0 + a_1 BS_t + a_2 QP_t - a_3 NPM_t \quad (7)$$

Price Block

Agricultural Development and Marketing Corporation (ADMARC) maize price

$$\log NPM_t = b_0 + b_1 \log IPP_t - b_2 \log \left(\frac{QP_t}{QC_t} \right) + b_4 DI - b_5 DLIB \quad (8)$$

Model Closure

$$\text{Imports} \quad \log IM_t = a_0 - a_1 \log NXP_t - a_2 S06 + a_3 Dpvt + a_4 DNF \quad (9)$$

$$\text{Net exports} \quad NXP_t = QP_t - QC_t + BS_t - ES_t \quad (10)$$

$$\text{Exports} \quad XP_t = NXP_t + IM_t \quad (11)$$

Equations (1) to (11) represent the national maize market. The national maize market is linked to local market economies using a price-linkage equation of the ADMARC maize price (equation [8]) with local market maize prices. This linkage is possible because the majority of local maize market prices in Malawi have a long-run equilibrium relationship with the ADMARC maize price (Mapila 2011). The relationship is one in nature, with the ADMARC maize price Granger-causing all local market maize prices. The local economy model can therefore be represented as follows:

Local Maize Economy

$$\text{Local consumption} \quad \log LQC_t = a_0 + a_1 \log LQP_t - a_2 \log LPM_{t-1} - a_i DA_i \quad (12)$$

$$\text{Local production} \quad \log QLP_t = a_0 + a_1 LRn_t + a_2 LPM_{t-1} - a_i DK_i \quad (13)$$

$$\text{Local maize price} \quad \log LPM_t = b_0 + b_1 \log NPM_t - b_2 \log LQC_t + b_3 D02 - b_i DK_i, \quad (14)$$

where the variables are as follows:

QP_t	Domestic maize production ('000 mt)	LPM_t	Local price of maize in market nearest to extension planning area (USD/mt)
AM_t	Area of maize planted (ha) used as a proxy for area of maize harvested	QLP_t	Aggregate local maize production ('000 mt)
YM_t	Yield (mt/ha)	LRn_t	Total local annual rainfall (mm)
NPM_t	National (ADMARC) price of maize (USD/mt)	DAG_1	Public recruitment: extension service retraining (0/1)
Rn_t	Total annual rainfall (mm)	DAG_2	Maize irrigation scheme changes (0/1)
PF_t	Local price of fertilizer (USD/mt)	DR	Emergency food relief years (0/1)
BS_t	Beginning stock ('000 mt)	DXP	Policy allowing large volumes of exports (0/1)
ES_t	Ending stock ('000 mt)	DNF	Policy allowing large volumes of imports (0/1)
QC_t	Domestic maize consumption ('000 mt)	DI	Government price policy interventions (0/1)
PCC_t	Per capita consumption (mt/capita)	$DLIB$	Reforms in maize marketing (0/1)
$pGDP_t$	Per capita gross domestic product	$Dpvt$	Private sector greater involvement in maize trade
PP_t	Population (millions)	$S06$	Shift variable: shift to full input fertilizer subsidy program in 2005/06
IPP_t	Import parity price	TN_t	Trend variable
IM_t	Maize imports ('000 mt)	DK_2	Dummy variables capturing area-specific climatic occurrences
NXP_t	Net exports ('000 mt)	DA	Dummy variables capturing factors that affect accessibility to local area
XP_t	Maize exports ('000 mt)	$D02$	Drought (2001/02 season)
LQC_t	Aggregate local maize consumption for an extension planning area ('000 mt)	DK_t	Dummy variables capturing agricultural extension programs that negatively affect production data
$b's$	Price elasticities	$Dsub$	Type of fertilizer subsidy program (1 = Starter Pack Initiative, 2 = Targeted Inputs Program, 3 = Farm Input Subsidy Program)
LQP_t	Aggregate local maize production for an extension planning area ('000 mt)	$a's$	Elasticities in the supply, demand, and trade equations

Notes: mt = metric tons; ha = hectares; USD = US dollars; mm = millimeters.

The model was solved using the Gauss–Seidel iterative algorithm, which involves a stepwise iterative process to estimate a solution (Ferris 1998). The estimation of the single equations did not adhere only or strictly to economic theory but included aspects based on empirical evidence and institutional factors that affect the pricing of maize and the maize-based farming system in the country. By including these factors, the model took into account market imperfections prevailing in the country that arise from government price interventions. Key features for each block are summarized below:

General features of the model:

- The majority of farmers within the maize-based farming system in the country do not substitute maize with any other crops. In the absence of substitute goods, the homogeneity condition will not strictly hold, and as such, the standard errors of the estimated models may be biased upward, thus reducing the magnitude of significance of the estimated coefficients (Fuglie, Suherman, and Adiyoga 2002). However, this is a reasonable tradeoff so long as the estimated equations reasonably reflect the real maize-based farming system in Malawi. It is therefore expected that all estimated demand- and supply-related equations will exhibit price inelasticity, since this is a sign that the commodity under analysis has no close substitutes (Tewari and Singh 1996).
- In the absence of substitutes, the symmetry matrixes cannot be estimated, since there are no cross-price elasticities.
Domestic supply block
- In economic theory, area harvested is modeled as a partial adjustment function with the current maize prices and the prices of other crops (Agcaoili and Rosegrant 1995). Equation (2) uses the lagged ADMARC maize prices, as opposed to current maize prices, because Malawi does not have a futures market. Instead, ADMARC prices are announced at the end of the cropping season. Farm production decisions are therefore based on the prices from past seasons.
- For maize production, the price of substitutes has not been included in the equation, since the majority of smallholder farmers within the maize-based farming system are also consumers of their own crop and hence do not produce solely for the market. Therefore, they do not substitute maize for other crops, regardless of the price.
- Typically, yield functions are estimated as a function of past yields in combination with other variables (Agcaoili and Rosegrant 1995). Lagged yields, however, are not included in this study because empirical evidence demonstrates that crop yield variability in Malawi is mainly due to climatic factors, especially erratic rainfall, which results in recurrent droughts in some years and floods in others (Kanyama-Phiri 2008).
Domestic demand block
- Domestic maize demand in Malawi is mainly composed of domestic human consumption, with some maize going toward seed, feed, industrial use, and ending stock. Data for seed, feed, and industrial use in Malawi are unreliable and difficult to obtain. Therefore, total domestic maize demand is taken as a function of domestic consumption and ending stock, with seed, feed, and industrial use being incorporated as exogenous variables in the mathematical calculation of aggregate domestic demand.
- The modeling of ending stock follows Gallagher's (1978) approach.
Maize price block
- The determination of maize prices in Malawi is a complex matter confounded by government intervention. The estimation of the national producer price of maize (the ADMARC price) includes dummy variables that capture the liberalization of ADMARC (*DLIB*) and direct government price policies (*DI*). These dummy variables capture the effects of government policy instruments on the pricing of maize in the country.

Model closure (trade block)

- Maize exports and imports are relatively small in comparison with domestic maize production, implying that maize prices are essentially determined by the dynamics of domestic demand and supply, apart from policies. Since the late 1980s, maize prices in Malawi have approximated import parity prices. In such cases, it is expected that the country would be a net exporter of maize, that domestic prices would largely be determined by world prices, and that this situation would be reflected in a high price transmission rate (Meyer et al. 2006). However, this has not been the case in Malawi due to government intervention.
- Given this situation, the Malawi maize market is taken as being under an import parity regime, with the ADMARC maize prices determined by a behavioral price-linkage equation, equation (8). Price-linkage equations define the extent of price transmission from world markets to domestic markets (Helmar, Devadoss, and Meyers 1991; Meyers, Devadoss, and Helmar 1991). As such, they are considered appropriate in markets in which domestic prices are determined by world prices (Pearse, SriRamaratnam, and Daké 1994; Meyer et al. 2006). The Malawi maize market is not well integrated with world markets because its price transmission is insulated by government intervention. Nevertheless, the use of a price-linkage equation is still relevant because trade still takes place, even though full price transmission is not allowed (Helmar, Devadoss, and Meyers 1991; Meyers, Devadoss, and Helmar 1991). The price-linkage equation that has been specified for this model therefore includes not only import parity prices but also other domestic factors, including direct government price intervention, maize market reforms, and domestic demand-and-supply dynamics, which play an important role in determining ADMARC maize prices.
- Therefore, the Malawi maize market is under an import parity regime, but one in which the level of correlation between the domestic price and the world price is less than 1 due to government control. This has been reflected in the specification of the price-linkage equation for domestic maize prices. Under an import parity regime, net exports are used as a closing identity for the model (Meyer et al. 2006).

Local maize economy block

- The local rural maize market economy is linked to the national maize market via a price-linkage equation with the ADMARC maize price, equation 14. The method of linking the local market via the ADMARC price-linkage equation can be replicated for all markets in Malawi with the empirical estimation capturing local area-specific production, consumption, price, and other factors.
- Local maize consumption (equation [12]) is modeled as a function of local maize production (equation [13]) and other variables (local price of maize and dummy variables that affect accessibility to an area). The inclusion of local production in the local consumption equation creates a feedback loop because local population dynamics and changes that occur in local maize production filter through to local maize consumption, affecting maize prices in local markets and thus creating a recursive system at the local-economy level. Local maize consumption in combination with the ADMARC maize price determines prices in local maize markets. Price changes occurring in local maize markets affect farm/household-level maize pricing, and this in turn affects household income portfolios. Through this linkage, changes occurring within national maize markets and those occurring within local economies are felt at the household level and are manifested as changes in household income. This feedback effect (or local area consumption loop) creates a recursive system of the local maize market.
- The equation for local maize production is estimated as a function of rainfall received in the local area, the lagged maize price in the local market, and a dummy variable capturing the years in which the local area experienced concurrent natural disasters (for example, a combination of floods, long dry spells, and diseases and pests in one cropping season).

- The yield and the acreage of maize planted/harvested are not included in the equation for local maize production because data at the level of the extension planning area for these variables are highly inconsistent and discontinuous.

Because rural household income data at extension planning area level are often not available, a household income variable has not been included in the local consumption equation, even though household income is known to influence staple food consumption patterns in semisubsistence communities such as those that are commonly found in Malawi. The maize production variable, however, does reflect household income, since maize accounts for the largest share of household income in rural household income estimations, especially for households that do not have lucrative commercial enterprises or large ownership of livestock. If household data are available, a household income variable can be included in the estimation of local consumption. See Mapila (2011) and Mapila et al. (2013) for the full derivation of a rural household income variable for inclusion in the local economy block.

It should be noted that the use of lagged variables in estimating the single equations can lead to first-order serial correlation. In such cases, the parameter estimates are inefficient; however, they remain unbiased, consistent, and asymptotically normal (Pindyck and Rubinfeld 1991). Based on these facts as well as the fact that the serial correlation in this study is the result of inertia and economic phenomena (that is, lagged area of maize planted and lagged maize prices), we accept the serial correlation. Thus, the goodness-of-fit test statistics will be slightly inflated (Pindyck and Rubinfeld 1991); however, they remain valid as long as the data used are stationary (Wooldridge 2009). Furthermore, all the continuous variables in all the single equations are used in their logarithmic form. The use of the logarithmic form ensures that the error terms have a normal distribution and that they are homoscedastic, thus ensuring the validity of the t- and F-statistics. In addition, stationarity of all the time-series data used in developing the Malawi maize model has also been established (for full diagnostic checks see Mapila et al. 2013) and therefore the goodness-of-fit measures for the t-statistic of the model remain acceptable.

Model Validation

The efficacy of the Malawi maize market model was validated using three separate robustness checks. Each single equation was validated using the R-square statistic and the root mean square error (RMSE) to test for the relative fit and the absolute fit to the actual data, respectively. Since the partial equilibrium model has been developed mainly for simulation, the RMSE is the key criterion for accepting a fitted equation because the RMSE measures the deviation of the estimated variable from its true path (Ferris 1998). The RMSE also helps to overcome the conflicting interests of model interpretability and goodness of fit, since it takes into account the number of parameters that have been included in a model and, as such, it does not improve as more parameters are added to the estimated model (Browne and Cudeck 1992). As a rule of thumb, a model is accepted as a good fit of actual data if the RMSE does not deviate much from zero (Browne and Cudeck 1992). The F-statistic was then used to test the overall goodness of fit of the estimated equations in order to test for significance of the estimated equations and ability of all the independent variables to effectively predict the dependent variable. The fitted single equations with the various robustness tests are presented in the appendix.

From Table A.1 in the appendix, it can be seen that, first, each of the fitted single equations has an adjusted R-square statistic that is greater than 50 percent, implying that at least 50 percent of the total variation in each of the endogenous variables is explained by the estimated equation. The fitted single equations for local maize consumption and per capita consumption have adjusted R-square statistics that explain about 90 percent of the total variation in the endogenous variables. Second, each of the fitted equations has an RMSE that is not far from zero, implying that the absolute fit of each of the fitted equations is not far from the actual data. Finally, each of the fitted single equations has an F-value that is statistically significant, with the equations for the yield of maize, per capita consumption, ending stock, local maize consumption, local maize production, and local maize prices having F-statistics that are highly statistically significant. Therefore each estimated equation, as a whole, is able to effectively explain the variation of the endogenous variable being modeled. Stationarity of all the time-series data

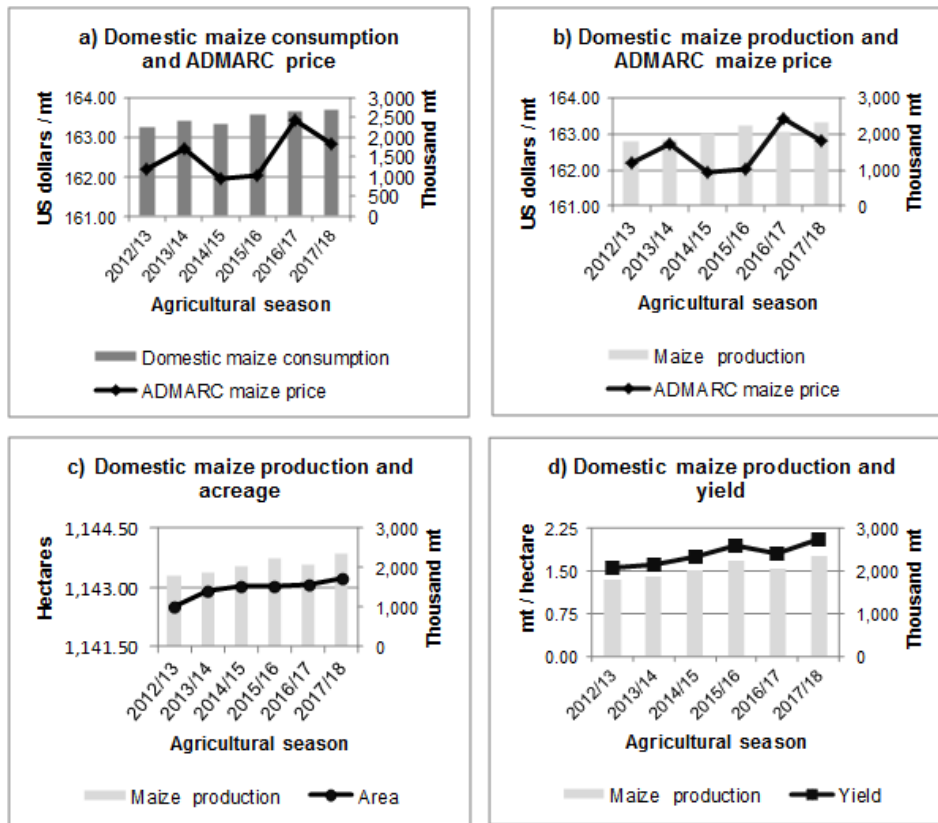
used in developing the Malawi maize model was established (Table A.2, in the appendix), and therefore the goodness-of-fit measures for the model remain acceptable.

The three robustness tests (adjusted R-square statistic, RMSE, and F-statistic) validate the single equations separately, but they do not provide a check for the partial equilibrium model as a whole. To test for overall model performance, the study employed different types of sensitivity analysis. First, small changes were made to the paths of three exogenous variables in the model—rainfall, population, and gross domestic product. From these changes, it was observed that there were very small changes in the historical simulation of the endogenous variables. Second, small changes were made to the coefficient estimates for the fitted single equations, and it was observed that the historical simulation of the model did not alter significantly as a result. Therefore, the Malawi maize model as a whole is an appropriate representation of the real maize subsector, since small changes in the paths of some selected exogenous variables and small changes in the parameter estimates of the endogenous variables do not radically alter the performance of the historical simulation, as is the case in the real world (Pindyck and Rubinfeld 1991). Figure A.1 (in the appendix) provides a diagrammatic representation of the national maize market with linkages to the local market economy and rural household income.

3. RESULTS AND DISCUSSION

The Malawi maize commodity model is used to simulate the impact of exit from the Farm Input Subsidy Program (FISP). A baseline scenario is first presented (Figure 3.1), which shows the status of the maize commodity market over the next five cropping seasons (2012/13–2017/18). It is assumed in the baseline scenario that FISP will continue in its current status. This entails that the program target 1.5 million beneficiaries, who each receive coupons to purchase 100 kg of fertilizer at a price that is 4 percent of the prevailing market price.¹ This assumption is based on the implementation plan of the 2012/13 subsidy program. In addition, it is further assumed in the baseline scenario that the country’s macroeconomic performance as well as other agricultural development programs and investment will remain unchanged. Three main exogenous factors will drive changes in the maize subsector over the baseline period: population growth, the real per capita gross domestic product, and the exchange rate. The projections of the maize commodity market over the baseline period will therefore be based on the forecast growth rates of these three exogenous macroeconomic variables.

Figure 3.1—Baseline scenario



Source: Author’s computations based on data from FAO, Malawi National Statistics Office, and Malawi Agricultural Market Information Survey of the Ministry of Agriculture and Food Security.

Notes: ADMARC = Agricultural Development and Marketing Corporation; mt = metric tons.

Baseline projections for domestic maize production and consumption, Agricultural Development and Marketing Corporation (ADMARC) maize price, and the acreage allocated to maize, as well as maize yields, are presented in Figure 3.1. Figure 3.1 makes it clear that maize production will continue to rise

¹ Market price for a 50kg bag of fertilizer as of January 2013 was MK 13,000 (Malawian kwacha). Farmers with coupons for subsidized fertilizer could redeem the coupons at MK 500.

over the baseline period as a result of increasing maize yields and acreage allocated to maize. Yields rise by more than 30 percent over the period, from 1.55 mt/ha in 2012/13 to 2.04 mt/ha in the 2017/18 season. Acreage allocated to maize rises by a negligible amount of less than 0.1 percent between the 2012/13 and 2017/18 agricultural seasons. Hence, improvements in maize yields arising mainly from the provision of subsidized fertilizer will be the key driver of national domestic maize production over the baseline period.

Figure 3.1 further shows the ADMARC maize price with an increasing trend that fluctuates with changes in domestic maize production. In years of projected high domestic maize production, such as the 2014/15 and 2015/16 cropping seasons, ADMARC maize price exhibits a decline. This situation is reversed in years in which domestic maize production is projected to be low. These fluctuations are the result of the discretionary pan-territorial price-setting regime of the country, which accounts for national supply-and-demand dynamics. Domestic maize consumption has a slow but upward trend. In rural Malawi the majority of smallholder producers consume their own production with supplementation from the market to meet any shortfall in subsistence needs. In addition, food baskets of rural households in the country are nondiversified, with maize being the main staple food crop, with few or no substitutes. This situation implies that maize consumption is not very responsive to market prices, which is indeed observed in Figure 3.1 (panel a), with domestic maize consumption continuing to rise even in the face of high ADMARC maize prices.

Simulation Analysis—Model Linkages

Exit from FISP is introduced into the model in 2012/13 as different (and separate) shocks: (1) complete removal of the subsidy program, (2) reduction in the amount of subsidized fertilizer, (3) reduction in the number of targeted beneficiaries, and (4) an integrated exit strategy. The first three shocks are then coupled with improvements in the agricultural extension service delivery system. All the shocks filter differently within the model to affect the maize commodity market. Complete removal of the subsidy program directly affects maize yields (equation [3]), which has a direct effect on the production identity (equation [1]). Changes in the production identity will in turn affect the ADMARC maize price (equation [8]) and domestic maize consumption (equation [5]). Reduction in the amount of subsidized fertilizer and reduction in the number of targeted beneficiaries are captured through a fertilizer subsidy dummy variable (D_{sub}), which directly affects the pricing of fertilizer in the country. Reduction in amount of fertilizer being subsidized is modeled as being equivalent to the subsidy that was given under the Starter Pack Initiative ($D_{sub} = 1$). The Starter Pack Initiative was implemented in Malawi between the 1998/99 and 1999/2000 cropping seasons and involved providing all smallholder farmers in the country with a small package of hybrid maize seed, legume seed, and fertilizer that was sufficient for cultivating 0.1 ha of land. The Starter Pack Initiative aimed for universal coverage of all the estimated 2.8 million smallholder households (Holden and Lunduka 2013). Reducing the number of beneficiaries is modeled as having the same number of beneficiaries as there were under the Targeted Input Program ($D_{sub} = 2$). The Targeted Input Program was implemented between the 2000/01 and 2004/05 cropping seasons, and at its inception it targeted about 1 million of the poorest households. Between inception and phasing out, the number of beneficiaries under the Targeted Input Program varied between 1 million and 2 million households—numbers that are smaller than the target under the current FISP.

The introduction of improvements in the agricultural extension service system is captured through a dummy variable (DAG). These improvements directly affect area of maize harvested (equation [2]), which in turn affects the production identity. This leads to changes in ADMARC maize prices and domestic maize consumption. In all the scenarios, a “smart subsidy” is assumed in that there are guidelines for beneficiary identification and targeting; use of coupons to redeem subsidized fertilizer; and involvement of the private sector in fertilizer procurement, distribution, and marketing—as is the case with the prevailing subsidy program. Removing or scaling down the subsidy program entails an increase in the market price of fertilizer for some segments of the population. This effect is captured through a discretionary increase of the price-of-fertilizer variable (PF). This modeling technique can cause problems because it is possible that the differences in “smartness” of the subsidy programs may not be

effectively captured by dummy variables or by the magnitude of the increase in the fertilizer price. To overcome this problem, the ADMARC liberalization variable (*DLIB*) is utilized to introduce *smartness* into the model. The *smarter* the subsidy, the more positive the ADMARC liberalization dummy variable—such an approach is supported by evidence that smart subsidies are implemented more in more liberalized economies (de Silva and Tuladhar 2006).

Simulation Analysis—Results and Discussions

Scenario 1 simulates the complete removal of FISP, entailing removal of all households from the subsidy program. This policy change is introduced into the model in 2012/13 and is sustained over the simulation period. As Table 3.1 shows, this scenario leads to an immediate decline in maize yields of almost 17 percent. Decreased yields result in a decrease in domestic maize production of almost 20 percent. From the long-run dynamic elasticity, we see that both yields and domestic maize production are affected negatively over the simulation period, with domestic maize yields and production exhibiting declines of more than 50 percent each between 2012/13 and 2017/17. Reduction in yields is the result of smallholder farmers' buying insufficient amounts of fertilizer, which they then either apply sparingly to a large piece of farmland or apply to a smaller fraction of their farm. Both methods reduce the yield per unit area, which in turn affects maize production.

Table 3.1—Complete removal of fertilizer subsidy program

Scenario 1—Complete removal of subsidy		2012/13	Total long-run dynamic elasticity (% change)*
Acreage planted (ha)	Baseline	1,143.00	
	Scenario 1	1,142.19	
	<i>% change (impact multiplier)</i>	0.00	0.00
Yield (mt/ha)	Baseline	1.56	
	Scenario 1	1.29	
	<i>% change (impact multiplier)</i>	-16.98	-53.61
Domestic production ('000 mt)	Baseline	1,777.38	
	Scenario 1	1,475.10	
	<i>% change (impact multiplier)</i>	-17.01	-53.79
Domestic consumption ('000 mt)	Baseline	2,239.32	
	Scenario 1	2,239.28	
	<i>% change (impact multiplier)</i>	0.00	1.96
ADMARC price (US dollars / mt)	Baseline	162.20	
	Scenario 1	162.20	
	<i>% change (impact multiplier)</i>	0.00	2.32
Scenario 2—Complete removal of subsidy + improved agricultural extension services			
Acreage planted (ha)	Baseline	1,143.00	
	Scenario 2	1,191.13	
	<i>% change (impact multiplier)</i>	4.26	25.94
Yield (mt/ha)	Baseline	1.56	
	Scenario 2	1.29	
	<i>% change (impact multiplier)</i>	-16.98	-53.61
Domestic production ('000 mt)	Baseline	1,777.38	
	Scenario 2	1,538.31	
	<i>% change (impact multiplier)</i>	-13.45	-29.98
Domestic consumption ('000 mt)	Baseline	2,239.32	
	Scenario 2	2,239.28	
	<i>% change (impact multiplier)</i>	0.00	0.87
ADMARC price (US dollars / mt)	Baseline	162.20	
	Scenario 2	162.20	
	<i>% change (impact multiplier)</i>	0.58	1.03

Source: Author's calculations.

Notes: * Total percentage change observed between the 2012/13 and 2016/17 cropping season; mt = metric tons; ha = hectares; ADMARC = Agricultural Development and Marketing Corporation.

Acreage allocated to maize does not change in either the short or long term as a result of the removal of the fertilizer subsidy program in the country. In an ideal world, policy changes such as removal of the fertilizer subsidy program would lead to changes in the acreage allocated to the subsidized crops because such a policy change has the potential to affect the price of the subsidized crop as well as substitute crops, which in theory influence the acreage allocated to a crop (Agcaoili and Rosegrant 1995). In Malawi, however, the removal of the subsidy does not have an immediate or large effect on land allocated to maize. This result is attributed to two factors: First, farm production decisions are based on lagged prices, and second, the lagged area of land allocated to maize crop influences future acreage allocated to maize (Mapila 2011). This is the case in Malawi, where smallholder farmers have very small landholding sizes with little or no prospects for acquiring additional land or for expanding their cultivation.

ADMARC maize prices do not exhibit any immediate change as a result of the removal of the subsidy, a result that can be attributed to government controls that mostly determine the movement of national maize prices. In addition, supply-and-demand dynamics have a lagged effect on maize pricing; hence, the effects of changes in supply and demand are not reflected immediately in ADMARC prices. The dynamic total long-run elasticity, however, shows that over the simulation period, exit from FISP leads to an increase in the ADMARC maize price of about 3 percent. Despite higher maize prices, domestic maize consumption exhibits no changes in the short term and only small changes in the long term, because consumption of maize in Malawi is generally unresponsive to rising food prices, with food baskets being fairly constant and unchanging over time.

In scenario 2, the complete removal of the subsidy is coupled with improvements in the agricultural extension service system. Table 3.1 shows that this scenario also results in a decline in both yields and domestic maize production in both the short term and the long term. On the other hand, ADMARC maize prices, the acreage of maize harvested, and (to some extent) domestic maize consumption rise over the long term. The negative effects on maize yields and domestic production are smaller than in the first scenario due to the improvements in the agricultural extension service system, which enhance smallholder farmers' management practices (Mapila 2011). Table 3.1 shows that complementing the removal of the subsidy with greater investments in extension service delivery leads to an increase in the acreage of maize harvested in the short term (4.25 percent) and in the long term (25.94 percent). Changes in yields remain the same with or without the improved extension services. Therefore the reduction in losses in domestic maize production is attributed to an increase in the area of maize harvested. In addition, ADMARC maize prices exhibit more stability when the subsidy removal is coupled with extension service improvements, since maize prices increase in total over the simulation period by only 1.03 percent under scenario 2, as compared with an increase of 2.32 percent under scenario 1. Complementing complete removal of the subsidy program with improved agricultural extension services therefore leads to a reduction in losses in the maize commodity market as well as smaller increases in market prices.

The trends observed in the maize subsector in scenarios 1 and 2 are further observed with other types of exit strategies. Table 3.2 shows the results for exit strategies that involve either scaling down the amount of fertilizer being subsidized (scenarios 3 and 4) or reducing the number of targeted beneficiaries (scenario 5), as described earlier.

Table 3.2—Reduction in amount of subsidized fertilizer and in number of subsidy beneficiaries

Scenario 3—Reduced amount of subsidized fertilizer		2012/13	Total long-run dynamic elasticity (% change)*
Acreage planted (ha)	Baseline	1,143.00	
	Scenario 3	1,143.00	
	<i>% change (impact multiplier)</i>	0.00	0.00
Yield (mt/ha)	Baseline	1.56	
	Scenario 3	1.42	
	<i>% change (impact multiplier)</i>	-8.49	-46.61
Domestic production ('000 mt)	Baseline	1,777.38	
	Scenario 3	1,626.12	
	<i>% change (impact multiplier)</i>	-8.51	-46.75
Domestic consumption ('000 mt)	Baseline	2,239.32	
	Scenario 3	2,239.28	
	<i>% change (impact multiplier)</i>	-0.0002	2.06
ADMARC price (US dollars / mt)	Baseline	162.20	
	Scenario 3	162.20	
	<i>% change (impact multiplier)</i>	0.00	2.44
Scenario 4—Reduced amount of subsidized fertilizer + improved agricultural extension services			
Acreage planted (ha)	Baseline	1,143.00	
	Scenario 4	1,161.18	
	<i>% change (impact multiplier)</i>	1.63	9.93
Yield (mt/ha)	Baseline	1.56	
	Scenario 4	1.47	
	<i>% change (impact multiplier)</i>	-5.66	-31.07
Domestic production ('000 mt)	Baseline	1,777.38	
	Scenario 4	1,704.16	
	<i>% change (impact multiplier)</i>	-4.12	-21.66
Domestic consumption ('000 mt)	Baseline	2,239.32	
	Scenario 4	2,239.28	
	<i>% change (impact multiplier)</i>	-0.002	0.94
ADMARC price (US dollars / mt)	Baseline	162.20	
	Scenario 4	162.20	
	<i>% change (impact multiplier)</i>	0.00	1.12
Scenario 5—Reduced number of beneficiaries			
Acreage planted (ha)	Baseline	1,143.00	
	Scenario 5	1,143.00	
	<i>% change (impact multiplier)</i>	0.00	0.00
Yield (mt/ha)	Baseline	1.56	
	Scenario 5	1.48	
	<i>% change (impact multiplier)</i>	-5.10	-27.97
Domestic production ('000 mt)	Baseline	1,777.38	
	Scenario 5	1,626.12	
	<i>% change (impact multiplier)</i>	-8.51	-46.75
Domestic consumption ('000 mt)	Baseline	2,239.32	
	Scenario 5	2,239.28	
	<i>% change (impact multiplier)</i>	-0.002	2.06
ADMARC price (US dollars / mt)	Baseline	162.20	
	Scenario 5	162.20	
	<i>% change (impact multiplier)</i>	0.00	2.44

Source: Author's calculations.

Notes: * Total percentage change observed between the 2012/13 and 2016/17 cropping season; ha = hectares; mt = metric tons; ADMARC = Agricultural Development and Marketing Corporation.

Table 3.2 shows that reducing the amount of fertilizer being subsidized (scenario 3) leads to a large decrease in yields and in domestic maize production, in both the short term and the long term. Domestic maize consumption remains fairly stable in the short term while rising steadily over the simulation period. ADMARC maize prices are unaffected in the short term, but over the simulation period they rise in total by nearly 3 percent. A key observation from scenario 3 is that reducing the amount of subsidized fertilizer has less of a negative impact on maize yields and domestic production complete removal of the subsidy. In addition, complementing the reduction in amount of subsidized fertilizer with improved extension services (scenario 4) further minimizes the losses associated with exit from FISP. Similar results can also be observed for the exit strategy that reduces the number of targeted beneficiaries (scenario 5). In scenario 5, Table 3.2 also shows that the losses in maize yields and domestic maize production are less than those from the complete removal of the subsidy program.

Finally, an integrated exit strategy is simulated, involving a combination of a 50 percent sustained reduction in the scale of FISP, investment to improve agricultural extension service delivery, and a 10 percent sustained appreciation of the exchange rate of the Malawi kwacha against the US dollar. The integrated exit strategy has a push–pull effect on the maize commodity market due to the different linkages within the model. First, the appreciation of the local currency lowers the local cost of imported inorganic fertilizer and also lowers the maize import parity price. A reduction in the scale of FISP and investments in agricultural extension delivery both affect maize production, with the former expected to negatively affect yields while the latter positively affects acreage harvested. Results from the simulation of the integrated exit strategy are given in Table 3.3.

Table 3.3—Integrated exit strategy

Scenario 6—50% sustained reduction in FISP + improved agricultural extension services + 10% sustained appreciation of exchange rate of MK against USD		2012/13	Total long-run dynamic elasticity (% change)*
Acreage planted (ha)	Baseline	1,143.00	
	Scenario 6	1,158.00	
	<i>% change (impact multiplier)</i>	1.36	11.22
Yield (mt/ha)	Baseline	1.56	
	Scenario 6	1.58	
	<i>% change (impact multiplier)</i>	-1.19	4.72
Domestic production ('000 mt)	Baseline	1,777.38	
	Scenario 6	1,832.08	
	<i>% change (impact multiplier)</i>	0.15	16.04
Domestic consumption ('000 mt)	Baseline	2,239.32	
	Scenario 6	2,196.74	
	<i>% change (impact multiplier)</i>	-0.22	0.89
ADMARC price (US dollars / mt)	Baseline	162.20	
	Scenario 6	158.59	
	<i>% change (impact multiplier)</i>	-0.25	1.07

Source: Author's calculations.

Notes: * Total percentage change observed between the 2012/13 and 2016/17 cropping season; MK = Malawi kwacha; USD = US dollar; ha = hectares; mt = metric tons; ADMARC = Agricultural Development and Marketing Corporation.

From Table 3.3 the push–pull effect of the integrated subsidy exit strategy can be observed. First, domestic maize production exhibits a very small increase (0.15 percent) in the short term and a relatively large total increase of just over 16 percent over the simulation period. Increases in domestic maize production in the short term are the result of increased acreage of maize harvested, while over the entire simulation period, increases in maize production result from increases in both maize yields and acreage harvested. Increases in acreage in the short term (1.36 percent) and over the simulation period (11.22 percent) are the result of improvements in the agricultural extension service system. Yields initially decrease in the short term (-1.19 percent) as a result of scaling down FISP. However, over the simulation period the total long-run dynamic elasticity is positive, at almost 5 percent. The increase in yields over the

simulation period is attributed to the lower prices of inorganic fertilizer, which arise from the exchange rate appreciation of the Malawi kwacha. Maize prices decrease slightly in the short term (0.25 percent), but they increase slightly over the simulation period (1.07 percent). The latter occurs despite increased maize production over the simulation period and is attributed to the influence of many factors apart from supply-and-demand dynamics on maize pricing in Malawi. Domestic maize consumption increases by less than 1 percent in total over the simulation period, an expected outcome due to the previously mentioned inelasticity with respect to price and income of domestic maize consumption in Malawi.

Several observations and implications arise from these findings. First, complete and abrupt exit from FISP in Malawi is not a feasible option. Such a strategy would lead to drastic reduction in maize productivity, which would negatively impact the maize subsector. The importance of maize in the Malawi economy (World Bank 2007) implies that such a strategy would ultimately also negatively affect the economy. Complete removal remains unfeasible even when coupled with investments to improve the delivery of agricultural extension and advisory services. Second, exit strategies that minimize the losses for the maize subsector arising from removal of the subsidy are those that scale down either the number of beneficiaries or the amount of subsidized fertilizer. Such strategies, however, entail continuing subsidy for some proportion of the population. Losses in crop yields and domestic production are further minimized when these exit strategies are complemented by investments to improve the delivery of agricultural extension and advisory services.

Third, all exit strategies lead to slight increases in ADMARC maize prices. The increases are more pronounced in the long term as compared with the short term, and although they are seemingly small, there is still concern. ADMARC maize prices are mainly determined by government price policies, the aim of which is to keep the prices reasonably low due to welfare considerations. This pricing strategy implies that the increases being observed in the ADMARC maize price in Tables 3.1 and 3.2 do not fully capture the magnitude of change that would occur in market prices if subsidies were removed. It is most likely that the maize price in the private sector would increase far more than the ADMARC price. Such increases in the maize price would create complexities for rural households because they are both producers and consumers of maize, and hence their livelihood outcomes are affected by both demand-side and supply-side factors (Chirwa 2010). An increase in the market price of maize would mean an increase in income for households that are net sellers of the crop but a decrease for net buyers as food becomes more costly. Households that play the dual role of both consumer and producer can be affected from either the supply side or demand side by any increase in maize market prices. These findings therefore imply that in designing farm input exit strategies there is a need to go beyond production outcomes to assess how seemingly small changes in market prices will affect household welfare, an essential consideration for economies in which staple food pricing is plagued by market imperfections arising from government price controls.

In addition, both Tables 3.1 and 3.2 shows that domestic maize consumption is not negatively affected by removal of FISP but in fact continues to rise slightly even in the face of high maize prices. This finding is not surprising, nor is it unique to Malawi. Empirical evidence shows that staple food consumption in many parts of eastern and southern Africa is generally price inelastic (Jayne et al. 2009). In countries like Malawi, in which the majority of the population is poor, this price inelasticity occurs as the poorest households forgo other goods and services in order to buy maize at the higher prices (Chirwa 2010). Hence, policymakers designing exit strategies also need to critically assess the impact of seemingly negligible changes in staple food consumption on other factors in the household. Without such considerations it is possible to design and implement farm input exit strategies that will be detrimental to overall household welfare.

Finally, it has been seen that the integrated exit strategy is the only scenario in which the national maize commodity market is not adversely affected by removal of the subsidy program. This outcome is achieved in two ways—first, the integrated exit strategy incorporates market interventions and a cost-neutral macroeconomic adjustment (exchange rate appreciation), as well as farmer innovation-enabling investments through improved agricultural extension service delivery. In addition, in comparison with all the other exit strategy scenarios, the integrated exit strategy is the only one that minimizes yield losses.

Yield response is therefore the key factor in determining the effect of the exit strategy on the Malawi maize commodity market. That is, the key to developing and implementing an effective exit strategy from or a sustainability strategy for FISP in Malawi will depend on maize yield response. Understanding maize yield response to inorganic fertilizer, however, requires further investigation, since current empirical evidence on maize yield response to fertilizer in Malawi is not widely available (Ricker-Gilbert, Jayne, and Blake 2009).

4. CONCLUSION AND LESSONS LEARNED

This study has shown that abrupt and complete removal of farm input subsidies in the African context is not a feasible option because complete exit has the potential to negatively affect all outcomes of a subsector, including yields, production, consumption, and market prices. Complete exit from farm input subsidies can only lead to the detriment of the sector being subsidized, which can potentially affect an entire economy. This is even more the case in countries such as Malawi, whose economies are highly dependent on the agricultural sector and in which food security hinges on both production and consumption of the subsidized commodity. More practical strategies are those that provide a gradual reduction either in the number of targeted beneficiaries or in the amounts of fertilizer being subsidized. In general, losses from any type of exit strategy from farm input subsidies are minimized when the strategy is coupled with complementary strategies, such as improvements in agricultural extension and advisory services. Furthermore, apart from the obvious losses in yield and production resulting from the removal of subsidies, there are other seemingly negligible effects that need to be considered in designing exit strategies because such negligible or positive changes in staple food prices and domestic consumption can have underlying negative impacts on household welfare. In Malawi as well as in many other countries on the continent, smallholder farmers play the dual role of producer and consumer. As a result, changes in market prices and consumption patterns are confounded by both supply-side and demand-side dynamics. Therefore policymakers considering removal of farm subsidies need to critically look beyond yield and production outcomes to assess the impact of seemingly negligible changes in market price and consumption patterns on household welfare. Furthermore, such considerations are especially important for economies in which staple food pricing is plagued by market imperfections arising from government price controls.

Given these findings as well the entrenchment of fertilizer subsidies in the political agenda of many African countries, it is unlikely that fertilizer subsidies can be feasibly removed from the African agricultural policy dialogue. Strategies that can be effectively adopted by governments are therefore those that are integrated in nature and that over time scale down the subsidies while ensuring sustained yields and production. As demonstrated in this study, such a strategy should incorporate market interventions, cost-neutral macroeconomic adjustments, and interventions to improve farmer innovation and capacity.

Other recommendations for policymakers designing farm input subsidy programs or strategies to exit such programs are as follows: First, it is essential for countries already implementing farm input subsidies to develop strategies for sustainably managing the programs in place so that beneficiaries can be gradually weaned off. Weaning off beneficiaries can be achieved effectively only if subsidy implementation is coupled with investments in agricultural support services and improved institutions. Support services include investments in agricultural extension and advisory services and innovative rural credit programs as well as infrastructure development. In addition, investments to improve the functioning and participation of the rural poor in markets are essential. All these investments would enable farmers that graduate from farm input subsidy programs to effectively gain independence. Second, countries that are planning to implement large-scale farm input subsidy programs need to take into account all these considerations at the time of program conceptualization.

Future areas of research are still needed to better understand the potential and real effects of removal of farm input subsidies. Further exploration should assess the potential of other complementary strategies that can be coupled with exit strategies. Such research should follow a two-pronged approach that considers complementary policies within the agricultural sector as well as in other sectors. The former might be easier to implement since they would not shift funding out of the sector. Understanding interactions between agriculture and other sectors in the face of the removal of subsidies is, however, equally important. This would require going beyond single-market partial equilibrium approaches to the

use of either multimarket partial equilibrium approaches or other analytical tools that can encompass different sectors and markets. Finally, there is a need for research that assesses the impact of removing input subsidy programs on both beneficiary and nonbeneficiary households. In order to effectively inform policymakers, these studies should analyze impacts on household food security, household welfare, and farm input use. Such studies would go far in energizing the policy debate surrounding the removal of farm subsidies in Africa.

APPENDIX: SUPPLEMENTARY TABLES AND FIGURE

Table A.1—Fitted equations with robustness tests

Domestic supply block			
1. Domestic maize production (identity)		Area * yield	
2. Area of maize planted	<i>Parameter</i>	<i>t-value</i>	<i>Elasticity</i>
Intercept	1,802.2	1.550	
NPM _{t-1}	0.006	0.075	0.013
AM _{t-1}	0.653	2.978**	0.021
DAG ₁	104.59	0.506***	
$\bar{R}^2 = 0.678$	DW = 1.98	RMSE = 0.043	F-value = 7.901**
3. Yield of maize		<i>Parameter</i>	<i>t-value</i>
Intercept	0.010	1.194	
Rn _t	0.002	5.749***	1.80
PF _t	-0.003	-1.759*	-0.52
S06	0.5	2.621*	
DAG ₂	-0.05	-3.831**	
$\bar{R}^2 = 0.789$	DW = 2.23	RMSE = 0.013	F-value = 20.67***
4. Beginning stock (identity)		Lagged ending stocks	
Domestic demand block			
5. Domestic consumption (identity)		Per capita consumption * population	
6. Per capita consumption	<i>Parameter</i>	<i>t-value</i>	<i>Elasticity</i>
Intercept	110.881	1.583	
NPM _t	-0.201	-3.074**	-0.233
TN _t	-0.015	-3.228**	-0.001
pGDP _t	0.395	3.487**	0.474
DR	14.20	3.955**	
DXP	-18.00	-2.961*	
$\bar{R}^2 = 0.897$	DW = 1.59	RMSE = 0.028	F-value = 35.874***
7. Ending stocks		<i>Parameter</i>	<i>t-value</i>
Intercept	0.017	2.095*	
BS _t	0.41	2.760*	0.50
QP _t	0.001	3.683**	0.67
NPM _t	-0.002	-2.400	-0.18
$\bar{R}^2 = 0.727$	DW = 2.15	RMSE = 0.062	F-value = 15.062***
Price block			
8. ADMARC maize price		<i>Parameter</i>	<i>t-value</i>
Intercept	179.20	5.319***	
IPP _t	0.23	2.39	0.26
QP _t / QC _t	-22.01	-2.181*	-0.12
DLIB	-71.56	-3.765**	
DINT	137.23	2.241	
$\bar{R}^2 = 0.503$	DW = 1.963	RMSE = 0.035	F-value = 6.058**
Model closure			
9. Net exports (identity)		QP - QC + BS - ES	
10. Maize imports		<i>Parameter</i>	<i>t-value</i>
Intercept	198.03	3.517*	
NXP _t	-0.0014	-2.002	-0.001
S06	-160.20	-3.989*	
DNF	56.87	2.214	
Dpvt	442.2	2.012	
$\bar{R}^2 = 0.546$	DW = 2.17	RMSE = 0.093	F-value = 2.519*
11. Exports (fall-away equation)		NXPORTS + IMPORTS	

Table A.1—Continued

Local economy block (using one local market, Nsundwe in Ukwe Extension Planning Area)			
<i>12. Local maize consumption</i>	<i>Parameter</i>	<i>t-value</i>	<i>Elasticity</i>
Intercept	95.8	118.76***	
LQP _t	0.18	2.668	0.04
LMP _{t-1} (Nsundwe)	-0.01	-2.904	-0.01
DACC _{Nsundwe}	-7.2	-17.403***	
$\bar{R}^2 = 0.942$	DW = 1.80	RMSE = 0.004	F-value = 108.998***
<i>13. Local maize production</i>	<i>Parameter</i>	<i>t-value</i>	<i>Elasticity</i>
Intercept	7.3	2.269	
LRn _(Nsundwe) I	0.008	5.372***	0.604
LMP _{t-1} (Nsundwe)	0.001	2.010	0.008
DUkwe ₂	-2.45	-3.641**	
$\bar{R}^2 = 0.670$	DW = 2.40	RMSE = 0.064	F-value = 11.513***
<i>14. Local maize price</i>	<i>Parameter</i>	<i>t-value</i>	<i>Elasticity</i>
Intercept	141.59	2.18	
NPM _t	0.10	2.06**	0.91
D02	97.48	5.02	
LQC _t	-0.012	-9.52	-0.01
DUkwe	-45.68	-4.73	
$\bar{R}^2 = 0.630$	DW = 1.98	RMSE = 0.048	F-value = 52.813***

Source: Author's calculations.

Notes: * Significant at 10% level, ** significant at 5% level, *** significant at 1% level; DW = Durban Watson; RMSE = root mean square error; ADMARC = Agricultural Development and Marketing Corporation.

Variables:

LQP_t = maize production in Ukwe Extension Planning Area (mt).

LMP_(Nsundwe) = price of maize in the Nsundwe market in Ukwe (US dollars / mt).

LRn_(Nsundwe) = average annual rainfall in Ukwe (mm).

LQC_t = total estimated local maize consumption for Ukwe (thousand mt).

D02 = dummy variable capturing effects of the 2001/02 drought (0/1).

DUkwe = dummy variable capturing the effects of overestimated crop production for Ukwe.

DUkwe₂ = dummy variable for years with concurrent natural disasters (floods, long dry spells, locusts) (0/1).

DACC_{Nsundwe} = accessibility dummy variable: main bridge to Ukwe unusable (0/1).

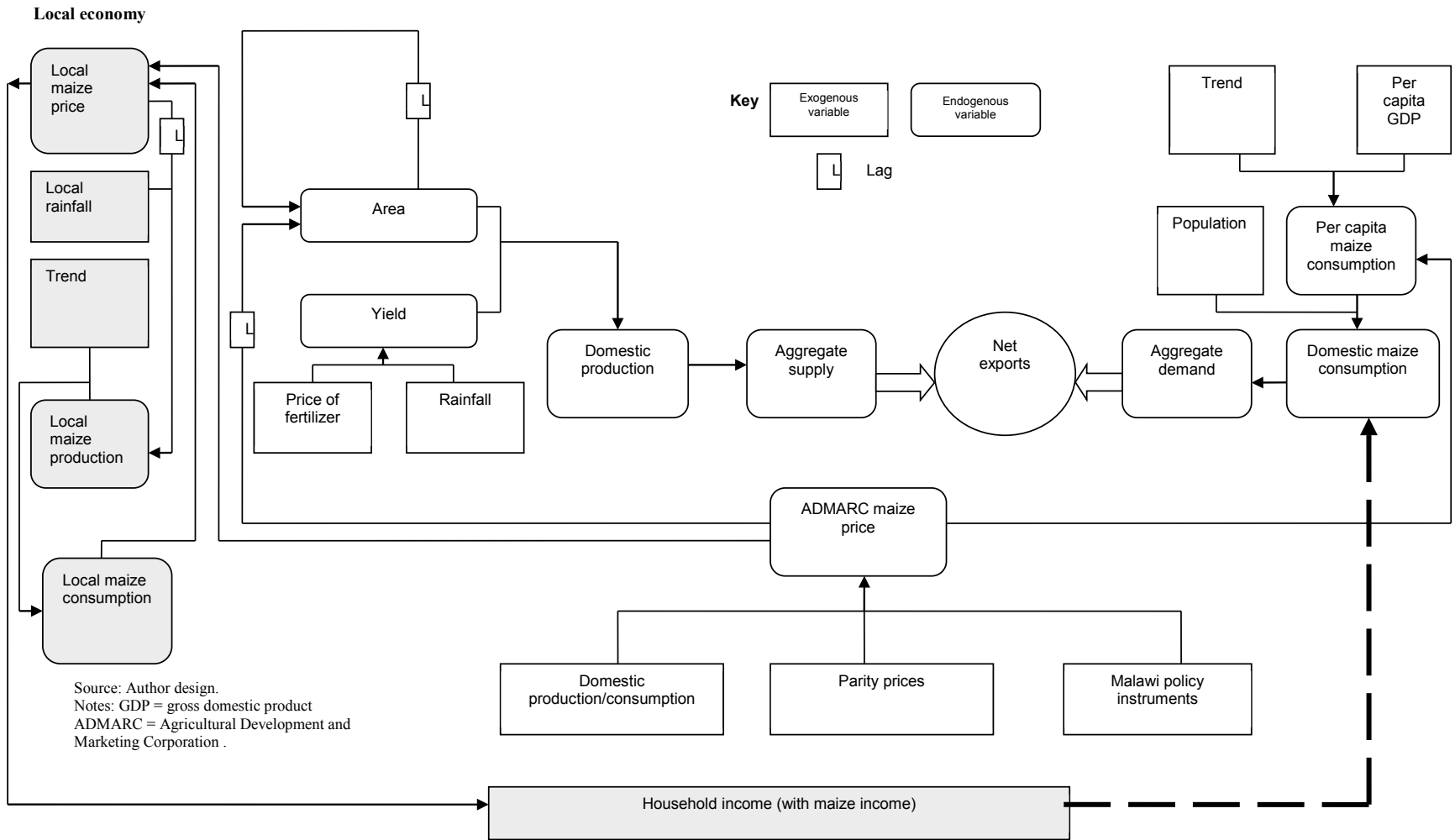
Table A.2—Augmented Dickey–Fuller test results, maize-sector data

Dataset	Augmented Dickey–Fuller statistic	MacKinnon critical value	Levels/differences
Maize production	-3.843	-3.000	1st difference
Domestic maize consumption	-4.095	-3.000	4th difference
Ending stock	-4.436	-3.000	1st difference
Area of maize	-4.342	-3.000	1st difference
Yield of maize	-7.905	-3.000	1st difference
Population	-2.760	-3.000	1st difference
Exports	-3.320	-3.000	1st difference
Imports	-4.280	-3.000	1st difference
Exchange rate	-4.395	-3.000	1st difference
Rainfall	-4.280	-3.000	Levels
ADMARC maize price	-4.176	-3.750	Levels
Consumer price index: food	-5.728	-3.000	2nd difference

Source: Authors' calculations based on Ministry of Agriculture and Food Security data.

Note: ADMARC = Agricultural Development and Marketing Corporation.

Figure A.1—Structure of the Malawi maize commodity market



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