CHAPTER 5

DYNAMICS OF THE MALAWI MAIZE MARKET

5.1 INTRODUCTION

This chapter provides insight into the structure and dynamics of the maize market in Malawi, with particular emphasis on the factors determining price formation within national and local maize markets and on unravelling the price discovery mechanism within farm/household-level maize markets. These analyses are carried out in order to discover the nature of the linkages between the farm/household, local and national maize prices and markets and, in so doing, put in place a framework which can be used to assess the impact of macro-level policy changes on the livelihood outcomes of rural smallholder farmers who engage in the marketing of maize. In essence to better appreciate the price transmission mechanism between the three price levels thus allowing for better understanding of the patterns, trends and relationships governing price formation in the country which is essential for developing a robust model. Finally, the chapter also aims to validate the maize partial equilibrium model in order to demonstrate its robustness and suitability as a tool for policy analysis.

The ultimate goal of this chapter is to develop a framework that can be used to assess the impact of different agricultural sector policies and other macro-economic policy changes on rural incomes for households that are involved in maize production and marketing. In order to develop such a framework, it is essential to initially understand the dynamics and inter-relationships between maize prices in the farm/household market, the local economy market and the national market; and in so doing, to determine the nature and the extent of linkages between these three levels. The first section of this chapter aims to provide such insight into the dynamics of price formation in the Malawi maize market. It includes a statistic analysis of price discovery mechanism at the farm/household level using primary data from households as described in Chapter 4; a statistical and visual analysis of the inter-relationship between maize prices within the country and with regional maize markets and an econometric analysis of the factors influencing price formation at the local and national level. These sections inform the development of a partial equilibrium maize model which is then described in detail in the last section of this chapter, and which is used in Chapter 6 to simulate the impact of different policy changes on rural household incomes.

5.2 DESCRIPTION OF THE DATA

Time series data from 1989 to 2008 was used to estimate single equation models for the maize market and to build the partial equilibrium framework. For consistency, data should be obtained from a single source (Mukhatar & Muhammad, 2009:67). However, due to lack of such a comprehensive source, data was obtained from various data bases. These included the World Bank, Food and Agricultural Organization of the United Nations, the Malawi Ministry of Agriculture, the Malawi National Statistical Office, The Malawi Department of Meteorological Services, and the United Nations Conference on Trade and Development. Data from international data bases was validated with industry players and government experts to ensure accuracy. Table 5.1 presents the mean values for area of maize planted, maize yields, domestic maize production, domestic maize consumption, per capita maize consumption, national producer price of maize (ADMARC) and the local price of maize (Nsundwe), and imports and exports for the period 1989 to 2009. The full data sheet is provided in Appendix 2 and results of the tests for stationarity for all the data are given in Appendix 3.

Table 5.1: Various maize production and marketing data in Malawi

	1989-1994	1995-1999	2000-2004	2005-2009
		Thousand hectares		
Area planted	1300.88	1142.23	1238.58	1206.68
		Tons per hectare		
Yield	0.925	1.15	1.05	1.40
		Thousand tons		
Domestic production	1194.50	1312.83	1278.94	1672.48
Domestic consumption	1491.72	1551.51	1602.79	1713.38
Maize imports	298.26	241.08	324.35	83.72
Maize exports	0.949	2.31	0.718	42.19
Ending stocks	2.21	2.37	2.15	4.34
Local production (Ukwe EPA)	17.57	20.12	21.15	23.22
Local consumption (Ukwe EPA)	97.62	90.80	92.68	97.14
		Kg/capita		
Per capita maize consumption	157.91	153.51	139.22	136.47
		Millions		
Population	9.53	10.11	11.53	13.39
		USD per ton		
ADMARC price	144.14	179.05	175.33	177.92
Local price (Nsundwe market in Ukwe EPA)	113.72	139.97	155.34	167.10
US yellow maize (FOB Gulf)	107.03	119.41	98.82	154.41

As can be seen from Table 5.1, maize production and domestic maize consumption have been increasing steadily since 1989; with the average national maize production rising from 1 194 500 metric tons between 1989 and 1994 to 1 672 480 metric tons between 2005 and 2009. Similarly, average domestic maize consumption has been steadily increasing; with the national average annual consumption rising from 1 491 720 metric tons between 1989 and 1994 to 1 713 380 metric tons between 2005 and 2009. On per capita basis however it can be seen that consumption has a slow but decreasing trend with per capita maize consumption decreasing from 157.91 kg/capita between 1989 and 1994 to 128.47 kg/capita between 2005 and 2009. This change represents nearly a 23% decline in per capita maize consumption over the 20 year period (1989 to 2009). The decrease in per capita maize consumption can be attributed largely to a rapidly rising national population with the average population rising from 9.53 million between 1989 and 1994 to an average of 13.39 million people between 2005 and 2009. In addition, the decreasing trend in per capita maize consumption can also; to a smaller extent; be attributed to a growing urban population that consumes less maize. In addition changes in government policy in the early 2000's that led to greater market liberalization of the economy could also have contributed to the decline in per capita maize consumption due to the availability of cheaper alternative food stuffs; especially for urban consumers.

It can further be seen that maize yields have consistently risen in the country, with the average yield rising from less than one ton per hectare between 1989 and 1994 to 1.40 tons per hectare between 2005 and 2009. The area of maize planted, on the other hand, does not have a clearly discernable pattern; with the average acreage decreasing from 1 300 880 hectares between 1989 and 1994 to 1 142 230 hectares between 1995 and 1999. However, between 2000 and 2004, the average area planted with maize increased to 1 238 580 hectares; but decreased slightly again between 2005 and 2009, to 1 206 680 metric tons.

Maize price data for the national producer price of maize (ADMARC) and the local maize price for the Nsundwe market was collected from the Ministry of Agriculture and Irrigation in Malawi. From Table 5.1, it can be seen that both the ADMARC maize price and the local maize price have an increasing trend, with the average ADMARC maize prices rising from USD144.14 per ton between 1989 and 1994 to USD USD177.92 per ton between 2005 and 2009. The average local maize price for the Nsundwe market also rose from USD113.72 per ton between 1989 and 1998 to USD167.10 per ton between 2005 and 2009. In comparison to the international maize price, it can also be seen that although the yellow maize price generally decreased between 2000 and 2004; the general trend since 1989 is an upward one with the average yellow maize price increasing from USD107.03 in between 1989 and 1994 to an average of USD154.41 in between 2005 and 2009. Maize price data was used to assess trends in price levels over time as well as the nature and direction of price transmission within the maize market in Malawi. It should be noted that the terms ADMARC maize price and the national producer price of maize are used interchangeably.

5.3 PRICE FORMATION IN THE MALAWI MAIZE MARKET

Understanding the behaviour of maize prices in Malawi is important for determining the structure of the maize market and the linkages existing between the national, local and farm/household maize markets. In addition, price discovery is essential for formulating effective policies for ensuring food security. This section provides an in-depth analysis of the relationship between local maize market prices and national (ADMARC) prices using both quantitative and qualitative methods. Its aim is to assess the relationship between maize prices at the national, local and farm/household level and, in so doing, provide an insight into the macro-micro linkages that exist between rural smallholder farming households that produce and market maize and the macro-economy.

As stated in Chapter 1, the Malawi maize market is comprised of three levels (Figure 1.1). The farm/household market consists mainly of rural individual households that are both producers and consumers of maize. The price prevailing in the farm/household market is the farm gate price which is also referred to as the farm/household price in this chapter. This is the price at which producers sell to roving traders that travel to their villages and communities and the price at which farmers sell to each other within a community. In addition the farm gate price is also the equivalent price at which maize is exchanged for other crops and services in any community

The second market is the rural market which is found in rural trading centres across the country and it can be seen as a ‘central’ market for a specific rural locality that comprises several villages and communities. The price prevailing in the rural market (rural economy) is referred to in this study as the local price with the Nsundwe market being used as a case study. In the local market, there are different types of maize trade that take place. First producers; who choose not to sell at the farm gate price; sell their maize to either larger buyers/traders stationed at the local market or to consumers. Second the roving traders who buy maize at the farm gate price from producers also sell maize to the larger traders. For example in the study area, it was found that individual roving traders were buying maize from producers (at the farm gate price) in both the intervention and counterfactual communities and selling it at a higher price (the local market price) to Mulli Brothers Ltd- a large agricultural trading firm that had set up buying points in the local market.

Finally, there is the integrated national maize market controlled by government and in which the Agricultural Development and Marketing Corporation (ADMARC) price prevails. ADMARC depots can be found in some but not all rural trading centres in the country and as such producers also have the option of directly selling to ADMARC. In many instances producers prefer to sell to private traders who start buying maize from farmers at the onset of the harvest period while ADMARC takes longer as it awaits the announcement of the official ADMARC price. In many instances private traders offer a lower price than ADMARC, however many farmers often are cash strapped and opt for the lower price offered at the onset of the harvest season by private traders.

5.3.1 Understanding farm/household-level maize price formation

At the farm/household level, the dynamics of maize pricing are far more complex as compared to the national or local market level. This is due to the nature of the rural household economy, which is limited by the absence of cash income, and the extremely important role that maize plays in the diets and nutritional attainment of many rural households in Malawi. In addition, it is complicated by farmers who are both producers and consumers of maize. In Katundulu village, the intervention community in this study, farmers used maize as a form of currency to purchase salt from hawkers (Figure 5.1). These hawkers are the smallest unit in terms of maize traders and they have on average 2 to 3 bags (50 kg) of maize, which they exchange for salt on a monthly basis. The hawkers in turn sell the maize to households in the residential areas in the city of Lilongwe for a much higher price. Households that use maize as currency are those that are food self-sufficient. However because they have no alternative sources of income apart from farming, they lack the cash with which to purchase other essential goods and services. Apart from salt, many other goods such as labour, clothing and services are exchanged for maize.

Figure 5-1: Use of maize as currency

Apart from using maize as a currency, the study also finds that there is a thriving maize market at the village level. Households that are food secure normally keep sufficient amounts of maize for their own consumption and then use the surplus to either pay labourers for work on their farm during the cropping season, or market it as a cash crop. In this study, at the onset of the 2009/2010 agricultural season, a 20 kg tin of maize was sold for approximately USD4.64 (MK650), which is about USD0.23 per kg. This price, which was 30 % lower than the prevailing ADMARC maize price for the 2009/2010 agricultural season of USD0.34 per kg, was considered very high for the households that were selling maize in the study area.

In general, it is the most productive households that market part of their maize harvest. This is illustrated in Table 5.2, which shows the average number of bags (50 kg's each) of maize harvested per household in both communities in the 2007/2008 and the 2008/2009 cropping seasons and the patterns of maize marketing. On average, households that sold maize in either the 2007/2008 or the 2008/2009 cropping season had higher maize harvests in both communities than households that did not sell maize. This is demonstrated by households who sold part of their maize in the intervention community harvesting on average 45 and 65 bags (50 kg's each) of maize in the 2007/2008 and 2008/2009 seasons respectively; as compared to households that did not sell maize who harvested on average 16 and 34 bags (50kg's each) of maize in the same respective cropping seasons.

Table 5.2 Average maize harvest for sellers and non-sellers of maize

	Maize marketing	Cropping season	
		Number of bags (50 kg[8]) harvested per season	
		2007/2008	2008/2009
Intervention community	Sells maize	46	65
	Does not sell maize	16	34
Counterfactual community	Sells maize	29	28
	Does not sell maize	11	9

The findings are similar in the counterfactual community. Households that sold maize harvested on average more maize than households that did not sell their maize. Households selling maize harvested on average 29 and 28 bags (50 kg) of maize in the 2007/2008 and 2008/2009 seasons respectively; as compared to households that did not sell maize, who harvested on average 11 and 9 bags (50 kg) of maize in the 2007/2008 and 2008/2009 cropping seasons, respectively.

An analysis of the unit prices that individual households received for their maize demonstrates that households in the intervention community received on average USD0.20 per kg of maize, while households in the counterfactual community received on average USD0.18 per kg of maize in the 2008/2009 season. From scatter plots of the unit prices received by different households in each community, it can be seen that in the intervention community, households received more or less similar prices, with very few households deviating from the average price of USD0.20 per kg (Figure 5.2).

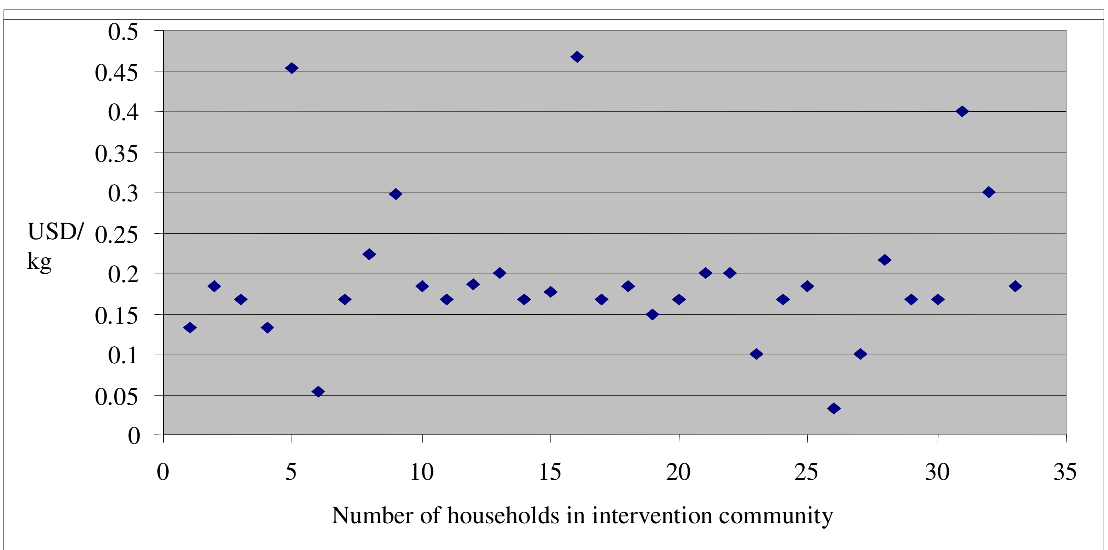

Figure 5-2: Maize unit price variations in the intervention community

[8] Production quantity was not reported in kg equivalent because actual bags of maize were not weighed. However farmers package de-cobbed harvested maize in 50 kg sacks. Reporting in number of bags therefore provides room for actual verification of the weight.

For the counterfactual community, however, it can be seen from the scatter plot in Figure 5.3 that the unit price per kilogram of maize that households received was more varied as compared to the unit prices that households in the intervention community received. There are two major reasons for the differences between the scatter plots of the unit prices in the two communities. First from the descriptive analysis of the two communities in Chapter 4, it was seen that the counterfactual community is closer to a tarred road and, hence, producers have greater accessibility to more markets and traders who offer different prices. This is in contrast to the intervention community, which is far from a tarred road and hence less accessible to different markets. Ideally, given that there are more market outlets, it would have been expected that counterfactual community households could get higher prices as compared to the intervention community households; as other studies have shown that accessibility to marketing outlets affects the pricing of goods, with communities that are in more remote areas receiving a relatively lower price (Matungul, *et al.* 2001). This was not the case for this study, because households in the intervention community were more organised and as such marketed their maize as a group. This is the second reason for the observed differences in the variability of unit prices between the two communities.

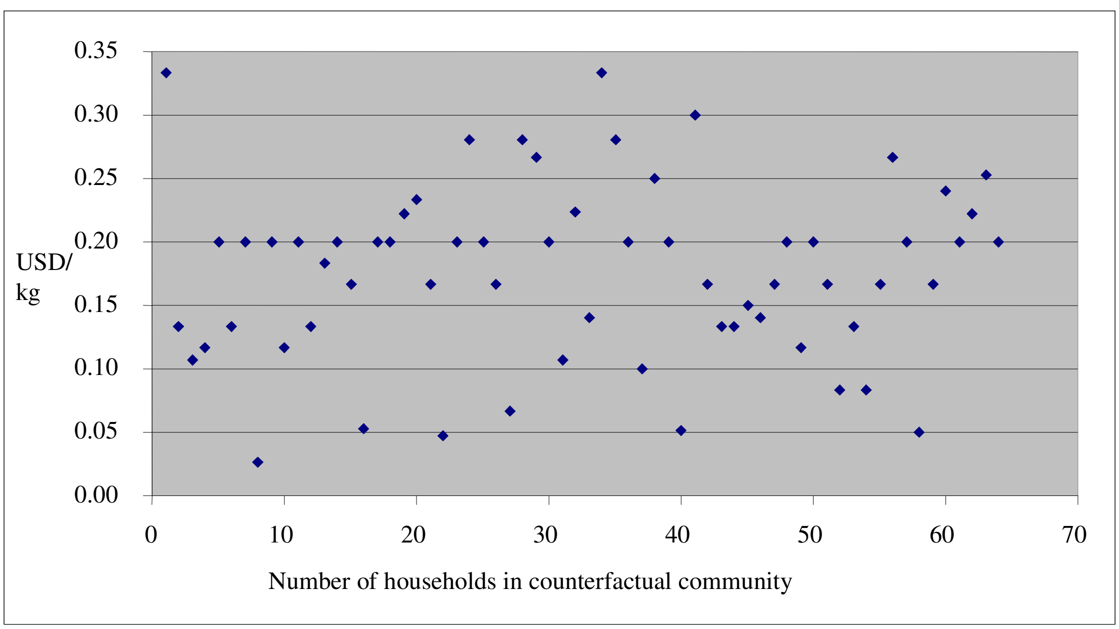

Figure 5-3: Maize unit price variations in the counterfactual community

Under the ERI program, households in the intervention community had organised themselves into a group in order to find marketing opportunities for the piggery agro-enterprise. However, this study finds that the same group that had been organised for the piggery enterprise also used their newly-attained marketing skills to negotiate for marketing of other crops, including maize. Through this organisation, members of the group who wanted to sell their maize were able to negotiate for a better price. Observed differences in unit prices in the intervention community are attributed to some households selling their maize either before or after a price had been negotiated by the group with the traders. Most households that sold in an individual capacity received a lower unit price, with very few obtaining a higher unit price.

A general statistic analysis of the price differences between the farm gate price, the local market price (Nsundwe) and the ADMARC price of maize shows that the farm gate price is consistently lower than either the local market price (Nsundwe) or the ADMARC price. In Table 5.3, it can be seen that the farm gate price for the households sampled in this study was 37.9 % and 11.5 % lower than the local market price (Nsundwe) for the 2008/2009 and 2009/2010 cropping seasons, respectively. In the 2007/2008 season, it can, however, be observed that the farm gate price was equal to the local market price. This can be attributed to maize prices being generally low throughout the country in the 2007/2008 season, with the ADMARC maize price of USD128.68 per ton being at its lowest since the 2002/2001 season.

Table 5.3: Variations in maize unit prices across different markets

	Unit price (USD/kg)	Absolute difference	% difference
	2007/2008 cropping season		
ADMARC price	0.13		
Local market price Nsundwe)	0.12	0.01	7.7
Farm gate price	0.12	0.0	0.0
	2008/2009 cropping season		
ADMARC price	0.33		
Local market price (Nsundwe)	0.29	0.04	12.1
Farm gate price	0.18	0.11	37.9
	2009/2010 cropping season		
ADMARC price	0.34		
Local market price Nsundwe)	0.26	0.08	23.5
Farm gate price	0.23	0.03	11.5

The low prices observed in the 2007/2008 agricultural season can be attributed to inflated production estimates. The inflated production estimates led to a government decision to export maize. This resulted in food shortages and high maize prices at the end of the 2007/2008 season (Jayne, *et al.* 2010), which are reflected in the ADMARC and local maize markets for the 2008/2009 season with the ADMARC price and the local market price

(Nsundwe) rising by nearly 20 % and 17 %, respectively. The farm gate price also rose in the 2008/2009 cropping season, but at a lower rate of 6 %. In the 2009/2010 cropping season, however, this trend is reversed with the farm gate price continuing to rise by 5 %, whilst the ADMARC maize price rose by only 1 % and the local price decreased by 3 %.

Variations in the farm gate price and price differentials between the farm/household price and the local or national level prices can be explained by three inter-related reasons. First, the remoteness and isolation of rural smallholder producers arising from poor road networks and the lack of reliable transportation implies that accessing markets with higher maize prices is difficult and ultimately very costly. Hence, in the case where rural producers are aware of a market with higher prices, they are unable to participate in it as a result of the high transaction costs that they would incur. Second, rural producers are further isolated due to poor information technology and community networks. This entails that maize traders who provide the main market for rural maize producers often have more information than the producers about the prices of maize prevailing in other markets. Hence, rural producers are not able to negotiate effectively for higher prices as they lack the necessarily market information.

In addition, price formation at the farm gate level is also greatly influenced by producer price expectations, which are formed mainly on the basis of prices from the previous season. This is because farm gate prices and negotiations are based on lagged information that producers themselves have gathered and on the information that maize traders are willing to share. Hence, the producers of maize often lack sufficient information with which to negotiate their prices as they have lowered expectations based on lagged maize prices.

5.3.2 Understanding national and local level maize price formation

The pricing of maize differs at the farm/household level, the local economy and at the national level due to the nature and structure of the country and the thriving rural economies that vary spatially across the country. At the national level, prices for maize are set by government based on national annual production estimates, the supply and demand structure of the country, as well as on welfare considerations for low-income consumers. In addition, the government also sets the maize price to ensure that smallholder producers are able to obtain a price that encourages production and reinvestment in the farm. Furthermore regional prices of maize also influence the ADMARC maize price as in times of food shortages; maize is imported from the region (mainly South Africa). However since the Malawi maize market is not fully liberalized, government often buffers the effects of regional and international maize price fluctuations (to ensure food security) and as such transmission is often low. The government buffers regional and international maize price fluctuations using import and export bans and price controls.

The national producer price governs the purchase and selling price of maize in all government markets that are operated by ADMARC, which is a government parastatal responsible for buying and selling food crops throughout the country. The national producer price is the same throughout all ADMARC markets in the country regardless of the spatial differences in production and availability of maize. The ADMARC maize price is announced through the radio and other communication media at the end of the cropping season.

On the other hand, the local market maize price is the prevailing price in different local markets throughout the country. For this study, the local market price that was used was the average annual price for maize prevailing in the Nsundwe market, which is the biggest and closest in proximity to the households in the study area. Ideally, price should be competitively set depending on the supply and demand dynamics as well as the prices of substitutes and complements. In Malawi, this is not the case as the maize market is uncompetitive, which leads to direct government intervention (Jayne, *et al.* 2010). Government intervention has taken place in many forms in Malawi, with the private sector initially being excluded from maize trade. After liberalisation of the maize market in 1994, the private sector has played a greater role in maize trade, but with government still controlling maize trade through price interventions and export bans.

5.3.2.1 Maize price transmission

To better understand the relationship between the ADMARC price and other prices in local maize markets in the country, co-integration analysis was carried out. Six local markets were included for Malawi and consisted of two markets from each of the three regions in the country; Mzuzu and Mzimba markets from the Northern Region, the Lunzu and Limbe markets from the Southern Region, and the Lilongwe and Nsundwe markets from the Central Region.

As a pre-testing for co-integration analysis and to determine the degree of stationarity, the Augmented Dickey-Fuller (ADF) test was carried out to test for the presence of unit roots. As can be seen in Table 5.4, all the maize price time series from the six local markets and the ADMARC market have ADF statistics that are, in absolute terms, greater than the MacKinnon crucial values.

Table 5.4: ADF unit root tests for maize prices

Maize market	ADF Statistic	MacKinnon critical value	Durban-Watson statistic
ADMARC	-3.84	-3.83***	1.98
Nsundwe	-3.15	-3.02**	2.09
Lilongwe	-4.06	-3.83***	2.07
Lunzu	-3.90	-3.83***	1.82
Limbe	-4.12	-3.85***	2.11
Mzimba	-2.82	-2.65*	1.89
Mzuzu	-3.18	-3.02*	1.96

Test critical values: *** at 1 % level, ** at 5 % level and * at 10 % level

This implies that the null hypothesis of non-stationarity for the price time series can be rejected; with the ADMARC, Lilongwe, Lunzu and Limbe price series having the null hypothesis rejected at the 1 % level of confidence; Nsundwe at the 5 % level of confidence; while Mzimba and Mzuzu prices having the null hypothesis of non-stationarity being rejected at the 10 % level of confidence. Since all the maize prices were stationary (in differences and not in levels), an analysis of the long-run relationship between each of the six local prices with the ADMARC maize price was also carried out. The Johansen co-integration test was used to determine if the maize prices in the local markets are integrated with the ADMARC price.

Table 5.5: Results of the Johansen co-integration test

Maize market	Eigenvalue	Trace statistic	0.05 critical value	Hypothesised no. of CE(s)[9]
Nsundwe	0.673	27.092	18.397	None*
	0.320	6.962	3.841	At most 1*
Lilongwe	0.662	30.718	18.397	None*
	0.462	11.189	3.841	At most 1*
Lunzu	0.671	24.262	18.397	None*
	0.210	4.246	3.841	At most 1*
Limbe	0.678	29.393	15.494	None*
	0.393	8.992	3.841	At most 1*
Mzimba	0.675	27.146	18.397	None*
	0.318	6.904	3.841	At most 1*
Mzuzu	0.700	28.415	18.397	None*
	0.311	6.717	3.841	At most 1*

[9] Co-integration equation(s)

Further analysis shows that the ADMARC maize price is co-integrated with all the six local market prices (Table 5.5), as the estimated Johansen trace statistic for each of the six markets is greater than the 0.05 critical cut-off values. This implies that each of the six local maize market prices has a long-run equilibrium relationship with the ADMARC maize price.

In addition using Granger causality tests shows that the relationship between the ADMARC maize price and each of the local market maize prices is one way in nature. From Table 5.6, it is evident that the ADMARC price of maize Granger causes local market maize prices, but none of the local market prices Granger causes the ADMARC price. This implies that the lagged values of the ADMARC price can be used to predict current local market maize prices; but lagged values of local maize prices cannot be used to predict current prices of maize in ADMARC markets. This result is expected given the nature of the price system in the country.

Table 5.6: Results of the pairwise Granger causality test

Null hypothesis	Observations	F-statistic	Probability
ADMARC does not Granger cause Nsundwe	18	1.84	0.019
Nsundwe does not Granger cause ADMARC		0.89	0.433
ADMARC does not Granger cause Mzuzu	18	0.74	0.049
Mzuzu does not Granger cause ADMARC		0.64	0.850
ADMARC does not Granger cause Mzimba	18	2.47	0.012
Mzimba does not Granger cause ADMARC		1.83	0.199
ADMARC does not Granger cause Lilongwe	18	1.05	0.037
Lilongwe does not Granger cause ADMARC		0.83	0.451
ADMARC does not Granger cause Lunzu	18	1.65	0.022
Lunzu does not Granger cause ADMARC		0.38	0.686
ADMARC does not Granger cause Limbe		0.78	0.038
Limbe does not Granger cause ADMARC	19	0.12	0.733

These findings show that there is no feedback relation from local maize markets to the ADMARC markets; hence there is the existence of a one-way Granger causality. The implication of this finding is that Goletti and Babu's (1994) radical model of price transmission can apply to the Malawi maize market, in that prices in local maize markets are determined by a combination of the current and past prices of a "central market" and the past prices of the local market itself. In this case, the ADMARC market is the central market. The application of the radical model of price transmission in Malawi may, however, not be able to completely explain all the variation in local maize prices, as the political and geographical division of the country entails that there may be more than one "central" market arising from the existence of regional centres (Central, South and Northern regions) which may create other market networks at the regional level.

The results of the Granger causality tests imply that despite the existence of thriving rural local market economies, macro-level price changes in the national maize market transmit to rural maize markets. It is through this maize price transmission mechanism that rural farming households are affected by macro-level policy changes, as maize is the main staple food crop for the majority of rural smallholder farmers in the country and many farmers depend on local markets for either marketing any surplus maize production or for purchasing maize in times of food scarcity.

Maize prices in Malawi are far more volatile than other prices in the region. Figure 5.4 shows the monthly movements for the six local maize markets in Malawi; four regional markets, namely the South African SAFEX market, Kenya, Zambia and Mozambique; and the Chicago white maize price representing the international maize markets for January 2004 to October 2008. Figure 5.4 shows that Malawi maize markets are more volatile as compared to either regional or international maize markets.

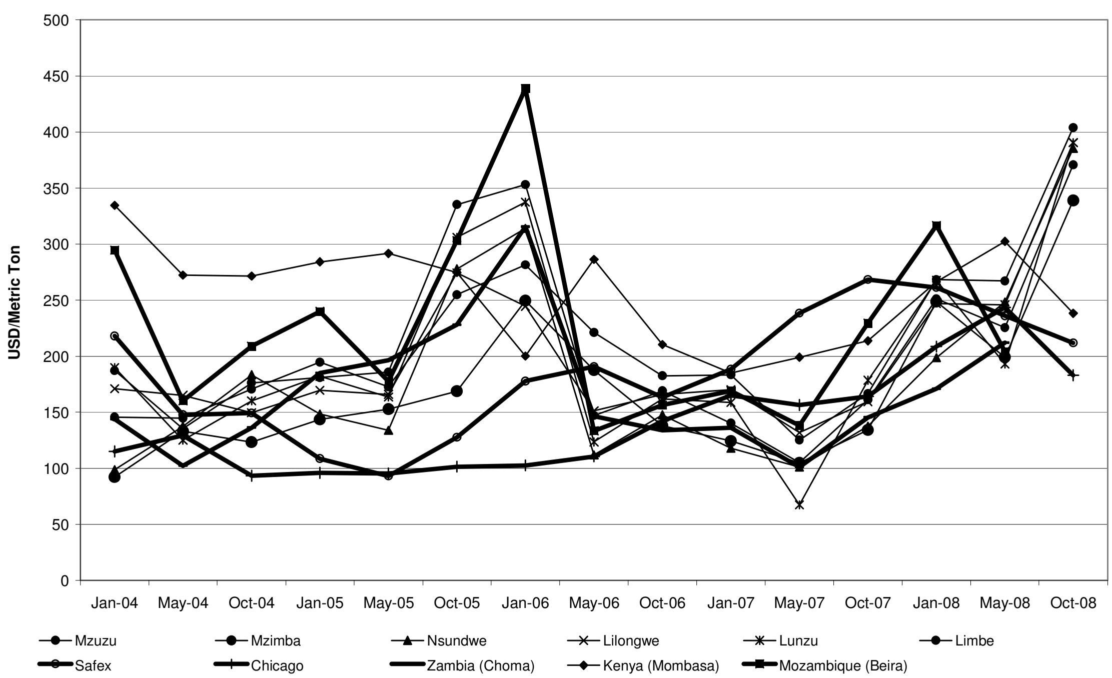

Figure 5-4: Maize price co-movements in selected markets

It is also clear from Figure 5.4 that there is weak co-movement between domestic maize prices in Malawi and the SAFEX white maize price. Correlation co-efficient analysis further shows that there is clearly no linear relationship between maize grain prices in local markets in Malawi with the South African SAFEX market (Table 5.7). However, the ADMARC maize price shows a positive but very weak linear relationship with the SAFEX white maize price, as it exhibits correlation co-efficient measures of 0.44 and 0.41 in price levels and in differences respectively. This implies that the ADMARC price tends to either rise or fall with the SAFEX price. However, since the level of correlation is weak, there are other factors that influence maize pricing in national maize markets in Malawi. These include, but are not limited to, government policies that directly affect maize pricing and trade, such as price bands, welfare considerations for low income urban consumers as well as considerations for resource-poor maize producers (FAO, 2009).

Table 5.7: Correlation co-efficient measures

Market	SAFEX	ADMARC
Levels		
SAFEX	1.00	
Mzuzu	0.15	0.97
Mzimba	0.19	0.96
Nsundwe	0.02	0.98
Lilongwe	0.14	0.98
Lunzu	0.04	0.98
Limbe	-0.08	0.99
ADMARC	0.44	1.00
Differences		
SAFEX	1.00	
Mzuzu	-0.03	0.89
Mzimba	0.07	0.84
Nsundwe	-0.19	0.94
Lilongwe	-0.04	0.97
Lunzu	-0.05	0.97
Limbe	-0.22	0.99
ADMARC	0.41	1.00

An analysis of the relationship between local market maize prices with the ADMARC price shows that there is evidence of the existence of a strong linear relationship between the maize prices in all the six local markets under analysis and the ADMARC price, with the correlation co-efficient for any of the six markets with the ADMARC price not being below 0.96 in levels. This implies that the ADMARC price is a key factor in price formation in local markets in Malawi. Despite inter-regional and intra-regional differences that affect maize price formation in different local markets, it is evident from these results that government policy plays a key role in influencing individual local market prices in different markets throughout the country.

The high correlation measures between the local maize markets and the ADMARC price might, however, be an indication of spurious correlation (Goletti & Babu, 1994). To cater for this, an assessment of the correlations in the price differences was also carried out. As can be seen from Table 5.7 it is evident that although the correlation measures in price differences are slightly lower than those for the price levels (indicating a lower degree of integration), there is still clear evidence of the existence of a strong positive linear relationship between the maize prices in local markets and the ADMARC price in differences.

Since all the six maize prices exhibit a strong linear positive relationship with the ADMARC maize price in both levels and in differences, it was also assumed that local market maize prices have a linear relationship with each other. In order to ascertain this, correlation analysis was also carried for the six local markets. These results are given in Table 5.8.

Table 5.8: Local maize grain market correlation measures

Maize market	Mzuzu	Mzimba	Nsundwe	Lilongwe	Lunzu	Limbe
Levels						
Mzuzu	1.00					
Mzimba	0.96	1.00				
Nsundwe	0.91	0.84	1.00			
Lilongwe	0.94	0.87	0.92	1.00		
Lunzu	0.87	0.81	0.90	0.91	1.00	
Limbe	0.87	0.81	0.96	0.90	0.97	1.00
Differences						
Mzuzu	1.00					
Mzimba	0.95	1.00				
Nsundwe	0.89	0.82	1.00			
Lilongwe	0.94	0.87	0.92	1.00		
Lunzu	0.87	0.80	0.90	0.91	1.00	
Limbe	0.86	0.80	0.95	0.89	0.96	1.00

There is evidence of a strong linear positive relationship between maize grain prices in different local markets within the country. Correlation measures for the price differences are slightly lower than for the price levels, indicating a lower degree of integration. These findings imply that the prices of maize in various local markets in different parts of the country have a tendency to move in the same direction. This finding is expected and can be attributed to the results found earlier, which show that all maize prices in Malawi, regardless of geographical location, are influenced strongly by the ADMARC price.

The influence of geographical effects on maize grain pricing can, however, not be completely ruled out. This is because evidence of the influence of regional differences in maize prices is discernable by looking at the strength of correlation between markets in the same region. This shows that markets such as Mzuzu and Mzimba in the northern region and Lunzu and Limbe in the southern region exhibit nearly perfect correlation, with correlation co-efficient measures of 0.96 and 0.97 respectively. Although positive correlation between markets in different regions exists, it is weaker as compared to the correlation between markets in the same region. This implies that there are intra-regional factors that influence the pricing of maize. These are factors related to regional and local maize supply and demand, the availability of both formal and informal maize markets, and differences in road networks and accessibility which affect local producers' ability to access more lucrative markets. In addition transport costs associated with moving maize grain from rural production areas to urban and peri-urban markets further influences maize prices in local markets that are in urban and peri-urban centres with prices in such markets being higher.

Another key issue that is clear from Figure 5.4 is that maize price volatility in Malawi is influenced by seasonal variations in maize grain stocks. First, in January of every year since 2004, with the exception of 2006, it can be seen that maize prices in all the six local markets are generally high. This can be attributed to the majority of poor smallholder farmers often experiencing food shortages during the month of January, as their maize grain from the previous season gets depleted while the current crop is still in the field. This period, dubbed the "hunger period", is characterised by food shortages which lead to high local market maize prices. Surplus maize producers tend to keep their maize until this period in order to take advantage of the higher maize prices prevailing in local maize markets. The hunger period is further characterised by surplus maize producers milling maize and packaging it into small packets which are sufficient for one or two meals and which cost relatively higher than either maize grain or milled maize at other times of the year. It is mainly rural smallholder farmers who are not food self-sufficient who depend on such milled maize.

Figure 5.4 further shows that maize prices in the six local markets tend to be lower during the month of May. This can be attributed to the availability of maize during the period of the main harvest. This period, the majority of poor smallholder farmers sell their maize in order to meet short-term cash needs (Jayne, *et al.* 2010). As such, they are unable to take advantage of the higher maize prices that prevail during other times in the year when maize grain is scarce.

Another important contributor to maize price volatility in Malawi is unfavourable climatic conditions. As can be seen from Figure 5.5, an analysis of the annual maize prices for the ADMARC market and the Nsundwe market shows that the movement of maize price is associated with erratic weather conditions. Price spikes are observed in the 2001/2002 and

2005/2006 cropping seasons, following droughts that lowered maize production in those seasons.

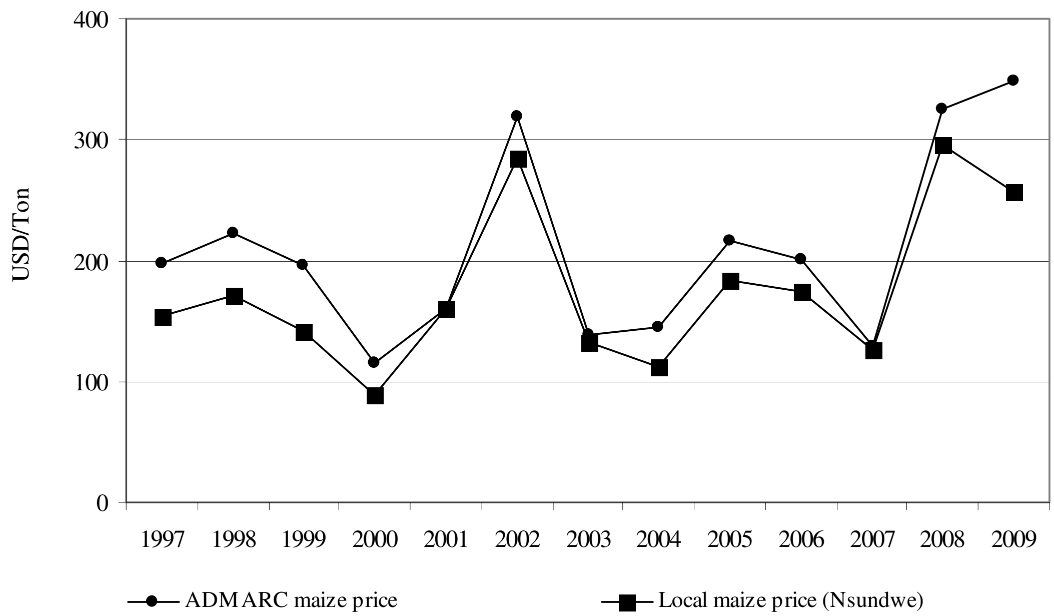

Figure 5-5: Maize price movements over time: 1997-2009

Furthermore, analysis of monthly maize price changes showed that in 2005, monthly maize grain prices in all six markets in Malawi increased greatly; with price increases of 32.2 %, 52 %, 39.4 %, 46.4 % and 44.5 % being observed between May and October of 2005 for the Mzuzu, Nsundwe, Lilongwe, Lunzu and Limbe markets, respectively. These price spikes can be attributed to the drought that affected agricultural production in the 2004/2005 cropping season. The price hike for the 2008/2009 season can be attributed to the government's official maize production estimates being very high in the 2007/2008 cropping season, which led to government exporting maize to other countries in the region. This policy decision caused maize scarcity in the country, hence the higher maize prices (Jayne, *et al.* 2010) in the 2008/2009 season.

In addition, the markets in the central region (Lilongwe and Nsundwe) and in the southern region (Limbe and Lunzu) exhibited maize price monthly increases that were greater than 40 % at the beginning of the 2005/2006 agricultural season. Northern region markets were, however, less volatile and this can be attributed to the majority of smallholder farmers in the northern region of the country being food self-sufficient, as households have more diversified food baskets with households consuming other staple food crops such as rice and cassava. This is in contrast to other parts of the country, especially the Southern Region where the majority of households are unable to meet their subsistence food requirements and hence depend largely on the market. Additionally the Southern Region is densely populated with households cultivating on much smaller pieces of farm land (NSO, 2008b) and some parts are highly prone to annual droughts and flooding (IFPRI, 2009). As a result of these differences, the food security situation in the northern part of the country is often more favourable than in the southern region (FEWSNET, 2010).

5.3.2.2 Parity price analysis

To further understand the Malawi maize market and to assess the incentives for maize production in the country, an import and export parity price analysis was carried out, with the South African white maize price being taken as the 'world price' or the reference price of maize for Malawi. The import parity price for maize in Lilongwe was calculated as the price of white maize in South Africa (Gauteng) plus transport costs, insurance and tariffs. Figure 5.6 presents a comparison of the wholesale ADMARC maize price, import parity price, export parity price and the volumes of maize imports from 1988 to 2009. As can be seen in the figure, between 1988/1989 and 2008/2009, ADMARC maize prices were more often either above or approximated import parity price. Very high differences between the ADMARC wholesale price and the import parity price were observed in the 1992/1993, 1997/1998, 2001/2002 and 2007/2008 agricultural seasons, with the first three seasons being years in which the country was hit by droughts. The higher price for the 2007/2008 agricultural season cannot, however, be explained by climatic factors, as government maize production data indicate that this was a good harvest year (Jayne, *et al.* 2010).

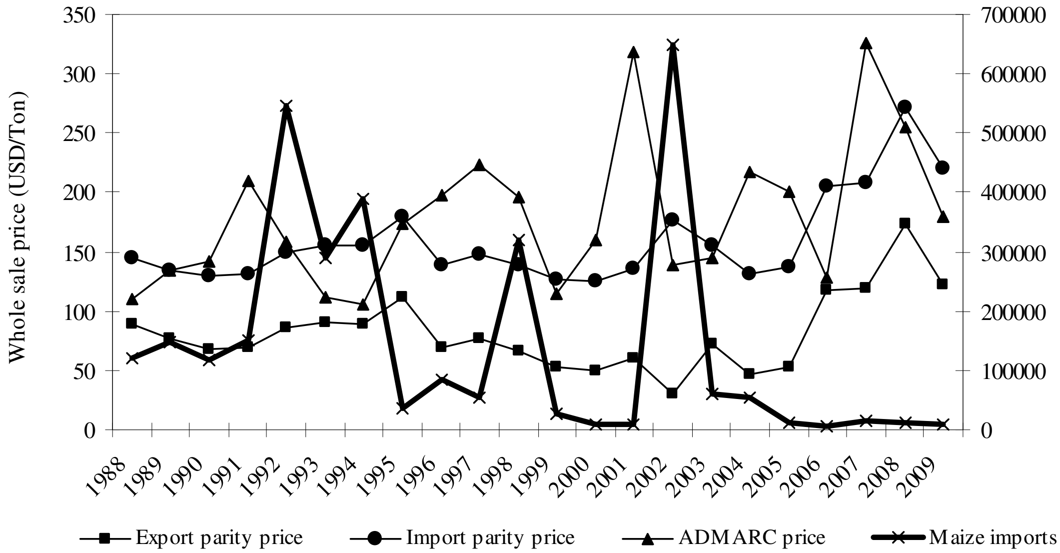

Figure 5-6: Import and export parity price analysis

Further observation shows that, apart from the years in which the country was hit by drought, Malawi maize imports are generally non-responsive to changing domestic prices. In theory, when wholesale domestic prices are higher than import parity price, it provides incentives for traders to import goods into a country, as the imported good is cheaper than a locally-produced good (FEWSNET, 2008). From the observation above, it can be seen that despite the ADMARC price being above or approximating import parity price, imports were not responsive. This is expected as government is the sole importer of maize. It is only in the 1992/1993 and 2002/2003 cropping seasons in which high maize prices are positively correlated with maize imports. These are both years of extreme droughts in which Malawi experienced severe food shortages. In these years, it can also be observed that there is a lag between high maize prices and large maize imports which shows the delays in response by government. For the 2007/2008 season, it can also be seen that the domestic wholesale price for ADMARC maize was much higher than the import parity price (as high as price differentials observed for both the 1992/1993 and 2002/2003 cropping seasons). However, in this season, maize exports remained low and non-responsive. As stated earlier, this is attributed to the government's official maize production estimates being very high in the 2007/2008 cropping season, which led to government exporting maize to other countries in the region.

There are several issues that arise from these observations. First, government policy and government's perception of the domestic food security situation of the country determine to a large extent imports. This is clearly evidenced by government importing large volumes of maize in the 1992/1993 and 2002/2003 cropping seasons as opposed to the 2007/2008 season. Government viewed the first two seasons as years of maize scarcity; while the latter agricultural season, although exhibiting equally high maize prices, was not deemed an emergency. As a result of this, maize imports in Malawi are non-responsive to price changes and it is clear that government regulates maize trade and pricing in the country. Further, these observations imply that the Malawi maize market is not well integrated with regional maize markets. Hence, with the exception of years of very low food production, domestic maize prices in Malawi are unlikely to be impacted upon by regional maize price changes.

These findings concur with the statistical analysis carried out earlier which showed that there is no evidence of co-movement between local maize markets in Malawi and regional markets. The ADMARC price, however, exhibited a weak linear relationship with the SAFEX maize price. Hence, it is plausible to postulate that the world price of maize (SAFEX) has a weak but inconsistent influence on the ADMARC maize price. This is especially the case in years of droughts and in years of food shortages. Since the majority of maize imported into Malawi is from South Africa (Dana, *et al.* 2006), in years of droughts and food shortages (1992/1993, 1998/1999 and 2002/2003), the SAFEX white maize price has a stabilising effect on the domestic maize price, because as imports reach the country, they reduce the gap between supply and demand and hence lead to a lowering of the domestic price.

5.3.3 Modelling of national and local maize prices

The statistical and parity price analysis carried out above has provided an insight into the relationship between domestic and regional maize prices as well as between national and local-level maize prices in the country. Using this understanding of economic theory and empirical evidence, it becomes possible to develop quantitative single equations for modelling maize prices at both the local and national levels, which will feed into the partial equilibrium model for maize that this chapter aims to develop. This section provides an overview of the methodology used to validate each estimated equation, the exogenous variables in each model as well as the actual estimated equations. Correlation matrices for all equations presented in this chapter can be found in Appendix 4.

5.3.3.1 Model validation

The estimated equations were validated using a combination of statistical methods. Validation is the most important step in model building, as it ascertains the predictive ability of the estimated model (Snee, 1977). There are three main statistical methods for evaluating the goodness of fit of a model. These are the corrected R-Square statistic, the overall F-test and the Root Mean Square Error (RMSE). For robustness, this study employed all three statistical quantitative techniques to test the goodness of fit of the estimated regression equations.

The corrected R-Square ($\overline{R^2}$) statistic is the proportional improvement in the prediction from the regression model compared to the mean and it measures the percentage in the dependant variable as explained by the estimated equation (Gujarati, 1992). As such, it indicates the goodness of fit of the model. The corrected R-Square statistic has been chosen for use as opposed to the R-Square statistic, as the former is concerned with the explained and unexplained variances in the dependant variable and thus accounts for the number of degrees of freedom. In this way, the corrected R-Square statistic is able to indicate the goodness of fit of an estimated equation without regard to the number of independent variables that have been included in the model (Pindyck & Rubinfeld, 1991).

Whereas the R-Square statistic indicates the relative fit, the RMSE indicates the absolute fit of the model to the actual data and it is derived from the square root of the variance of the residuals. The RMSE is the most important and frequently-used criteria for measuring goodness of fit of a model if the main objective of modelling is for simulation purposes (Ferris, 1998), as it measures the deviation of the estimated variable from its true path. The RMSE has also been chosen as the main statistical test for model validation in this study, as it is able to overcome the conflicting interests of model interpretability and goodness of fit. The RMSE is able to do this as 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 & 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 & Cudeck, 1992). The F-Statistic was used to test the overall goodness of fit of the estimated equations in order to test for significance of the estimated equations and the ability of all the independent variables to effectively predict the dependant variable.

5.3.3.2 Equation for the ADMARC maize price

The national producer price of maize (ADMARC) was modelled (Equation 5.1) as an endogenous variable that is dependent upon a set of exogenous variables. These variables consist of the import parity price of maize; the ratio of domestic maize production to domestic maize consumption; a dummy variable capturing the further liberalization of the ADMARC (see Appendix 5 for historical basis); and a dummy variable capturing direct government price policies. The dummy variables have been included as they capture the effects of government policy instruments on the pricing of maize in the country.

$$ADMARC = f(IPP, PROD / CONS, DUM : INT, DUM : LIB) \qquad (5.1)$$

Where:

IPP Import parity price in USD/ton (SAFEX maize price)

$PROD / CONS$ Ratio of maize production to maize consumption

$DUM : INT$ Dummy variable: Government price policy interventions (0/1)

$DUM : LIB$ Dummy variable: Reforms in maize marketing (0/1)

The empirical estimation of the ADMARC maize price is presented in Table 5.9.

Table 5.9: Equation for the ADMARC maize price

	ADMARC maize price (USD/ton)		
	Parameter	**t-value**	**Elasticity**
Intercept	179.20	5.319***	
IPP	0.23	2.39	0.26
Prod/Con	-22.01	-2.181*	-0.12
DUM:LIB	-71.56	-3.765**	
DUM:INT	137.23	2.241	
$\overline{R}^2$ *=0.503*	*DW = 1.963*	*RMSE=0.035*	*F-value=6.058***

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the ADMARC maize price had a corrected R-Square statistic of 0.503, implying that at least 50.3 % of the total variation in the ADMARC price is captured by the estimated model. Furthermore, the estimated ADMARC maize price equation had an RMSE that was not far from zero (0.035) and an F-value of 6.058 that was statistically significant at the 5 % level of confidence, implying that the estimated model as a whole is capable of effectively capturing changes in the actual ADMARC maize price.

Results of the estimated equation showed that the dummy variable capturing the liberalization of maize marketing in Malawi (ADMARC_LIB) was statistically significant at the 5 % level of confidence in negatively influencing the ADMARC maize price. This implies that the liberalization of government marketing board (ADMARC) led to a reduction in the ADMARC maize prices. This can be attributed to the type of liberalization which took place in Malawi which mainly involves the reduction of the trading operations of ADMARC in order to allow for the growth of the private sector and to improve the efficiency of the parastatal (Jayne, *et al.* 2008). The liberalization allowed ADMARC to be more efficient and to lower the price at which it sold maize. Additionally due to the closure of ADMARC satellite deports throughout the county; there was an increase in private traders in local rural economies. Due to the lack of regulation, information asymmetries and isolation of many rural households; private traders offered a price that was below the ADMARC maize price. Hence the majority of smallholder producers received lower prices than the ADMARC maize price as a result of the liberalization of ADMARC.

In addition the ratio of production to consumption was statistically significant at the 10% level of confidence in negatively influencing the ADMARC maize price. This implies that increases in the ratio of maize production to consumption would lead to lower maize prices as maize supply would be greater than domestic demand. This finding is in line with existing theoretical and empirical evidence which stipulates that the ratio of production to consumption is key to changes in prices of food commodities with an increasing ratio leading to a reduction in food prices; while a decreasing ratio contributing to increased food prices (Pinstrup-Andersen, *et al*. 1999).

In terms of elasticities, it can be seen that the ADMARC maize price is inelastic, with a 10 % increase in the ratio of domestic maize production to domestic maize consumption leading to a 1.2 % decrease in the ADMARC price. In addition, a price transmission elasticity of less than one is observed (0.26). However, this is expected as it was demonstrated earlier that there is low price transmission between the ADMARC maize price and world maize prices. This is the case despite economic theory stipulating that world prices are frequently the main source of variation in domestic prices (Baffer & Garner, 2003). The findings of this study are, however, feasible, as empirical evidence has demonstrated that agricultural markets differ from other types of markets in that there is often little or no transmission of international prices to domestic agricultural markets (Baffer & Garner, 2003; Fafchamps, *et al.* 2003).

In conclusion, the equation of the ADMARC maize price shows that the ADMARC price is influenced to some extent by the world price of maize and the local supply and demand dynamics. In addition, government policies in the form of direct price interventions and institutional reforms of the maize marketing boards in the country are also key contributors towards variability of the national maize price. This equation essentially stipulates that maize markets are to a large extent affected by government control. This finding is in agreement with the empirical results (statistical and parity price analysis) from earlier in this chapter which demonstrated that government policy is one of the main drivers of the ADMARC maize price and maize trade in general.

5.3.3.3 Equation for local maize price (Nsundwe)

The equation for the local price of maize (Nsundwe) was estimated as an endogenous variable that is dependent upon a set of exogenous variables which included the ADMARC maize price; total maize consumption for Ukwe Extension Planning Area (EPA) where Nsundwe market and the rural communities under study are located; a dummy variable capturing the effects of the 2001/2002 drought; and a dummy variable capturing the effects of over-inflated crop estimates for Ukwe EPA for several years (1989-1991, 1993-1996, 1999, 2007).

$$PPMZ_{loc} = f(ADMARC, DUM02, LCON, DUM:UKWE) \quad (5.2)$$

Where:

$ADMARC$	ADMARC maize price (USD/ton)
$DUM02$	Dummy variable capturing effects of the 2001/2002 drought (0/1)
$LCON$	Total estimated local maize consumption for Ukwe EPA (thousand tons)
$DUM:UKWE$	Dummy variable capturing the effects of overestimated crop estimates for Ukwe EPA

The empirical estimation of the local maize price is presented in Table 5.10.

Table 5.10: Equation for the local maize price (Nsundwe)

	Local maize price (USD/ton)		
	Parameter	**t-value**	**Elasticity**
Intercept	141.59	2.18	
ADMARC	0.10	2.06**	0.91
DUM02	97.48	5.02	
LCON	-0.012	-9.52	-0.01
DUM:UKWE	-45.68	-4.73	

$\overline{R}^2$ *= 0.630 DW =1.98 RMSE= 0.048 F-value=52.813****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated model for the local price of maize in the Nsundwe market had a corrected R-Square statistic of 0.630. This implies that at least 63 % of the total variation in the local maize price had been captured by the estimated equation. In addition, the equation had an RMSE that was not far from zero (0.048) and an F-value of 52.813 that was highly statistically significant. This implies that overall; the estimated equation effectively captures actual local maize prices in Nsundwe market.

The results in Table 5.10 suggest that local maize prices are inelastic with respect to either the ADMARC maize price or the level of maize consumption in the area. However, local maize prices are generally more sensitive to the ADMRC price than to local maize consumption. This is because a 10 % increase in the ADMARC maize price would lead to a 9.1 % increase in local maize price in the Nsundwe market. These findings are in line with the Granger causality tests and the correlation tests carried out earlier in this chapter, which demonstrated that there is a one-way causality between the ADMARC maize price and the Nsundwe maize market price; with the ADMARC price greatly influencing the Nsundwe maize market price. Further, the correlation measures showed that there is a high degree of correlation between the ADMARC maize price and the Nsundwe maize price, with more than 90 % of the total variation in the different local markets (including Nsundwe) being attributable to the ADMARC price. The statistical results of the estimated model also concur with these findings, as they show that the ADMARC price of maize is statistically significant in positively influencing the local maize price in the Nsundwe market at the 5 % level of confidence.

In addition, a 10 % increase in local maize consumption in Ukwe EPA would lead to a 0.1 % decrease in the local maize price in the Nsundwe market. This effect is basically the result of household maize consumption in rural areas of Malawi being mainly dependent upon own production (Equation 5.10). As such, increases in household consumption are mainly the result of higher own production, implying lesser demand from the market and therefore a lowering of market prices. However, as is seen here, this effect is very weak as there are always households in the rural areas of Malawi that depend on the market to supplement their subsistence maize requirements. This finding is generally plausible as empirical evidence has shown that changes in staple food prices are the result of the interaction and a combination of various factors that include changes in consumption (Dorélien, 2008; Southgate, 2009).

In general, the equation for the local price of maize shows that there is high price transmission between the local maize price in the Nsundwe market and the ADMARC maize price; and variability in the Nsundwe maize market price can be explained mainly by changes in the ADMARC maize price.

5.4 MODEL SPECIFICATION, ESTIMATION AND VALIDATION

This section provides a description of the partial equilibrium model that was developed for the maize market in Malawi. The model is based on economic theory and an understanding of the economic and production dynamics of the maize sub-sector, as revealed by the price discovery analysis provided earlier in this chapter and from literature. A summary of the model is provided in Figure 5.8.

The Malawi maize model is a multi-equation partial equilibrium model that is recursive in nature and consists of the national maize market and the local economy maize market. At the national level, the maize market has four blocks consisting of domestic supply, domestic demand, prices, and the model closure which encompasses the trade block. The different blocks are made up of both exogenous and endogenous single equations. The local economy block can be considered as being "exogenous" to the national maize market; however, it is linked to it via a price-linkage equation with the ADMARC maize price. Despite the local economy block being "exogenous" to the national maize market, it also consists of both exogenous and endogenous single equations. The following sections describe each block of the model providing the results of the estimated equation, the validation of the equations, as well as the statistical and economic interpretation of the results. The last section provides a description of the feedback effects within the model and the linkages of the household to the local economy and the national maize market. The price blocks are not described here, as these have been described earlier in this chapter (Section 5.3.3).

It should be noted that the estimation of maize production and supply functions is based on both economic theory and understanding of the maize-based farming system in Malawi, which is characterised by farmers who are both producers and consumers of maize and hence are affected by both demand and supply-side dynamics. Another key issue is that the majority of farmers within the maize-based farming system in the country do not substitute maize with any other crops. This has two implications. First, 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 upwards; thus reducing the magnitude of significance of the estimated coefficients (Fuglie, *et al.* 2002). However, this is a reasonable trade-off so long as the estimated equations reasonably reflect the real maize-based farming system in Malawi. As such, it is expected that all estimated demand and supply-related equations will exhibit price inelasticity, as this is a sign that the commodity under analysis has no close substitutes (Tewari & Singh, 1996). Second, in the absence of substitutes, the symmetry matrices cannot be estimated as there are no cross-price elasticities.

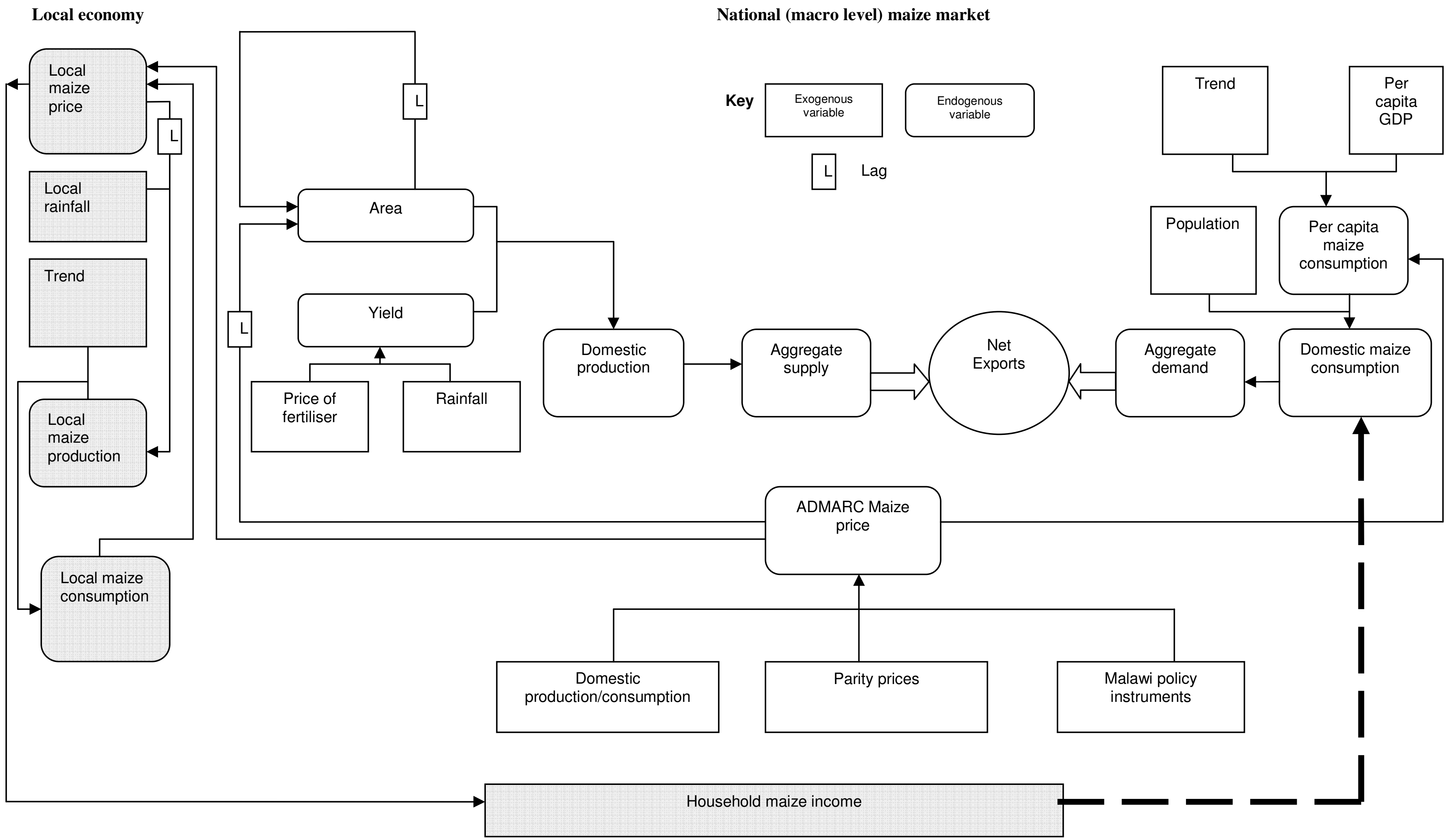

Figure 5-7 Structure of the Malawi maize model

5.4.1 The domestic supply block

Total domestic maize supply is the sum of domestic production and lagged ending stocks (beginning stocks). Domestic maize production was calculated as an identity of total area planted multiplied by the total yield. Domestic production can be represented as follows:

$$DPROD = area * yield \qquad (5.3)$$

Where:

$DPROD$	Domestic production of maize (thousand tons)
$area$	Area of maize planted used as proxy for area harvested (thousand hectares)
$yield$	Yield of maize per unit area (tons per hectare)

The area of maize was modelled (Equation 5.4) as a partial adjustment function of the lagged ADMARC maize price; the lagged area of maize planted; and a dummy variable capturing the years in which the Ministry of Agriculture recruited new staff after a ten-year period of non-recruitment combined with a retraining of all field level extension agents (1991-1994, 1996, 1998, 2002, 2006). The equation is given below:

$$\text{area} = f(ADMARC_{t-1}, area_{t-i}, DUM:agri) \qquad (5.4)$$

Where:

$ADMARC_{t-1}$	Lagged price of maize in ADMARC markets (USD/ton)
$area_{t-i}$	Lagged area of maize planted (thousand hectares)
$DUM:agri$	Dummy variable: Public recruitment and extension service retraining (0/1)

Frequently, area harvested is modelled as a partial adjustment function with the current maize prices and the prices of other crops (Agcaoili & Rosegrant, 1995). For maize production in Malawi, the price of substitutes has not been included in the model, as 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 and, as such, they do not substitute maize for other crops regardless of the price. The lagged ADMARC maize prices have been used as opposed to current maize price, as Malawi does not have a futures market; hence, prices are announced at the end of the cropping season. As a result of this, farm production decisions are based on the prices from past seasons.

The empirical estimation of the equation for area of maize planted is presented in Table 5.11.

Table 5.11: Equation for area of maize planted

	Area of maize planted (hectares)		
	Parameter	t-value	Elasticity
Intercept	1802.2	1.550	
$ADMARC_{t-1}$	0.006	0.075	0.013
$area_{t-1}$	0.653	2.978**	0.021
DUM:agri	104.59	0.506***	

$\overline{R^2}$ =0.678 *DW =1.98* *RMSE=0.043* *F-value=7.901***

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the area of maize planted has a corrected R-Square statistic of 0.678. This implies that at least 67.8 % of the total variation in the area of maize harvested in Malawi has been captured by the estimated equation. In addition, the estimated equation is a good estimate of actual area of maize planted, as it has an RMSE that is not far removed from zero (0.043) and overall model F-value of 7.901 which is statistically significant at the 5 % level of confidence. This implies that the model as a whole is able to significantly explain the variation in the area of maize harvested.

An analysis of the estimated parameters indicates that the lagged area of maize planted and the dummy variable capturing government recruiting and training of existing field level extension agents were both found to be statistically significantly in positively influencing the area of maize planted at the 10 % and 1 % significant levels respectively. These findings imply firstly that government efforts to improve the agricultural extension service system in the country led to increases in the acreage of maize that was harvested. It is possible that in years without this government program, farmers might have planted the same area of land but harvested less due to the lack of proper agricultural advisory services. Furthermore one key criterion for training a field extension agent was their performance. Hence it is possible that field extension officers had greater motivation in the years in which this program was in place to work harder so as to be selected for the training program. Secondly the positive significant result for the lagged area of maize planted variable implies that the area of land that farmers planted in a past season will influence the area that is cultivated in next season. This is especially the case for Malawi as farmers have very small land holding sizes with little or no prospects for acquiring additional land or for expanding their cultivation.

In terms of elasticities, it is clear that the area of maize planted is inelastic in terms of the lagged price of maize and the lagged area planted. The lagged ADMARC price has an elasticity of 0.013, implying that a 10 % increase in the lagged ADMARC price would lead to an increase of 0.13 % in the area allocated to maize. The lagged area of maize planted has an elasticity of 0.021, implying that a 10% increase in the lagged area of maize planted would lead to a 0.21 % increase in the area of maize planted. These findings are not surprising. Firstly, the inelasticity of the area of maize planted to the ADMARC maize price arises because the majority of smallholder farmers are not influenced by market signals, as the majority produce for own consumption, and hence decisions to plant depend largely on the assessment of subsistence requirements. The inelasticity of the area planted to the lagged area of maize planted is also not surprising, because it has been well documented that the majority of rural farming households in Malawi have insufficient land for their own cultivation. As such, there is repeated cultivation on the same piece of land (Kanyama-Phiri, 2008) with small increases in area planted or harvested over time; possibly arising from cultivation by land constrained households on marginal land and small increases in cultivation of maize by the estate sector.

Maize yield was modelled (Equation 5.5) as a function of rainfall; the retail price of inorganic fertiliser (unsubsidized price of fertilizer), a shift variable capturing the change in the input fertilizer subsidy program from a targeted input program to a full fertilizer subsidy program; and a dummy variable capturing the effects of changes in government legislature pertaining to support and development of small-scale maize irrigation schemes in the country (DUM:agr2).

$$\text{yield} = f(\text{rainfall}, PFERT, DUM: agri2, \text{Shift06}) \qquad (5.5)$$

Where:

rainfall	Average rainfall in Malawi (mm)
$PFERT$	Price of fertiliser in the country (USD/ton)
$DUM: agri2$	Dummy variable: small scale irrigation scheme legislation (0/1)
Shift06	Shift to a full fertilizer subsidy program (0/1)

Typically, yield functions are estimated as a function of past yields in combination with other variables (Agcaoili & Rosegrant, 1995). Lagged yields were, however, not included in this study, as 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).

The empirical estimation for the yield of maize is represented in Table 5.12.

Table 5.12: Equation for yield of maize

	Yield of maize (Tons/hectare)		
	Parameter	**t-value**	**Elasticity**
Intercept	0.010	1.194	
Rainfall	0.002	5.749***	1.80
PFERT	-0.003	-1.759*	-0.52
Shift 06	0.5	2.621*	
DUM:agri2	-0.05	-3.831**	

$\overline{R^2}$ *=0.789* *DW =2.23* *RMSE=0.013* *F-value=20.67****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the yield of maize has a corrected R-Square statistic of 0.789 implying that at least 78.9 % of the total variation in the yields of maize in Malawi is captured by the estimated model. In addition, the estimated equation is a good estimate of actual maize yields in the country, as it has an RMSE that is not far removed from zero (0.013) and it has an F-value of 20.67 that is highly statistically significant. This implies that the estimated model as a whole is significant in effectively explaining the variation in yields of maize in Malawi.

Rainfall was found to be highly statistically significant in positively influencing maize yields. This implies that an increase in rainfall would lead to an increase in the yields of maize. This finding concurs with the elasticity of rainfall which shows that maize yields in Malawi are elastic with respect to rainfall with rainfall having an elasticity of 1.80. Thus a 10 % change in rainfall in a given season would lead to an 18 % increase in maize yields. Given these findings, it is not surprising to find that the reforms in smallholder maize irrigation were found to be statistically significant in negatively influencing maize yields at the 5 % level of confidence. This finding further shows that water availability is a key factor influencing maize yields in the country. This is because in many instances, irrigation schemes that were left to smallholders become less efficient and in many cases communities were unable to maintain irrigation schemes due to high maintenance and the lack of proper managerial skills.

Yields are, however, inelastic with regards to the retail price of inorganic fertiliser. The yields decreased by 5.2 % as a result of a 10 % increase in the retail price of inorganic fertiliser. The negative relationship between price of fertilizer and yields is expected because an increase in the retail price of inorganic fertiliser would lead to a reduction in the yield of maize. This is further seen with the retail price of fertilizer being statistically significant at the 10 % level of confidence in negatively affecting maize yields. In practice, this arises because smallholders do not have sufficient cash at the beginning of the cropping season when inorganic fertiliser is readily available. As such, any increases in the price of inorganic fertiliser entails that smallholder farmers buy insufficient amounts of fertiliser, which they apply sparingly either to a large piece of farm land or which they apply to a smaller fraction of their farm. Both methods reduce the yields per unit area.

Furthermore, the results show that the shift in the input support program towards a full input fertilizer subsidy program in the 2005/06 season was also statistically significant at the 10 % level of confidence in positively influencing maize yields.

Beginning stocks were derived (Equation 5.6) as an identity and they were equal to the lagged ending stocks.

$$BSTOCK = ESTOCK_{t-1} \qquad (5.6)$$

Where:

$BSTOCK$	Beginning stock (thousand tons)
$ESTOCK_{t-1}$	Lagged ending stock (thousand tons)

5.4.2 The domestic demand block

The demand for a commodity is a function of its own price, the price of substitutes and complements, and per capita income (Ferris, 1998). Domestic maize demand in Malawi is mainly composed of domestic human consumption, with some maize going towards seed and feed or industrial use and ending stock. Data for seed/feed and industrial use in Malawi is unreliable and difficult to obtain. Therefore, total domestic maize demand was taken as a function of domestic consumption, and endings stock with seed/feed and industrial use were taken as exogenous and incorporated in the mathematical calculation of aggregate domestic demand. Therefore, domestic maize consumption (domestic human demand) was estimated as an identify that is equal to per capita maize consumption multiplied by the population (Equation 5.7):

$$DCONS = PCC * POP \qquad (5.7)$$

Where:

DCONS	Domestic maize consumption (thousand tons)
PCC	Per capita maize consumption (tons/capita)
POP	Total Malawi population (millions)

Per capita maize consumption was modelled (Equation 5.8) as a function of a trend variable capturing changing food baskets over time; the ADMARC price of maize; real per capita GDP; a dummy variable capturing the effects of years of emergency food relief (1992, 1997, 1998, 2002) and a dummy variable capturing a government policy which allowed the export of large amounts of maize out of the country based on extremely high production estimates.

$$PCC = f(ADMARC, trend, rPGDP, DUM : relief, \text{Policy} : XP) \qquad (5.8)$$

Where:

ADMARC	Price of maize in ADMARC markets (USD/ton)
trend	Trend variable: 1988= 0 and 2015=29
rPGDP	Real per capita GDP (USD/capita)
DUM : *relief*	Emergency food relief years
Policy : *XP*	Policy to exports large volumes of maize (0/1)

The empirical estimation for per capita maize consumption is represented in Table 5.13:

Table 5.13: Equation for per capita maize consumption

	Per capita maize consumption (kg/capita)		
	Parameter	**t-value**	**Elasticity**
Intercept	110.881	1.583	
ADMARC	-0.201	-3.074**	-0.233
Trend	-0.015	-3.228**	-0.001
rPGDP	0.395	3.487**	0.474
DUM:relief	14.20	3.955**	
Policy:XP	-18.00	-2.961*	
$\overline{R^2}$ =0.897	*DW =1.59*	*RMSE=0.028*	*F-value=35.874****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for per capita maize consumption has a corrected R-Square statistic of 0.897, implying that at least 89.7 % of the total variation in per capita maize consumption is captured by the estimated equation. In addition, the model has an RMSE that was not far from zero (0.028) and an F-value of 35.874 that was highly statistically significant, implying that as a whole, the estimated equation effectively and significantly approximates actual per capita maize consumption in Malawi.

Analysis of the estimated parameters shows that first the ADMARC maize price, the trend variable capturing changing food baskets over time and the policy allowing large volumes of maize exports from the country were statistically significant in negatively affecting per capita maize consumption in the country. The ADMARC maize price and the trend variable were negatively significant at the 5 % level of confidence while the policy of allowing exports was negatively significant at the 10 % level of confidence.

The implications of these findings are three fold. As the ADMARC price increases, per capita consumption of maize decreases as individuals are less able to afford the staple food crop. This effect however is small as demonstrated by the elasticity of price of -0.233 which implies that a 10 % increase in the ADMARC price would lead to a 2.33 % decrease in maize consumption per capita. Thus in general per capita maize consumption is inelastic with respect to price. Second in terms of the trend variable, which was included to capture changes in food baskets over time, the finding is in line with *a priori* expectations; as over time, changes in the economic and social structure of a country are expected to lead to changing food and dietary preferences, with individuals moving away from diets dominated by grains to diets dominated by dairy and animal protein. The effect of the trend variable is small, which was expected as the composition of food baskets in Malawi is fairly constant. The elasticity for the trend variable, of -0.001, implies that with each year, per capita maize consumption decreases by 0.001 %. The elasticity is small because the majority (85 %) of the Malawi population is rural (Kanyama-Phiri, 2008) and rural populations have constant food baskets, with maize being the main staple. Hence, the decreasing trend being captured at the national level is more a reflection of changes in the diets of urban consumers who are relatively small in number. Third, the findings pertaining to the policy of allowing large volumes of exports imply that ill devised policy strategies can negatively and significantly affect the consumption patterns of households in the country. This is because the policy to export maize was based on over inflated maize production estimates. In the years in which it was implemented this policy led to maize shortages within the country.

The results further show that real per capita GDP and the dummy variable capturing years of high food relief aid were both statistically significant in positively influencing per capita maize consumption at the 5 % level of confidence. This implies that as income increases, there is an increase in per capita maize consumption. These results also show that maize is a normal good, as its consumption increases with rising income. Furthermore, the results show that maize is a necessity good in Malawi, as the income elasticity is less than one at 0.474. This implies that if there is a 10 % increase in per capita GDP, then the per capita consumption of maize will rise by 4.74 %. The implications are that as per capita incomes rise, households will increase their consumption of maize, but at a slow pace. This is because maize is the staple food crop and often staple food consumption is inelastic with respect to income. For the dummy variable, the implications are that in years in which food relief aid was high, it had the effect of positively affecting per capita consumption.

In general, the estimated equation for per capita maize consumption is a demonstration that the consumption of maize in Malawi is generally unresponsive to rising food prices or increasing per capita incomes over time. Per capita maize consumption therefore generally remains stable. This concurs with economic theory and other empirical evidence which shows that staple food consumption is highly price inelastic (Jayne, *et al.* 2009), with the poorest households forgoing other goods and services in the face of rising food prices, in order to buy maize at the higher prices (Chirwa, 2010).

The modelling of ending stocks followed Gallagher's approach (1981), as cited by Poonyth *et al.* (2000), as they were modelled (Equation 5.9) as a function of beginning stocks (lagged ending stock), maize production and the prevailing price of maize in ADMARC markets.

$$ESTOCK = f(BSTOCK, DPROD, ADMARC) \quad (5.9)$$

Where:

ESTOCK	Ending stock (thousand tons)
BSTOCK	Beginning stocks (thousand tons)
DPROD	Total domestic maize production (thousand tons)
ADMARC	Price of maize in ADMARC markets (USD/ton)

The empirical estimation for the ending stocks is represented in Table 5.14:

Table 5.14: Equation for ending stock

	Ending stock (1000 tons)		
	Parameter	t-value	Elasticity
Intercept	0.017	2.095*	
BSTOCK	0.41	2.760*	0.50
PROD	0.001	3.683**	0.67
ADMARC	-0.002	-2.400	-0.18
$\overline{R}^2$ =0.727	*DW =2.15*	*RMSE= 0.062*	*F-value=15.062****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for ending stocks had a corrected R-Square statistic of 0.727, implying that at least 72.7 % of the total variation in the ending stocks was captured by the estimated model. In addition, the model had an RMSE that was not far from zero (0.062) and an F-value of 15.062 which was highly statistically significant, implying that overall, the estimated equation for beginning stocks was able to explain variations in ending stocks in Malawi.

Analysis of the parameter estimates shows that the beginning stock (lagged ending stocks) and domestic maize production were statistically significant in positively influencing ending stocks at the 10 % and 5 % confidence levels respectively; thus implying that an increase in the beginning stocks and an increase in domestic production would lead to an increase in the ending stock.

The elasticities show that the ending stocks are relatively inelastic with regards to the ADMARC maize price; with the ending stocks decreasing by 1.8 %, with a 10 % decrease in the ADMARC maize price. Ending stocks are also fairly inelastic with regards to the beginning stock, with the ending stock increasing by 5.0 % as a result of a 10 % increase in the beginning stock or the lagged ending stock. It is mainly with regards to domestic maize production that the ending stocks show slight sensitivity, with the ending stocks increasing by 6.7 % as a result of a 10 % increase in the domestic maize production. In general, ending stocks in the country are driven by production, implying that seasons in which domestic production has been high lead to larger ending stocks.

5.4.3 The local maize economy

Apart from the endogenous blocks of the maize market (supply, demand, prices and the closure), the Malawi maize model further consists of a block that represents maize markets in rural local economies. These rural local economies have thriving maize markets that are influenced by the ADMARC maize price; as demonstrated earlier in this chapter by the results of the Johansen co-integration test and the Granger causality tests. In this model, the local rural maize market economy under study (Ukwe EPA) was linked to the national maize market via a price-linkage equation with the ADMARC maize price (Equation 5.1).

Local maize consumption was modelled (Equation 5.10) as a function of local maize production; the price of maize in the nearest local market and a dummy variable capturing the years (1995-2002) in which the main bridge on the largest paved road leading to Ukwe EPA was unusable. A household income variable has not been included in the model; although it is known to influence staple food consumption patterns in semi-subsistence communities such as those that are commonly found in Malawi. This is because data on local household income from Ukwe EPA is discontinuous and the method of estimating household incomes in the study area has not been standardised and, as such, differs from year to year. In view of this, the variable for household income was excluded from the model. The maize production variables however caters for the household income variable as maize often accounts for the largest share of household income in rural household income estimations especially for households who do not have lucrative commercial enterprises or large ownership of livestock.

$$CONS_{local} = f(MZ\_PROD, PPMZ_{nsundwe}, DUM:Brdg) \qquad (5.10)$$

Where:

MZ_PROD	Maize production in Ukwe EPA (tons)
$PPMZ_{nsundwe}$	Price of maize in the Nsundwe market in Ukwe EPA (USD/ton)
$DUM:Brdg$	Dummy variable: main bridge unusable (0/1)

The empirical estimation for the equation of local maize consumption is represented in Table 5.15.

Table 5.15: Equation for local maize consumption

	Local maize consumption (1000 tons)		
	Parameter	**t-value**	**Elasticity**
Intercept	95.8	118.76***	
MZ_PROD	0.18	2.668	0.04
$PPMZ_{nsundwe}$	-0.01	-2.904	-0.01
DUM:Brdg	-7.2	-17.403***	
$\bar{R}^2$ = 0.942	DW =1.80	RMSE= 0.004	F-value=108.998***

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for local maize consumption had a corrected R-Square statistic of 0.942, implying that at least 94.2 % of the total variation in the local maize consumption was captured by the estimated equation. In addition, the equation had an RMSE that was not far from zero (0.004) and an F-value of 108.998 which was highly statistically significant, implying that the estimated equation as a whole is able to effectively explain the variation of local maize consumption for Ukwe EPA.

The dummy variable capturing the years in which the bridge on the main paved road to Ukwe EPA was impassable was found to be highly statistically significant in reducing local maize consumption. This implies that households in the study area, although producing for their own subsistence food requirements, also rely on maize that comes into the area from other areas. Further analysis shows that in general local maize consumption is inelastic with respect to either production or its own price. This is because a 10 % increase in the local production of maize would lead to a 0.4 % increase in local maize consumption. While a 10% increase in the local market prices would lead to a 0.1 % decrease in local maize consumption. Both the elasticities for price and for production are very small, signifying that local maize consumption is generally unresponsive to either production or market signals.

Local maize production was modelled (Equation 5.11) as a function of rainfall received in the study area; the lagged maize price in the Nsundwe market; and a dummy variable capturing the years in which Ukwe EPA experienced natural disasters ranging from alternating floods with long dry spells and locusts**.** The yield and the acreage of maize planted/harvested were not included in the model for local maize production; as the available data for Ukwe EPA for these variables was highly inconsistent and discontinuous and therefore unreliable.

$$MZ\_PROD_{loc} = f(\text{rainfall}_{\text{loc}}, PPMZ_{nsundwe_{t-1}}, DUM:ukwe2) \qquad (5.11)$$

Where:

$\text{rainfall}_{\text{loc}}$	Average rainfall in Ukwe EPA (mm)
$PPMZ_{nsundwe_{t-1}}$	Price of maize in the Nsundwe market in Ukwe EPA (USD/ton)
$DUM:ukwe2$	Dummy variable: years with concurrent natural disasters (floods, long dry spells, locusts) (0/)

The empirical estimation for the local maize production is represented in Table 5.16.

Table 5.16: Equation for local maize production

	Local maize production (1000 tons)		
	Parameter	t-value	Elasticity
Intercept	7.3	2.269	
$Rainfall_{loc}$	0.008	5.372***	0.604
$PPMZ_{nsundwet-1}$	0.001	2.010	0.008
Dum:Ukwe2	-2.45	-3.641**	

$\overline{R}^2$ *= 0.670* *DW =2.40* *RMSE=0.064* *F-value = 11.513****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the local maize production had a corrected R-Square statistic of 0.670, implying that 67 % of the total variation in local maize production is captured by the estimated equation. In addition, the model had an RMSE that was not far from zero (0.064) and an overall F-value of 11.513 that was highly statistically significant; implying that as a whole, the estimated model effectively captures the variation in local maize production for Ukwe EPA.

The results further show that the rainfall received in the Ukwe area and the dummy variable capturing the concurrent occurrence of several natural disasters in the same growing season were statistically significant in positively and negatively influencing local maize production at the 1 % and 5 % levels of confidence respectively. For the dummy variable, this implies that the concurrent occurrence of different natural disasters in the same growing season was a significant factor that lowered maize production in the study area. In terms of rainfall, the study finds that local level maize production is influenced very significantly by rainfall. Thus increases in rainfall would affect local maize production very significantly. For Malawi this is especially the case as smallholder farming is heavily reliant on rain fed farming with little or no irrigation. This effect can also be seen with the elasticity for rainfall which shows that a 10 % increase in rainfall would lead to a 6.04 % increase in production.

Although local production is relatively inelastic to rainfall, further analysis shows that rainfall is the key driver as local production is very inelastic to market prices. This is because a 10 % increase in maize prices in the local market would lead to a 0.08 % increase in production in the next cropping season. The effect of maize prices on production is lagged as there is a time span between when production decisions are made and when output is realised. The weak effect of lagged local price shows that rural households do not respond quickly to market forces. Lagged price and not the current price influence area harvested and therefore domestic production; because the majority of smallholder farmers rely mainly on income earned at the end of a cropping season. Based on the past prices (and therefore lagged incomes), decisions for the next season are made.

5.4.4 Model closure

The determination of maize prices in Malawi is a complex matter confounded by government intervention. An analysis of maize trade in the country has demonstrated that maize exports and imports are relatively small in comparison to domestic maize production, implying that maize prices are essentially determined by the dynamics of domestic demand and supply apart from policies. These findings have been reiterated in other recent studies of maize price formation in Malawi (Minot, 2010). Further analysis has, however, demonstrated that 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 and that domestic prices would largely be determined by world prices, and this 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. Such a situation is common with agricultural markets as they differ from other types of markets in that there is often little or no transmission of international prices to domestic agricultural markets (Baffer, *et al.* 2003; Fafchamps, *et al.* 2003).

Given this, the Malawi maize market was taken as being under an import parity regime with the ADMARC maize prices being determined by a behavioural price-linkage equation (Equation 5.2). Price-linkage equations define the extent of price transmission from world markets to domestic markets (Helmar, *et al.* 1991; Meyers, *et al.* 1991). As such, they are considered appropriate in markets in which domestic prices are determined by world prices (Pearse, *et al.* 1994; Meyer, *et al.* 2006). The Malawi maize market is not well integrated with world markets as price transmission is insulated by government intervention. Nevertheless, the use of a price-linkage equation is still relevant as trade still takes place; but full price transmission is not allowed as trade flows are constrained by government (Helmar, *et al.* 1991; Meyers, *et al.* 1991). The price-linkage equation that has been specified for this model therefore includes not only import parity prices but also other domestic factors which include direct government price intervention, maize market reforms, as well as domestic demand and supply dynamics which play an important role in determining ADMARC maize prices. This price-linkage equation is most appropriate for the Malawi maize market and it performs well with a corrected R-Square statistic of 0.806 and an RMSE that is not far from zero (0.051). This implies that at least a large proportion of the variation (80.6 %) in the maize price has been captured by the estimated equation and that the model can effectively simulate maize prices over time.

Therefore, the Malawi maize market is under an import parity regime but one in which the level of correlation between the domestic price and world price is less than one 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). The model is solved using the Gauss-Seidel iterative algorithm which involves a step-wise iterative process to estimate a solution (Ferris, 1998). The net exports identify is given below:

$$NXPORTS = PROD - DCON + BSTOCK - ESTOCK \qquad (5.12)$$

Where:

$NXPORTS$	Maize net exports (thousand tons)
$DCON$	Domestic maize consumption (thousand tons)
$BSTOCK$	Beginning stock (thousand tons)
$ESTOCK$	Ending stock (thousand tons)

The equation for maize imports (Equation 5.13) was estimated as a function of net exports; a dummy variable capturing years in which the government allowed great private sector involvement in maize trade; a dummy variable capturing government policy reforms pertaining to the National Food Reserve Agency (NFRA); a shift variable for the shift in the input support program to a full input fertiliser subsidy program from the 2005/2006 agricultural season onwards.

$$MPORTS = f\,(NXPORTS, SHIFT06, DUM : Pvt, Policy : NFRA) \qquad (5.13)$$

Where:

$NXPORTS$	Net exports (thousand tons)
$SHIFT06$	Shift to full input fertilizer program (0/1)
$DUM : Pvt$	Dummy variable: Private sector involvement in maize trade (0/1)
$Policy : NFRA$	Dummy variable: NFRA policy reforms (0/1)

The empirical estimation of the equation for maize imports is represented in Table 5.17.

Table 5.17: Equation for maize imports

	Maize imports (1000 tons)		
	Parameter	t-value	Elasticity
Intercept	198.03	3.517*	
NXPORTS	-0.0014	-2.002	-0.001
SHIFT06	-160.20	-3.989*	
Policy:NFRA	56.87	2.214	
DUM:Pvt	442.2	2.012	
$\overline{R}^2$ =0.546 DW =2.17 RMSE=0.093 F-value=2.519*			

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for maize imports had a corrected R-Square statistic of 0.546, implying that at least 54.6 % of the total variation in actual imports has been captured by the estimated equation. In addition, the estimated equation had an RMSE that was not far from zero (0.093) and an F-value of 2.519 which was statistically significant at the 10 % level of confidence, indicating that the estimated model as a whole is capable of effectively capturing the variation in actual maize imports.

Analysis of the parameter estimates shows that the shift variable capturing the effects of the changes that occurred as a result of the government shifting the input support programmes to a full input fertiliser subsidy programme for all rural and estate smallholder maize producers in the 2005/2006 agricultural season, statistically significant in negatively influencing maize imports at the 10% level of confidence. The implementation of a full input fertiliser subsidy programme led to record maize harvests, with maize production estimates reaching 2.7 and 3.4 million tons for the 2005/2006 and 2006/2007 cropping seasons respectively (FANRPAN, 2007). This higher maize production led to a reduction in the amount of maize being imported into the country, as maize imports are mainly to meet domestic food shortages. Hence, the surplus maize production that was seen after the implementation of the full input fertiliser subsidy programme rendered maize importation unnecessary. Further analysis shows that in general, imports are inelastic with respect to net exports; as a 10 % increase in the net exports would lead to a decrease of 0.1 % in total imports. This is the result of maize trade being controlled by government and mainly government policies determining the quantities of maize that are exported or imported.

Maize exports were derived as an identity (Equation 5.14) calculated as the addition of net exports and imports.

$$XPORTS = NXPORTS + MPORTS \tag{5.14}$$

5.4.5 Overall model performance

The corrected R-Square statistic and the F-values were used to test the goodness of fit of the estimated single equations, while the RMSE was used to test the simulation fit. These measures test on a one-by-one basis single equation fit. However, to test for overall model performance, the study employed different types of sensitivity analysis. Firstly, small changes were made to the paths of three exogenous variables (rainfall, population, GDP) in the model. From these changes, it was observed that there were very small changes in the historical simulation of the endogenous variables. Secondly, small changes[10] were made to the co-efficient estimates for the fitted single equations; and it was observed that the historical simulation of the model did not alter significantly as a result of this. From the sensitivity analysis, it can be concluded that the Malawi maize model as a whole is an appropriate representation of the real maize market, as 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 & Rubinfeld, 1991).

In addition, a visual method of graphically plotting each fitted equation against actual data was used to determine how well the estimated equations predict key turning points in the real data. The ability of a simulation model to correctly predict the key turning points in the actual data is an important criterion for model assessment (Pindyck & Rubinfeld, 1991). Figure 5.8 presents the graphs for all the estimated single equations.

[10] Small changes are defined as those that lead to at least a change of within one half of the estimated standard error for the co-efficient (Pindyck & Rubinfeld, 1991)

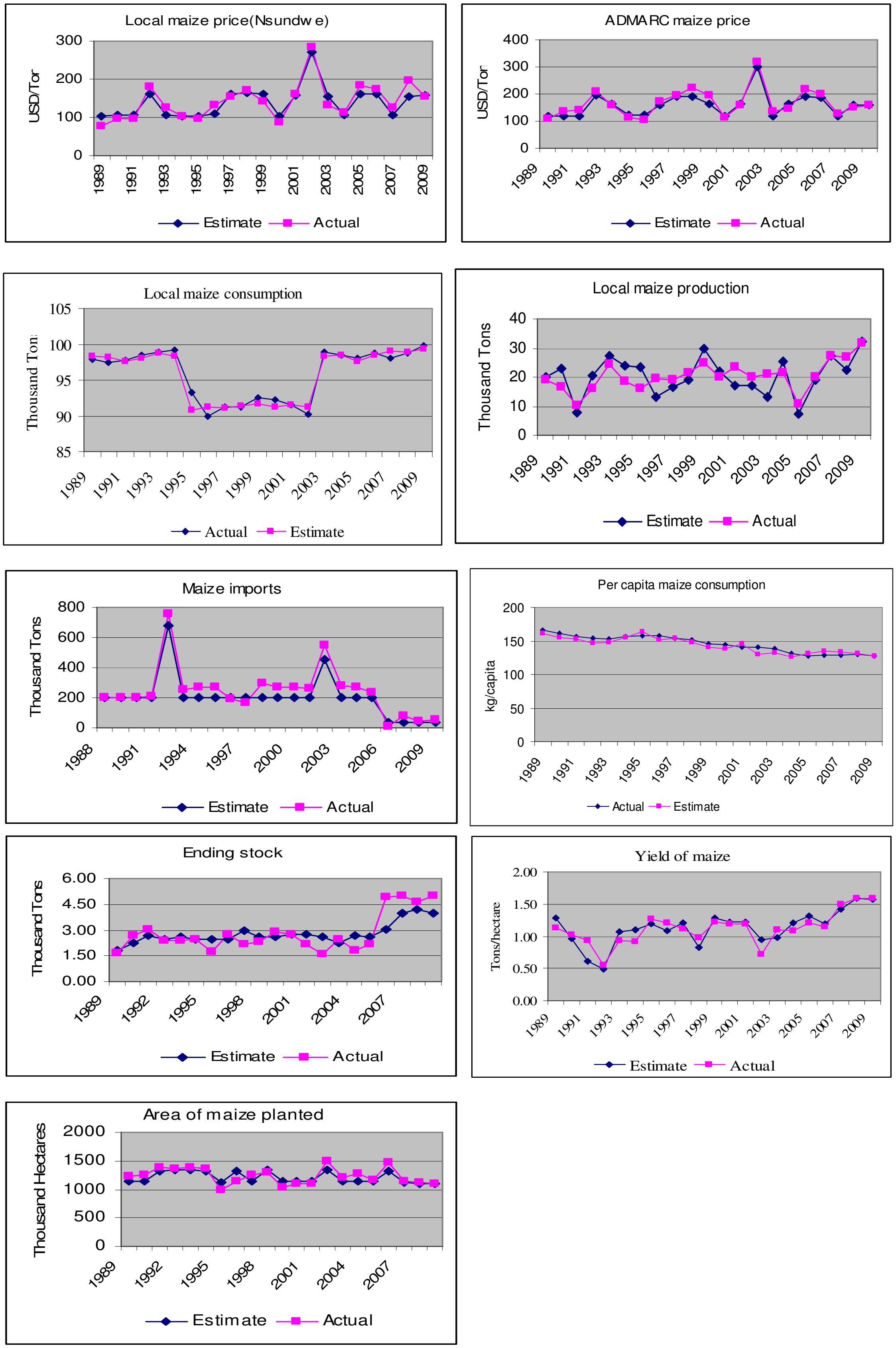

Figure 5-8: Historical simulation graphs

5.4.6 Feedback effects

The feedback effects occurring in the Malawi maize model are such that local population dynamics and changes that occur in local maize production filter through to local maize consumption. This then affects maize prices in local markets, 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 the local economies are felt at the household level and are manifested as changes in household income portfolios. Using this technique, it is possible to develop separate recursive local-level maize models for all the 187 Extension Planning Areas (EPAs) in the country. The ADMARC maize price would remain the same; however, local-level dynamics would lead to different maize prices in different local economy markets in the EPAs, which would result in differing household income portfolios, as is the case in practice. An aggregation of the household incomes from all the different EPA maize models in all local economies in the country would give an aggregate household income variable and changes in the aggregate household income would directly affect domestic maize consumption at the national level.

The estimation of 187 separate local economy household models with household income components is theoretically possible but impractical. Hence, this could be simplified by the use of behavioural models to develop functional forms for the local economy, using either behavioural linkage techniques or a mixture of parametric techniques with micro-accounting to create the macro-micro linkage. The parametric estimation of an aggregate household income variable and the behavioural linkages of the micro-component to the macro-component would change the Malawi maize model from a sequential model without upward feedback effects to a fully-integrated model with feedback from the micro-component (household level) to the macro-component (national level). Alternatively the use of weighted regional averages for the three administrative regions in the country would also be a useful means of generating national regional specific policy recommendations. This relationship is represented in Figure 5.7 by the dashed thick line. The implications of this are that smallholders have forward linkages; however, it is only in aggregation that changes in rural household incomes manifest within national maize markets. Changes in individual household incomes or separate local economies do not manifest in national maize markets and therefore do not show impact in national maize markets; as, separately, these changes are small.

5.5 CHAPTER SUMMARY

This chapter has investigated the dynamics of the Malawi maize market, with the main emphasis being on developing a functioning multi-equation partial equilibrium model of the maize market given government price controls. An establishment of the inter-relationships between farm/household, local economy and national maize market prices, as well as economic theory and existing empirical evidence, has been possible through the local area consumption to create a recursive system of the local maize market. The local maize market is linked through a price-linkage equation with the ADMARC maize price to the national maize market hence effectively showing how transmission of maize prices from national to local markets occurs. Using this system, it is possible to simulate changes occurring within national maize markets to assess how such changes affect rural households that are involved in the production and marketing of maize; thus providing the proof for the second hypothesis. This will be undertaken in the following chapter.