FOOD PRICING REFORMS AND PRICE TRANSMISSION IN MALAWI: IMPLICATIONS FOR FOOD POLICY AND FOOD SECURITY

WC/04/01

Ephraim Wadonda Chirwa
University of Malawi and Wadonda Consult

University of Malawi
Chancellor College, Department of Economics
P.O. Box 280, Zomba, Malawi

Tel: (265) 524 222 Fax: (265) 525 021

Working Papers No. WC/04/01

February 2001

FOOD PRICING REFORMS AND PRICE TRANSMISSION IN MALAWI: IMPLICATIONS FOR FOOD POLICY AND FOOD SECURITY

Ephraim Wadonda Chirwa ✧

University of Malawi
Chancellor College, Department of Economics
P.O. Box 280, Zomba, Malawi

Correspondence Address

14 Bateman Close
Chapel Break, Harpsfield
Norwich NR5 9LE, United Kingdom
Email: echirwa@yahoo.com

February 2001

✧ This study is part of a research project on Liberalization of Food Marketing and Market Integration in Malawi funded by the African Economic Research Consortium (AERC) Grant No. R0502. I gratefully acknowledge financial support from AERC. The study has also benefited from comments and suggestions from fellow researchers at various AERC Research Workshops in Group AT and under the guidance of Professors T. Ademola Oyejide, Terry Ryan, Robert Mabele, Jan Gunning and Bernard Decaluwe.

FOOD PRICING REFORMS AND PRICE TRANSMISSION IN MALAWI: IMPLICATIONS FOR FOOD POLICY AND FOOD SECURITY

Abstract

This study investigates the effect of food pricing liberalization in 1995, following the liberalization of food marketing liberalization in 1987, by examining the impact of pricing reforms on the long-run price relationships in eight spatial markets using monthly price data for four food crops (maize, rice, beans and groundnuts). We also identify markets that are weakly exogenous in the market and analyse the extent of price transmission using cointegration analysis. The results suggest that the markets for all four food crops are integrated and price liberalization has enhanced the degree of market integration. We find that Blantyre is central in the price transmission in the maize and groundnuts markets, Karonga is central in the rice markets and Blantyre and Lilongwe are central to the beans market. The short-run price dynamics reveal that, on average, the price changes in central markets explain between 18 percent (maize) and 70 percent (rice) of the variation in the price of peripheral markets, and between 15 percent and 47 percent of the price adjustment to the long-run equilibrium takes place within a month.

Keywords: Food Pricing Reforms, Market Integration, Malawian Agriculture

1. Introduction

Liberalization of agricultural marketing services has been part of a World Bank/IMF package of economic reform to developing countries within the Structural Adjustment Programs (SAPs). The argument by the Bretton Woods institutions has been that the agriculture sector in developing countries is inefficient due to various state interventions with respect to marketing, pricing and various forms of input subsidies. Such policies have not provided proper incentive to smallholder farmers, and this has led to insufficient production of food crops. Many countries in the developing world, particularly in Africa, have liberalised the marketing of agricultural produce.[1] Malawi adopted structural adjustment programs in 1981 after the economic crisis of 1979 through to 1981. Since 1981 Malawi has had seven Structural Adjustment Loans (SALs). The government has embarked on reforms in the agricultural sector within a

[1] Some notable examples in Africa include Zimbabwe, Zambia, Malawi, Ethiopia, Tanzania, Zambia and Somalia. There exist vast literature on the issue of food marketing liberalization in Africa (see Mkwezalamba, 1989; Dadi et al, 1992; Beynon et al, 1992; Coulter and Golob, 1992; Seppala, 1998; Chirwa, 1998; Rikuni and Wyckoff, 1991; Barrett, 1997; Jones, 1996; Kherallah and Govindan, 1999).

broader macro-adjustment programme with specific policy actions targeting marketing and pricing in the agriculture sector (Chirwa, 1998).

The study of market integration is important in order to determine the co-movements of prices and the transmission of price signals and information across spatially separated markets. Market integration ensures that a regional balance occurs between food-deficit and food-surplus areas. This study focuses on the integration of maize, rice, beans and groundnuts markets in eight spatially separated markets using monthly price information. Maize is the main staple food and rice is the alternative staple food in Malawi. The government maintains limited intervention on maize pricing which is binding to the state marketing agency while market forces completely determine the pricing of all other agricultural food produce. We organise the rest of the paper as follows. Section 2 briefly reviews developments in food marketing policies in Malawi in the post-independence era. In Section 3 we describe the methodology used in the study to test spatial price relationships. Section 4 reports and discusses the empirical evidence on the existence of long-run equilibrium relationships and the impact of the liberalization of government price controls. In section 5, we offers concluding remarks and policy implications.

2. Food Marketing Policies and Reforms in Malawi

Prior to food marketing liberalization in 1987, state intervention in marketing of agricultural crops in Malawi were in the form of monopsony power of the state marketing agency, the regulation of private traders, and price controls. The state marketing agency, the Agricultural Development and Marketing Agency (ADMARC), had monopsony power in the purchase of two main cash crops from smallholder farmers, cotton and tobacco, under the Agricultural and Livestock Marketing Act of 1964. Otherwise, private trade in other commodities produced by smallholder farmers preceded official marketing institutions and has always been acceptable.[2] The only restrictions formally applied to the activities of large and non-African traders, including upper limits on quantities of produce a single trader may purchase. Nonetheless, most food crops were under marketing control and required one to obtain a license to conduct trade.[3] Moreover, private traders had to obtain separate licenses for the right to purchase each separate class of produce.

The government officially determined prices for all food crops under control by announcing pan-territorial and pan-seasonal prices which were binding to ADMARC. Chirwa (1998) observes that the private market price for maize was generally higher than the official price administered by ADMARC even during price controls, an indication that government pricing policy was not particularly binding to private traders. The government used ADMARC marketing activities as instruments of enforcing price policy in the agricultural sector and the wage-earning sector, particularly for maize.[4]

Reforms in agricultural marketing commenced in 1987, following the inefficiencies in the state marketing agency, ADMARC, deteriorating terms of trade in agricultural exports and the macroeconomic problems that adversely affected parastatal finances. The agricultural marketing reform programme was based on two strategies. First, in the short-term periodic price adjustments of smallholder crop prices provided an interim solution to the problem. Second, introduction of competition by allowing more players in the marketing of smallholder crops provided a long term solution. The price

2 Scarborough (1990) argues that although ADMARC had limited monopsony power, private trade in other crops had been very effectively discouraged through alternative means, such as multiple licensing and red tape in the licensing of traders.

3 The following crops were under price control and trader licensing requirement: burley, beeswax, black gram, bulrush millet, Canadian wonder beans, capsicums (dried), cashew nuts, cassava, castor, chilies (dried), chick peas, delicious beans, dried peas, green gram, groundnuts, honey, macadamia nuts, maize, mixed beans, paddy rice, pigeon peas, sesame, sorghum, soya beans, sugar beans, wheat and white haricot beans.

4 Kandoole et al. (1988) and Harrigan (1988) elaborate on the pricing and storage policies that were supposed to be achieved, and the resultant conflicts.

incentive strategy was based on the assumption that smallholder farmers are responsive to price signals to expand their production and to improve their productivity within a land constrained environment.

The legislation of the Agriculture (General Purpose) Act of 1987 essentially eliminated ADMARC s quasi-monopsony power in smallholder agriculture marketing in the domestic market. Regulations governing the activities of private traders in a liberalised market system had the following features: market-specific annual traders licenses; restrictions on nationality;[5] pan-seasonal minimum producer prices; export licensing system for maize exports; traders monthly submission of statements of trading activities. The government also decentralised the licensing of private traders to Agriculture Development Divisions (ADDs). This decentralisation reduced the red-tape in the licensing process. Although, marketing of agricultural produce is liberalized, ADMARC continues to play a dominant role through its extensive marketing network (1200 markets in 1987) in the urban and rural areas across the country.

In 1995, the government embarked on agricultural pricing reforms and abandoned the system of pan-territorial and pan-seasonal pricing for agricultural produce. ADMARC was free to determine the prices of all smallholder produce except for maize producer price in which it is allowed to vary prices within a fixed price band which is reviewed regularly. The government monitors the prices of various agricultural produce in various markets through collection of monthly prices from private traders in fifteen spatially separated markets. Although, the price information is important, the monitoring system does not determine the extent of trade flows between markets and the number of private traders that actively operate in various markets.

Following these reforms, several studies have evaluate the supply response to liberalization of smallholder agriculture marketing activities in Malawi and highlight the problems and constraints that private traders face in marketing activities (Kaluwa,

---

5 This was in line with the restriction of Asian and European traders in retail and wholesale businesses in rural areas effected by the amendment of the *Business Licensing Act* in 1975.

1992; Kandoole et al., 1988; Mkwezalamba, 1989, Scarborough, 1990; Chirwa, 1998). The main constraint faced by private traders include transport availability and transport costs, credit availability, storage facilities and lack of pricing and marketing skills. Goletti and Babu (1994) investigate the integration of maize markets and use monthly retail prices of maize at eight main locations between 1981 and 1991, and find that liberalization increased market integration and that the major urban areas were pivotal in the price transmission.

3. Methodology

3.1 Concept and Measurement of Market Integration

The concept of market integration is modelled within the framework of the spatial price equilibrium (SPE) model of inter-market linkages, in the point-space tradition of Samuelson (1952) and Takayama and Judge (1964), that is subject to production shocks and general price information. Two markets may be said to be spatially integrated if, when trade takes place between them, price in the importing market equals price in the exporting market plus the transportation and other transfer costs involved in moving food between them. The measurement of the extent of spatial market integration is still a matter of considerable debate conceptually and empirically. Testing whether the arbitrage conditions are met requires information on prices, trade flows between markets and transfer costs. However, in empirical work only price information is readily available, and empirical tests of market integration concentrate on price analysis, which does not reveal whether there are trade flows among markets due to price differentials. Barrett (1996) notes that co-movements of prices has thus become synonymous with market integration.

The literature suggests several approaches to testing spatial market integration using market prices to examine the concept of spatial arbitrage and the effect of liberalization of food marketing systems in developing countries.[6] The conventional tests of market integration, when only price series data are available, include correlation analysis following Jones (1972) and Lele (1967), the Law of One Price (LOP) (Richardson, 1978), the Ravallion model (Ravallion, 1986), and the application of new econometric techniques of cointegration and Granger causality (Palaskas and Harriss-White, 1993; Alexander and Wyeth, 1994).[7]

The conventional approaches of testing market integration have been criticized for ignoring transaction costs in assessing food market integration. For example, Barrett (1996) argues that while cointegration indicates that a long-run reduced form linear relationship exists between two time series, it is neither a necessary nor a sufficient condition for market integration. Baulch (1997b) notes that the conventional tests of market integration ignore transfer costs and assume a linear relationship between market prices, not consistent with discontinuities in trade implied by the spatial arbitrage conditions, and proposes a Parity Bounds Model (PBM). . Nonetheless, available empirical studies that use the parity bounds model rely on best estimates of transaction costs, and the model falls short of telling us whether trade flows occur (Barrett, 1996). Zanias (1999) also notes that using proxy transport costs or transaction costs may create more problems than they intend to solve. Timmer (1996) also observes that in spite of sophistication in econometric techniques our understanding of market integration requires real data on transaction costs and trade flows between spatially separated markets.

Given that only price information from private traders is collected in Malawi, we test the existence of long-run equilibrium relationships among the main markets using the cointegration analysis. Although, government pricing policy is more binding on

---

[6] See among others Jones (1972), Silvapulle and Jayasuriya (1994), Palaskas and Harriss-White (1993), Jones (1996), Alexander and Wyeth (1994), Fafchamps and Gavian (1996), Baulch (1997 a, b) and Barrett (1997).

[7] Other recent studies using cointegration analysis include Dercon (1995), Fafchamps and Gavian (1996), Ismet et al. (1998), Bassolet and Lutz (1999), Asche et al. (1999), Zanias (1999) and Sanjuan and Gil (2001).

ADMARC s pricing behaviour, it can be argued that changes in government pricing policy can also influence the marketing and pricing behaviour of private traders. The direction of the influence depends on private traders perceptions on the signals such a policy sends in the market environment. If the policy creates uncertainty about the future of private marketing system, then we would expect a negative effect of the structural change on the extent of market integration. This may be plausible in a case where the pricing of other crops are completely liberalized, while limited control is maintained on other products and where government policy reversals are evident.

3.2 Market Integration and Cointegration Analysis

Cointegration focuses on the long-run relationships between bivariate or multivariate price series. Thus, cointegration among non-stationary prices means that a linear combination of the series is stationary and prices therefore tend to move towards the long-run equilibrium relationship. Given prices for two spatial markets, the long-run price relationship can be obtained by running the following regression

$$p_t^i = \alpha + \beta \, p_t^j + \varepsilon_t \qquad (1)$$

where ε_t is the error term. This tests whether $\beta = 1$ in equation (1) is the test of the Law of One Price, that imply that price changes in one market will be transmitted on a one-for-one basis to other markets instantaneously. New developments in time-series econometrics, suggest that if the price series are non-stationary, normal inference is not valid on the parameters and results from equation (1) are spurious. However, if the price series are integrated of the same order, then equation (1) can be used to test for cointegration using the Johansen vector autoregression (VAR) method.[8]

[8] Alternatively, the two-step Engle and Granger (1987) cointegration procedure can be used to test for cointegration. However, it is well known that the Engle-Granger procedure suffers from the simultaneity problem and the results are sensitive to the choice of the dependent variable. On the other hand, the advantage of the VAR procedure is that it avoids the simultaneity problem and allows hypothesis testing on the cointegration vector.

Cointegration implies that there is a linear long-run relationship between price series in spatially separated markets, and is interpreted as a test that $\beta \neq 0$. If $\beta \neq 0$, then the price series are cointegrated and a long-run equilibrium relationship exists between the prices, and hence there exist a cointegration vector (1, -**β**). Cointegration tests for market integration are only tests of whether there is a statistically linear relationship between different data series (Asche et al, 1999) and tests for more general notion of equilibrium.

The Johansen VAR-based procedure (Johansen, 1988) of testing cointegration is the maximum likelihood procedure which relies on the relationship between the rank of a matrix and its characteristic roots. The Johansen (Trace) test detects the number of cointegration vectors that exists between two or more integrated time series. The Johansen procedure can be used to test for the presence of a cointegration vector between different price series if they are integrated of the same order. It is based on maximum likelihood estimation of the error correction model and each two-variable system is modelled as a vector auto regression

$$\Delta x_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-k} + \varepsilon_t \qquad (2)$$

where x_t is an $n \times 1$ vector containing the series of interest (spatial prices), Γ and Π are the matrices of parameters, k is adequately large both to capture the short-run dynamics of the underlying VAR and to produce normally distributed white noise residuals and ε_t is a vector of white noise errors.

The Johansen methodology involves testing whether the Π matrix in (5) has less than full rank using the maximal eigenvalues test and the trace test. The rank of Π, r, determines the number of linear combinations of x_t that are stationary. If $r = n$, the variables in levels are stationary and if $r = 0$ then none of the linear combinations are stationary. When $0 < r < n$, there are r cointegration vectors or r stationary linear combinations of x_t. $\Pi = \alpha\beta'$, where both α and β are $n \times r$ matrices, with β containing the cointegration vectors and α containing the adjustment parameters.

3.3 *Weak Exogeneity and Price Transmission*

If there exist long-run relationships between markets, then knowledge about the markets that drive the market system may be important for government stabilization policy. Thus, it is important to identify markets that are exogenous in the market system and to determine the extent of price transmission. The Johansen procedure also allows a range of hypothesis testing on the coefficients α and β using the likelihood ratio test.

One such test relates to the exogeneity of price series in the system. The price in market i is weakly exogenous for the set of parameters of interest, say z, if the marginal process of prices in market i contains no useful information for the estimation of z. This implies that an inference of z can be sufficiently made conditionally on prices in market i alone and its marginal process contains no relevant information (Charemza and Deadman, 1997). The test for exogeneity involves testing the factor loading matrix, α, that contains information about the dynamic adjustment of the long-run relationships. The test of whether prices in market i are weakly exogenous to all other markets in the system is obtained by testing the restriction that all parameters in the corresponding row in the α matrix are zero in a cointegrating system (Johansen, 1994).

Once we identify weakly exogenous markets, using the Granger Representation Theorem (Engle and Granger, 1987) we investigate short-run dynamics of the price series by estimating the following error correction model for each of the price series between the peripheral and central market:

$$\Delta \ln p_t^i = a_0 + \sum_{k=1}^{3} d_k S_k + \sum_{l=1}^{q-1} a_l \Delta \ln p_{t-l}^i + \sum_{l=0}^{q-l} b_l \Delta \ln p_{t-l}^j + g\, ECT_{t-1} + \varepsilon_t \quad (3)$$

where S_k are seasonal dummies (quarterly), p_t^i is the price of maize or rice in a dependent market i, p_t^j is the price of maize or rice in weakly exogenous markets j, ECT_{t-1} is the lagged error correction term, ε_t is the error term. The most relevant parameters in equation (3) are the short-run parameter (b_0) and the adjustment parameter (g). The significance of the short-run parameters and the adjustment parameter has implications for causality and cointegration (Enders, 1995). If g is zero, then the change in price in market *i* does not respond to the deviation from the long-run equilibrium in (t - 1). If the adjustment parameter is zero and all b_l are zero, then the price in market *j* does not Granger cause price in market *i*. In addition, the price series are cointegrated if one or both of the coefficients are significantly different from zero.

3.4 Data and Data Sources

The analysis of market integration is based on monthly price series from medium and small-scale private traders in selected markets covering the period between 1989 and 1998. These data are available from the Ministry of Agriculture and Livestock Development for more than fifteen spatial markets across the country. The analysis of market integration focuses on eight spatial markets: Karonga and Mzuzu in the northern region; Nkhotakota, Lilongwe and Lizulu in the central region, and Blantyre, Luchenza and Bangula in the southern region. Mzuzu, Lilongwe and Blantyre are the three regional cities in Malawi.

We make a distinction between crops that are mainly staple foods from those that are supplementary foods. Maize and rice are staple food crops for an average household in Malawi while beans and groundnuts are supplementary and exportable food crops. The estimations were carried out on TSP 4.4 (Hall, Cummins and Schnake, 1995) and PcFiml 9.10 (Doornik and Hendry, 1997). We test, for each crop, whether the markets operate as a unified system using the full sample data. We test the effect of price liberalization on market integration by comparing the number of cointegrating vectors before price liberalization (1989:01 - 1995:03) and after price liberalization (1995:04 - 1998:12).

4. Empirical Results

4.1 Time-series properties of the data

Table 1 presents descriptive statistics of the nominal price series for five food crops in different markets. The three main urban centres Blantyre, Lilongwe and Mzuzu tend to have higher average monthly prices for most food crops. The average monthly price for maize is highest in Blantyre and lowest in Bangula. Blantyre and Mzuzu have higher average prices while Karonga and Bangula have lower average prices for rice. Average monthly prices for beans are higher in Mzuzu and Bangula and are lowest in Lizulu. Luchenza and Nkhotakota have higher average monthly prices for groundnuts while cassava prices are lowest in Lilongwe. In all food crops, the variability in monthly prices is quite high relative to the mean prices, particularly for maize and rice price series.

[Table 1 about here]

The first step in the analysis of time-series, to avoid spurious relationships, is to test for the presence of unit roots using the Augmented Dickey-Fuller unit root test (Dickey and Fuller, 1979). Figure A1 presents trends in the logarithm of nominal prices and Table 2 reports the results of the Augmented Dickey-Fuller unit root tests in levels and first difference in logarithms of price series. Unit root tests on price levels show that the null hypothesis of the existence of a unit root or non-stationarity can not be rejected at 5 percent level for all food crops in all markets. Differencing the series once, leads to rejection of the null hypothesis of a unit root at 5 percent level for all price series. The unit root test, therefore, imply that all the price series for all crops are stationary in first difference, and hence the price series are integrated of order 1, *I(1)*.

[Table 2 about here]

4.2 Cointegration and Long-run Relationships

Table 3 presents the results of the multivariate cointegration analysis for four food crops in eight spatial markets. The trace tests from the full sample results reveal the existence of three, six, three and four cointegrating vectors in maize, rice, beans and groundnuts price series, respectively. The results show that the markets for food crops in Malawi operate as a unified market system. In terms of the number of significant cointegrating vectors, the extent of market integration is higher for rice price series, followed by groundnuts price series and is lowest for maize and beans price series. The government pricing policy mainly focuses on maize, the main staple food crop, and the prices of other crops have been less restrictive with respect to private marketing. Relatively, we find that maize prices are less cointegrated compared to rice price series.

The difference in the level of market integration for the two main food crops, maize and rice, may be explained by the government pricing policy. The most explicit pricing policy enforced through ADMARC even before marketing and pricing liberalization has been on maize, while trade on rice has been conducted with remote interventions. Moreover, the restrictions on the exportation of rice have been moderate compared to maize on which government still maintains control. The results show high market integration for food crops that have fewer restrictions on pricing and international trade such as rice and groundnuts compared to maize which is still under limited control by the government.

Rice, beans and groundnuts are also the main food cash crops in Malawi. After marketing liberalization in 1989, large scale manufacturing enterprises directly purchase crops used in their production process such as rice and groundnuts from smallholder farmers and the activities of these large traders with limited transport constraints may facilitate the integration of markets.

[Table 3 about here]

We divide the sample into two different periods assuming April 1995 as the effective month for the new price regime and determine whether there are changes in rank of the cointegrating systems.[9] The trace tests in Table 3 show that although long-run relationships exist in both regimes although the extent of market integration is lower in the period before price liberalization than observed in the period after price liberalization. These results are contrary to the finding in the Indonesian rice market (Ismet et al., 1998) where price liberalization resulted in a decrease in the extent of market integration.

The improvement in the integration of markets after price liberalization is significantly evident in the groundnuts price series with five cointegrating vectors compared to two cointegrating vectors before price liberalization. We find no significant changes in the number of cointegrating vectors following price liberalization in maize, rice and beans price series. Generally, the liberalization of crop prices, which were binding for the state marketing agency, does not significantly change the integration of food markets in the private marketing system. However, the results suggest that market integration is higher in products in which there has been complete price liberalization, and the continued fixed price band may constrain the activities of private traders.

Table 4 presents weak exogeneity tests based on the multivariate cointegration analysis. We attempt to identify markets that drive the movement in the prices in the eight markets. With respect to maize the null hypothesis of weak exogeneity cannot be rejected for Blantyre market at the 5 percent level. The weak exogeneity of Blantyre, as the main commercial city in Malawi, suggests that demand forces drive the long-run spatial price relationships for the maize market in the private marketing system.

[Table 4 about here]

9 Quintos (1995), cited in Maddala and Kim (1998), provides a formal systems test for changes in the rank of the cointegration vector space based on the trace statistics and derives the LR test and its distribution for the null hypothesis that there are no differences in the rank of the systems in the full sample and sub-samples. Here, we simply look at the increase in the number of cointegrating vectors before and after price liberalization.

The null hypothesis of weak exogeneity for rice markets cannot be rejected for Karonga at the 5 percent level. Karonga is one of the surplus districts for rice and being a border town also benefits from international trade with Tanzania. Thus, the potential gains from international trade from the Karonga market are likely to affect the movement of prices. Weak exogeneity for Lilongwe and Blantyre, the two main commercial cities, for beans markets cannot be rejected at the 5 percent level suggesting that demand factors are important in the price formation. With respect to groundnuts markets, weak exogeneity for Blantyre cannot be rejected at the 5 percent level, and the involvement of large manufacturers in purchase of groundnuts as raw materials may explain the importance of Blantyre as a central market in groundnuts markets.

Overall, markets for food crops whose prices were completely liberalized show higher degree of market integration than maize markets in which the government maintains limited pricing policy. We also find Blantyre in the maize markets; Karonga in the rice markets; Blantyre and Lilongwe in the beans markets, and Blantyre in the groundnuts markets to be central in driving the long-run relationships in the private food marketing system.

4.3 Short-run Price Dynamics and Vector Correction Mechanism

With the identification of central markets or weakly exogenous markets for the four food crops, we model the short-run price relationship between the central market and the peripheral market. Tables A1 to A5 in the appendix presents results of estimates of error correction models assuming that Blantyre for maize, Karonga for rice, Lilongwe and Blantyre for beans and Blantyre for groundnuts are weakly exogenous markets. Four lags for the central and peripheral markets in estimating equation (3) were initially used in the short-run regression, and the lags which were highly insignificant were eliminated, resulting in more parsimonious specifications. We include quarterly seasonal dummies, with the first quarter (Q1) coinciding with the food crop growing period, the second quarter (Q2) coinciding with the harvesting season, the third quarter (Q3) is the marketing and slack season and the fourth quarter (Q4) is the garden preparation season. With respect to maize, prices tend to be higher in the first quarter and lower in the second quarter reflecting high demand/constraint supply and high supply, respectively. The importance of seasonality in the price behaviour is not significant for the data from the private traders, with most of the seasonal dummies statistically insignificant at the conventional levels in all the four food crops.

The most important parameters in equation (3) are the coefficient of the contemporaneous change (b_0) in the central market (a weakly exogenous market) and the coefficient of the lagged error correction term (g). The error correction term (ECT) is derived from the residual from the cointegration vector of the dependant and central market in the bivariate analysis. Table 5 reports the coefficients of the current change in the central market s price (the short-run parameter) and the adjustment speed parameter. Overall, the general interpretation of the short-run parameters and the adjustment parameters reveals that both causality and cointegration are high, further confirming the hypotheses of cointegration and market integration. For the maize price series, the contemporaneous change in the central market prices significantly affects the price change in the peripheral market in four markets with the coefficients ranging from 0.21 to 0.34, resulting in an average impact of 18 percent. Price changes in Blantyre do not significantly affect price changes in markets in the northern region of Malawi - Karonga, Mzuzu and Nkhotakota in the central region. However, the speed of the adjustment parameter is statistically significant in six of the seven market links and but the coefficients range from -0.29 to -0.10 suggesting that the adjustment process is slow, and about 15 percent of the adjustment takes place within the first month. The negative values of the adjustment parameter imply that positive deviations from the long-run equilibrium are corrected by decreases in prices in a particular market.

[Table 5 about here]

With respect to rice price series, the significance of Karonga as a central market in the rice market is also reflected in the large values of the short-run parameters, which range from 0.56 to 0.76. The coefficients for the contemporaneous change in rice prices in

Karonga are all statistically significant at the 1 percent level, and on average changes in rice prices in Karonga explain around 70 percent of changes in the peripheral markets. The coefficient of the lagged error correction term shows that the speed of adjustment is slowest for Lilongwe (-0.33) and highest for Mzuzu (-0.67), and about 47 percent of the price adjustment to the long-run equilibrium takes place within a month.

Two markets, Lilongwe and Blantyre, for the beans price series are weakly exogenous. The contemporaneous price change in Lilongwe significantly affects the price change in five of the six markets and the impact is stronger in Lizulu (0.46) and weakest in Nkhotakota (0.26). Similarly, changes in the price of beans in Blantyre significantly influence the price series in the peripheral markets, with the coefficients ranging from 0.18 in Nkhotakota to 0.52 in Lizulu. On average 30 percent and 24 percent of the changes in the prices of beans in the peripheral markets are explained by changes in the price of beans in Lilongwe and Blantyre, respectively. The adjustment to the long-run equilibrium assuming Lilongwe as a weakly exogenous market is slowest for Luchenza and fastest for Lizulu, and around 21 percent of the price adjustment takes place within the first months. Taking Blantyre as a weakly exogenous market for beans, the adjustment parameters are all statistically significant at the 1 percent level, and Lizulu reverts quickly to the long-run equilibrium while Bangula adjusts slowly to the long-run equilibrium. On average, around 29 percent of the adjustment in the prices of beans in the peripheral markets take place within the first month.

Granger causality and cointegration in the groundnuts markets with Blantyre as a central market is further confirmed by the significant coefficients of the short-run and adjustment parameters at the 5 percent level. The influence of changes in the groundnuts prices in Blantyre on other markets is strongest in Karonga (0.48) and weakest in Lizulu (0.22), resulting in an average impact of 31 percent. The adjustments to the long-run equilibrium show that about 27 percent of the adjustment takes places within the first month. Overall, we observe that the average speed of adjustment to the long-run equilibrium is slowest for maize price series and fastest for the rice price series, suggesting that the continued control of maize prices through a price band constrain the efficient transmission of prices.

5. Conclusion

This study set out to examine the extent of spatial market integration for four food crops in eight selected markets and to investigate the link between government pricing policy and market integration in Malawi. The marketing of agricultural produce in Malawi was liberalized in 1987 by allowing the participation of private traders, but the government still imposed restrictions on pricing - the policy which was binding for the state marketing agency - ADMARC. In 1995, the pricing of agricultural produce was fully liberalized except for maize where the government still maintains limited control over pricing through a fixed band that allows ADMARC s flexibility and full restrictions on the exportation of maize.

The analysis of market integration using the vector autoregression cointegration approach and the test for the existence of valid cointegration vectors, reveal that markets for food crops given the price information are highly integrated in Malawi. Markets for rice, beans and groundnuts in which pricing has been remote and completely liberalized are more integrated than maize markets in which the government still maintains limited pricing policy and export restrictions. The changes in the pricing policy which are mostly binding to ADMARC appear to have affected the extent of market integration, on average marginally increasing market integration in maize, rice and beans markets, but significant change in the groundnuts markets. The positive impact of price reforms is mostly evident in groundnuts markets in which the number of cointegrated vectors almost doubled after price reforms.

Tests of weak exogeneity reveal that Blantyre is a central market for maize, beans and groundnuts price series, Karonga is central in the rice markets and Lilongwe is also central in the beans markets. Blantyre and Lilongwe are the main commercial cities in Malawi and exogeneity implies that price improvements resulting from increased demand are positively transmitted to the supply markets. Though, Lilongwe is the second commercial centre and Mzuzu a regional centre, their commercialisation relative to surrounding markets cannot be taken for granted as central markets in the price formation. The exogeneity of Karonga for rice markets, as a border town and one of the rice growing district, implies that gains from cross-border trade with Tanzania are immediately transmitted to the other markets in Malawi, and about 70 percent of the price changes in Karonga are reflected in the price of rice in other markets, and nearly 47 percent of the adjustment to the long-run equilibrium takes place within the first month. Productivity increases in rice production in Karonga, leading to increases in the supply and hence a reduction in the price, would immediately lead to a decline in the prices of rice in other markets.

The implication for price stabilisation for food security in Malawi is that government direct intervention in the pricing of food crops has the potential for crippling the market mechanism and arbitrage opportunities for private traders. The evidence in this study is that the private market system is working well, and the exogeneity of Blantyre, Lilongwe and Karonga implies that government can influence the prices of food crops in the rural markets through market operations in the three markets. Hence, Blantyre for maize and groundnuts, Blantyre and Lilongwe for beans, and Karonga for rice may be the centres for government price stabilization policy by influencing supply and demand conditions in these markets.

The methods used in the study based on price information do not reveal whether trade flows occur due to the existence of spatial arbitrage opportunities. Nonetheless, the identification of central markets may facilitate government stabilisation efforts through the market mechanism, by targeting markets that are highly linked with other markets in Malawi. In any case, in order to fully understand the working of the private marketing system in Malawi further research is required particularly through a survey-based study within a structure, conduct and performance framework of the private marketing system, in a way generating data that will facilitate the application of the parity bounds model while gaining qualitative knowledge about trade flows between markets.

References

Alexander, C. and Wyeth, J. (1994) Cointegration and Market Integration: An Application to the Indonesian Rice Market , **Journal of Development Studies, 30 (4)**, 303-328

Asche, F., Bremnes, H. and Wessells, C. R. (1999) Product Aggregation, Market Integration, and Relationships between Prices: An Application to World Salmon Markets , **American Journal of Agricultural Economics, 81 (August)**, 568 - 581

Bassolet, B. and Lutz, C. (1999) Information Service and Integration of Cereal Markets in Burkina Faso, **Journal of African Economies, 8 (1)**, 31-51

Baulch, B. (1997a) Testing for Food Marketing Integration Revisited , **Journal of Development Studies, 33 (4)**, 512-534

Baulch, B. (1997b) Transfer Costs, Spatial Arbitrage, and Testing for Food Marketing Integration , **American Journal of Agricultural Economics, 79 (May)**, 477-487

Barrett, C. B. (1996) Market analysis Methods: Are our Enriched Toolkits Well-Suited to Enlivened Markets, **American Journal of Agricultural Economics, 78 (3)**, 825-829

Beynon, J., Jones, S. and Yao, S. (1992) Market Reform and Private Traders in Eastern and Southern Africa , **Food Policy, 17 (6)**, 399-408

Charemza, W. W. and Deadman, D. F. (1997) **New Directions in Econometric Practice: General to Specific Modelling, Cointegration and Vector Autoregression**, Cheltenham: Edward Elgar

Chirwa, E. W. (1998) Fostering Private Food Marketing and Food Policies after Liberalization in Sub-Saharan Africa - The Case of Malawi , in P. Seppala (ed.) **Liberalized and Neglected? Food Marketing Policies in Eastern Africa**, World Development Studies 12, Helsinki: UNU/WIDER

Coulter, J. and Golob, P. (1992) Cereal Marketing Liberalization in Tanzania , **Food Policy, 17 (6)**, 420-430

Dadi, L., Negassa, A. and Franzel, S. (1992) Marketing Maize and Tef in Western Ethiopia: Implications for Policies Following Market Liberalization , **Food Policy, 17 (3)**, 201-213

Dercon, S. (1995) On Market Integration and Liberalization: Method and Application to Ethiopia , **Journal of Development Studies, 32 (1)**, 112-143

Dickey, D. A. and Fuller, W. A. (1979) Distribution of Estimators for Autoregressive Time Series with a Unit Root , **Journal of American Statistical Association, 74 (366)**, 427-431

Doornik, J. A. and Hendry, D. F. (1997) **Modelling Dynamic Systems using PcFiml 9.10 for Windows**, London: Timberlake Consulting

Enders, W. (1995) **Applied Econometric Time Series**, New York: John Wiley & Sons, Inc

Engle, R. F. and Granger, C. W. J. (1987) Co-Integration and Error Correction: Representation, Estimation and Testing , **Econometrica, 55**, 251-276

Fafchamps, M. and Gavian, S. (1996) The Spatial Integration of Livestock Markets in Niger , **Journal of African Economies, 5 (3)**, 366-405

Goletti, F., Ahmed, R. and Farid, N. (1995) Structural Determinants of Market Integration: The Case of Rice Markets in Bangladesh , **Developing Economies, 23 (2)**, 185-202

Goletti, F. and Babu, S. (1994) Market Liberalization and Integration of Maize Markets in Malawi , **Agricultural Economics, 11**, 311-324

Goodwin, B. K. and Schroeder, T. C. (1991) Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets , **American Journal of Agricultural Economics, 73 (4)**, 452-464

Hall, B. H., Cummins, C. and Schnake, R. (1995) **Time Series Processor Version 4.3 - User Manual and Reference Manual**, California: TSP International

Harrigan, J. (1988) Malawi: the Impact of Pricing Policy on Smallholder Agriculture 1971-1988 , **Development Policy Review, 6**, 415-433

Ismet, M., Barkley, A. P. and Llewelyn, R. V. (1998) Government Intervention and Market Integration in Indonesian Rice Markets, **Agricultural Economics, 16**, 283-295

Johansen, S. (1988) Statistical Analysis of Cointegrating Vectors , **Journal of Economic Dynamics and Control, 12**, 231-254

Johansen, S. (1994) Testing Weak Exogeneity and the Order of Cointegration in U.K. Money Demand Data , in N. R. Ericsson and J. S. Irons (eds.) **Testing Exogeneity**, Oxford: Oxford University Press

Jones, S. (1996) Food Markets in Developing Countries: What Do We Know? , Food Studies Group, Working Paper No 8, University of Oxford

Jones, W. O. (1972) **Marketing Staple Food Crops in Tropical Africa**, Ithaca and London: Cornell University Press

Kaluwa, B. M. (1992) Malawi Food Marketing: Private Trader Operation and State Intervention in J. B. Wyckoff and M. Rukuni (eds) **Food Security Research in Southern Africa: Policy Implications**, proceedings of the Sixth Annual Conference on Food Security Research in Southern Africa, University of Zimbabwe/ Michigan State University Food Security Research Project.

Kandoole, B. F., Kaluwa, B. M. and Buccola, S. (1988) Market Liberalization and Food Security in Malawi , in M. Rukuni and R. H. Bernsten (eds) **Southern Africa: Food Security Policy Options**, proceedings of the Third Annual Conference on Food Security Research in Southern Africa, University of Zimbabwe/ Michigan state University Food Security Research Project.

Kherallah, M. and Govindan, K. (1999) The Sequencing of Agricultural Market Reforms in Malawi , **Journal of African Economies, 8 (2)**, 125-151

Maddala, G. S. and Kim, I. M (1998) **Unit Roots, Cointegration and Structural Change**, Cambridge: Cambridge University Press

Mkwezalamba, M. (1989) The Impact of Liberalization of Smallholder Agricultural Produce Pricing and Marketing in Malawi , Report submitted to Ministry of Agriculture, Lilongwe

Palaskas, T. B. and Harriss-White, B. (1993) Testing Market Integration: New Approaches with Case Material from the West Bengal Food Economy , **Journal of Development Studies, 30 (1)**, 1-57

Perron, P. (1989) The Great Crash, the Oil Price Shock and the Unit Root Hypothesis , **Econometrica, 57**, 1361-1401

Perron, P. (1994) Trend, Unit Root and Structural Change in Macroeconomic Time Series , in B. B. Rao (ed.) **Cointegration for the Applied Economist**, London: Macmillan Press

Quintos, C. E. (1995) Sustainability of the Deficit Process with Structural Shifts , **Journal of Business and Economic Statistics, 13**, 409-417

Ravallion, M. (1986) Testing Market Integration , **American Journal of agricultural Economics, 68 (1)**, 102-109

Richardson, D. (1978) Some Empirical Evidence on Commodity Arbitrage and the Law of One Price , **Journal of International Economics, 8 (2)**, 341-351

Rikuni, M. and Wyckoff, J. B. (eds) (1991) **Market Reforms, Research Policies and SADCC Food Security**, proceedings of the Sixth Annual Conference on Food Security Research in Southern Africa, University of Zimbabwe/ Michigan state University Food Security Research Project.

Samuelson, P. A. (1952) Spatial Price Equilibrium and Linear Programming , **American Economic Review, 42 (March)**, 283-303

Sanjuan, A. A. and Gil, J. M. (2001) Price Transmission Analysis: A Flexible Methodological Approach Applied to European Pork and Lamb Market, **Applied Economics, 33**, 123-131

Scarborough, V. (1990) Domestic Food marketing Liberalization in Malawi: A Preliminary Assessment , ADU Occasional Paper 13, Wye College, University of London

Seppala, P. (1998) Tanzania - Decisive Liberalization Path, in P. Seppala (ed.) **Liberalized and Neglected? Food Marketing Policies in Eastern Africa**, World Development Studies 12, Helsinki: UNU/WIDER

Silvapulle, P. and Jayasuriya, S. (1994) Testing for Philippines Rice Market Integration: A Multiple Cointegration Approach , **Journal of Agriculture Economics, 45 (3)**, 369-380

Takayama, T. and Judge, G. A. (1964) Spatial Equilibrium and Quadratic Programming **Journal of Farm Economics, 46 (1)**, 67-93

Zanias, G. P. (1999) Seasonality and Spatial Integration in Agricultural (Product) Market , **Agricultural Economics, 20**, 253-262

Table 1: Mean spatial prices for food crops in selected markets (nominal prices)

Market	Maize	Rice	Beans	Groundnuts
Karonga	1.81 (1.93)	6.20 (6.81)	8.38 (7.81)	12.06 (9.65)
Mzuzu	1.85 (2.12)	7.62 (8.01)	10.45 (9.56)	13.12 (11.03)
Nkhotakota	1.87 (2.11)	6.34 (6.00)	9.85 (8.76)	14.29 (11.20)
Lilongwe	1.77 (2.23)	7.06 (7.40)	8.07 (7.32)	9.24 (8.20)
Lizulu	1.57 (1.99)	6.61 (8.50)	7.04 (7.32)	9.69 (9.29)
Blantyre	2.01 (2.59)	7.86 (8.61)	9.90 (9.73)	12.42 (12.09)
Luchenza	1.92 (2.48)	6.25 (6.10)	8.43 (8.36)	15.08 (16.13)
Bangula	1.45 (2.10)	6.07 (6.68)	9.99 (10.01)	10.50 (11.11)

Notes: The figures in parentheses are standard deviations.

Table 2: Augmented Dickey-Fuller unit root tests (prices in natural logarithms)

District	Level				First Difference			
	Maize	Rice	Beans	G/nuts	Maize	Rice	Beans	G/nuts
Karonga	-3.368 (2)	-2.845 (2)	-2.253 (6)	-1.093 (1)	-5.713 (6)	-6.633 (2)	-5.324 (6)	-6.697 (6)
Mzuzu	-2.362 (2)	-2.650 (3)	-3.449 (3)	-2.768 (2)	-5.713 (6)	-7.100 (2)	-6.672 (6)	-6.674 (2)
Nkhotakota	-2.818 (2)	-2.842 (3)	-2.059 (3)	-2.656 (3)	-6.216 (6)	-6.844 (2)	-7.483 (2)	-7.581 (2)
Lilongwe	-2.267 (3)	-2.265 (3)	-2.376 (3)	-2.255 (6)	-5.402 (6)	-6.488 (2)	-7.222 (2)	-4.537 (6)
Lizulu	-2.236 (6)	-2.104 (3)	-0.719 (6)	-2.878 (2)	-5.054 (6)	-6.780 (2)	-5.330 (6)	-5.595 (4)
Blantyre	-2.883 (2)	-2.343 (3)	-2.973 (3)	-2.604 (4)	-7.326 (2)	-6.546 (2)	-6.688 (3)	-6.820 (3)
Luchenza	-0.938 (4)	-2.907 (2)	-2.878 (3)	-2.023 (3)	-6.544 (6)	-6.654 (2)	-4.420 (6)	-6.527 (2)
Bangula	-2.538 (2)	-3.031 (2)	-2.633 (2)	-1.660 (3)	-5.574 (4)	-6.166 (2)	-7.566 (2)	-7.388 (2)

Notes: The figures in parentheses are number of lags in the augmentation. The maximum number of lags used is 6. The MacKinnon critical values for the Augmented Dickey-Fuller test at 5 percent significance level are -3.46 and -2.98 for first difference.

Table 3: Extent of market integration (multivariate tests)

Trace Test	Full Sample (1989:01 - 1998:12)				Critical value 5%
H_0: rank=r	Maize	Rice	Beans	Groundnuts	
r = 0	187.20 **	235.70 **	197.40 **	218.90 **	156.00
r ≤ 1	136.20 **	173.80 **	142.20 **	158.00 **	124.20
r ≤ 2	97.75 *	122.10 **	95.51 *	114.00 **	94.20
r ≤ 3	64.31	86.24 **	64.91	77.57 **	68.50
r ≤ 4	39.89	58.19 **	41.37	47.01	47.20
r ≤ 5	21.92	34.69 *	19.67	26.54	29.70
r ≤ 6	8.10	15.36	8.07	9.79	15.40
r ≤ 7	0.78	0.26	0.18	0.08	3.80
	Before Reform (1989:01 - 1995:03)				Critical value 5%
H_0: rank=r	Maize	Rice	Beans	Groundnuts	
r = 0	168.20 **	184.7 **	202.00 **	189.10 **	156.00
r ≤ 1	115.30	137.8 **	134.30 *	133.30 *	124.20
r ≤ 2	74.58	98.55 *	90.94	86.91	94.20
r ≤ 3	50.36	64.49	61.96	54.48	68.50
r ≤ 4	31.14	40.67	34.78	31.26	47.20
r ≤ 5	13.53	25.23	18.86	17.09	29.70
r ≤ 6	5.31	10.19	7.39	8.01	15.40
r ≤ 7	0.47	3.28	0.92	2.13	3.80
	After Reform (1995:04 -1998:12)				Critical value 5%
H_0: rank=r	Maize	Rice	Beans	Groundnuts	
r = 0	232.4 **	219.3 **	249.80 **	306.40 **	156.00
r ≤ 1	150.3 **	157.6 **	154.50 **	202.00 **	124.20
r ≤ 2	83.08	103.7 **	104.00 **	140.70 **	94.20
r ≤ 3	50.75	61.45	67.28	88.85 **	68.50
r ≤ 4	28.19	32.70	38.21	48.65 *	47.20
r ≤ 5	14.34	15.65	17.76	21.22	29.70
r ≤ 6	6.51	7.93	6.18	7.91	15.40
r ≤ 7	0.28	2.04	0.60	3.31	3.80

Notes: ** significant at 1 percent level, * significant at 5 percent level

Table 4: Weak exogeneity tests (Chi-squared tests)

Market	Maize		Rice		Beans		Groundnuts	
	^{2}	*p-value*	^{2}	*p- value*	^{2}	*p-value*	^{2}	*p-value*
Karonga	14.40 *	0.045	13.98	0.052	16.92 *	0.018	24.12 **	0.001
Mzuzu	22.78 **	0.002	30.42 **	0.000	16.05 *	0.025	23.89 **	0.001
Nkhotakota	36.06 **	0.000	35.77 **	0.000	40.05 **	0.000	25.43 **	0.001
Lilongwe	26.88 **	0.000	24.53 **	0.001	13.04	0.071	30.13 **	0.001
Lizulu	21.20 **	0.000	16.43 *	0.022	17.73 *	0.013	21.75 **	0.003
Blantyre	8.66	0.278	27.15 **	0.000	11.69	0.111	12.90	0.075
Luchenza	20.11 **	0.005	17.04 *	0.017	25.14 **	0.001	20.70 **	0.004
Bangula	17.46 **	0.015	22.24 **	0.002	19.67 *	0.006	20.68 **	0.004

Notes: ** significant at 1 percent level, * significant at 5 percent level

Table 5: Short-run and adjustment speed coefficients

Dependent Market	Maize: Blantyre		Rice: Karonga		Beans: Lilongwe	
	b_0	g	b_0	g	b_0	g
Karonga	0.0173	-0.0516	-	-	0.2957 **	-0.2538 **
Mzuzu	0.1061	-0.1210 *	0.7268 **	-0.6650 **	0.4043 **	-0.2445 **
Nkhotakota	0.0105	-0.1688 **	0.7143 **	-0.4321 **	0.2551 **	-0.1929 **
Lilongwe	0.3123 **	-0.0975 +	0.7464 **	-0.3310 **	-	-
Lizulu	0.2127 *	-0.1535 *	0.6659 **	-0.4310 **	0.4627 **	-0.3535 **
Blantyre	-	-	0.7325 **	-0.5528 **	-	-
Luchenza	0.2970 +	-0.2934 **	0.7571 **	-0.5341 **	0.3166 **	-0.0979
Bangula	0.3418 *	-0.1658 **	0.5560 **	-0.3488 **	0.0607	-0.1343 **

Dependent Market	Beans: Blantyre		Groundnuts: Blantyre	
	b_0	g	b_0	g
Karonga	0.2004 **	-0.1994 **	0.4784 **	-0.2994 **
Mzuzu	0.2404 **	-0.3500 **	0.3165 **	-0.2918 **
Nkhotakota	0.1824 **	-0.3169 **	0.2878 *	-0.3009 **
Lilongwe	-	-	0.3689 **	-0.3440 **
Lizulu	0.5187 **	-0.5025 **	0.2189 *	-0.3212 **
Blantyre	-	-	-	-
Luchenza	0.2218 **	-0.2557 **	0.2767 **	-0.1853 **
Bangula	0.0819	-0.1045 **	0.2460 **	-0.1427 **

Notes: ** significant at 1 percent level, * significant at 5 percent level, + significant at 10 percent

Source: Tables A1 - A5.

Appendix

Figure A1: Trends in nominal spatial prices for food crops

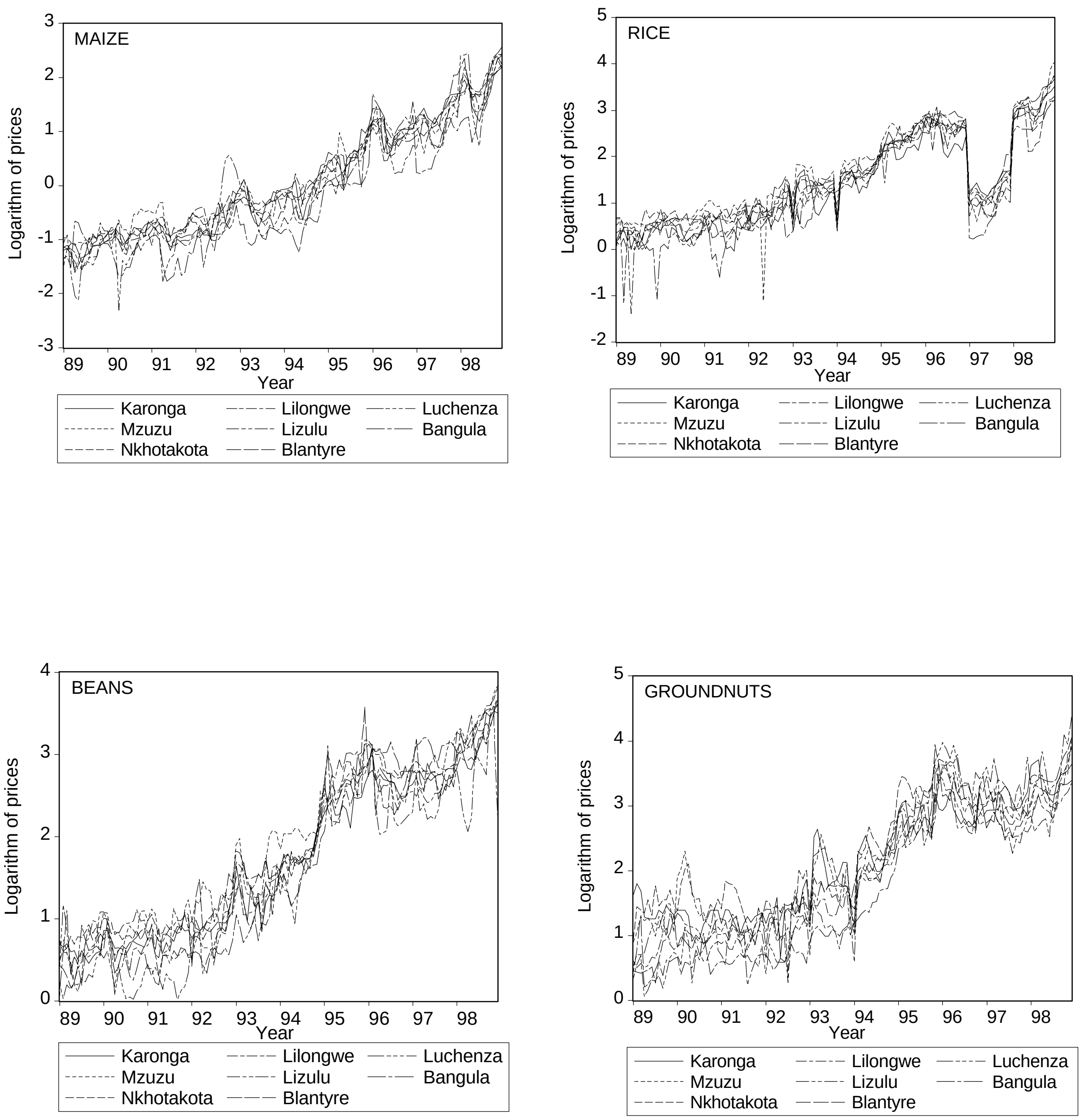

Table A1 : ECM models and price transmission for maize prices with Blantyre prices as exogenous

	Karonga		Mzuzu		Nkhotakota		Lilongwe		Lizuli		Luchenza		Bangula	
Variables	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*
constant	0.1118	0.006	0.1205	0.019	0.1831	0.000	0.1311	0.003	0.0848	0.087	0.1485	0.086	0.0289	0.617
Δp^i, t-1	-0.2142	0.012	-0.1068	0.274	-0.0451	0.638	-0.0395	0.675	0.0057	0.955	-0.1043	0.322	0.0054	0.958
Δp^i, t-2	-0.2227	0.005	-0.1301	0.183	-0.1709	0.063	-0.2733	0.002	0.1541	0.093	0.1036	0.332	0.0416	0.669
Δp^i, t-3	-	-	-	-	-	-	-	-	-	-	-	-	-0.0695	0.463
Δp^i, t-4	-	-	-	-	-	-	-0.1599	0.082	-	-	-	-	-0.0024	0.979
Q2	-0.2407	0.000	-0.0605	0.205	-0.1162	0.008	-0.3147	0.000	-0.1106	0.042	-0.0345	0.709	-0.0179	0.815
Q3	0.0435	0.250	-0.0361	0.433	0.0042	0.919	-0.1657	0.003	0.0436	0.424	0.1348	0.091	0.0666	0.352
Q4	0.0350	0.340	0.0377	0.392	-0.0054	0.891	-0.0443	0.360	0.0376	0.448	0.1303	0.093	0.0508	0.448
Δp^j, t	0.0173	0.817	0.1061	0.238	0.0105	0.895	0.3123	0.001	0.2127	0.034	0.2970	0.057	0.3418	0.013
Δp^j, t-1	0.0951	0.216	0.1935	0.061	-	-	0.1947	0.086	0.3002	0.009	0.0551	0.761	0.2726	0.077
Δp^j, t-2	-	-	0.1123	0.234	-	-	0.0067	0.948	0.0621	0.568	0.0253	0.874	0.0147	0.923
Δp^j, t-3	-	-	-	-	-0.0205	0.804	-	-	-	-	-	-	-0.1862	0.224
Δp^j, t-4	-0.0994	0.149	-	-	-0.1362	0.100	-	-	-	-	-	-	-0.0734	0.608
ECT, t-1	-0.0516	0.247	-0.1210	0.035	-0.1688	0.004	-0.0902	0.075	-0.1535	0.012	-0.2934	0.000	-0.1658	0.007
R^2	0.4645		0.2082		0.2460		0.4577		0.3537		0.2562		0.2227	
F	10.119	0.000	3.127	0.002	3.807	0.000	8.777	0.000	6.508	0.000	4.019	0.000	2.226	0.013
N	115		117		115		115		117		115		115	

Notes: *coeff*stands for coefficient and *p-v* stands for the probability of rejecting the null hypothesis that the coefficient is equal to zero, F is the F-test of the null hypothesis that all coefficient are equal to zero.

Table A2 : ECM models and price transmission for rice prices with Karonga prices as exogenous

	Mzuzu		Nkhotakota		Lilongwe		Lizuli		Blantyre		Luchenza		Bangula	
Variables	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*
constant	0.1886	0.005	0.0660	0.203	0.0092	0.879	-0.1648	0.004	0.0142	0.744	-0.0802	0.093	-0.1531	0.034
Δp^i, t-1	-0.0633	0.585	-0.1189	0.203	-0.1378	0.229	-0.1433	0.041	-0.0037	0.970	0.0240	0.832	-0.0081	0.933
Δp^i, t-2	-0.0448	0.641	-	-	-0.0069	0.950	-	-	-0.0275	0.704	0.1640	0.124	-	-
Δp^i, t-3	-	-	-	-	0.0048	0.964	-0.0659	0.299	-	-	0.1151	0.226	0.0357	0.697
Δp^i, t-4	-	-	-	-	0.0472	0.625	-	-	-	-	-	-	-	-
Q2	-0.0508	0.513	0.0213	0.737	0.0037	0.955	0.0389	0.596	0.0503	0.398	0.1027	0.111	0.0213	0.816
Q3	0.0561	0.496	0.1091	0.104	0.2069	0.009	0.2358	0.002	0.1967	0.002	0.1856	0.009	0.2171	0.024
Q4	0.0025	0.973	0.0906	0.153	0.0644	0.334	0.1858	0.015	0.1613	0.008	0.1352	0.025	0.0103	0.909
Δp^j, t	0.7268	0.000	0.7143	0.000	0.7464	0.000	0.6659	0.000	0.7325	0.000	0.7571	0.000	0.5560	0.000
Δp^j, t-1	-0.0177	0.907	0.0098	0.932	0.0257	0.853	-	-	-0.1736	0.088	-0.1024	0.429	0.0135	0.917
Δp^j, t-2	0.0733	0.590	0.0056	0.949	0.0346	0.797	-	-	-	-	-0.0278	0.826	-	-
Δp^j, t-3	-	-	-	-	0.0266	0.830	0.0983	0.348	-	-	-	-	0.1052	0.388
Δp^j, t-4	-	-	-	-	0.0360	0.742	0.0769	0.415	0.1361	0.063	-0.1103	0.310	-	-
ECT, t-1	-0.6620	0.000	-0.4321	0.000	-0.3310	0.001	-0.4310	0.000	-0.5528	0.000	-0.5341	0.000	-0.3488	0.000
R^2	0.5107		0.5344		0.5445		0.4961		0.5569		0.5755		0.2822	
F	12.409	0.000	15.493	0.000	9.286	0.000	11.486	0.000	14.662	0.000	12.695	0.000	4.630	0.000
N	117		117		115		115		115		115		116	

Notes: *coeff* stands for coefficient and *p-v* stands for the probability of rejecting the null hypothesis that the coefficient is equal to zero, F is the F-test of the null hypothesis that all coefficient are equal to zero.

Table A3: ECM models and price transmission for beans prices with Lilongwe prices as exogenous

	Karonga		Mzuzu		Nkhotakota		Lizuli		Luchenza		Bangula	
Variables	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*
constant	0.0370	0.277	0.0264	0.363	0.0720	0.009	-0.0143	0.800	0.0343	0.570	-0.0754	0.100
Δp^i, t-1	-0.1701	0.126	0.0141	0.866	-0.3499	0.001	-0.2423	0.097	-0.3879	0.001	0.0281	0.760
Δp^i, t-2	-0.2184	0.034	-0.1773	0.050	-0.1970	0.037	-0.3067	0.015	-0.0633	0.532	0.0269	0.749
Δp^i, t-3	-0.2169	0.023	-	-	-	-	-0.1263	0.226	-	-	-0.1862	0.022
Δp^i, t-4	0.1558	0.112	-	-	-	-	-	-	-	-	-	-
Q2	-0.0938	0.024	-0.0412	0.334	-0.0571	0.129	-0.1449	0.098	-0.0913	0.083	0.0315	0.434
Q3	-0.0606	0.107	-0.0060	0.875	-0.0640	0.073	0.0356	0.625	-0.1423	0.006	0.0215	0.590
Q4	-0.0637	0.068	0.0435	0.248	-0.0749	0.031	0.0068	0.923	-0.0111	0.810	0.0112	0.769
Δp^j, t	0.2957	0.000	0.4043	0.000	0.2551	0.000	0.4627	0.002	0.3166	0.001	0.0607	0.414
Δp^j, t-1	-0.0106	0.914	-	-	0.0918	0.281	0.2778	0.094	0.0971	0.345	-	-
Δp^j, t-2	0.0304	0.743	0.0568	0.479	-	-	0.1686	0.261	0.0220	0.811	0.0388	0.583
Δp^j, t-3	-0.0319	0.715	-0.0605	0.415	-	-	-	-	-	-	-	-
Δp^j, t-4	-0.0113	0.877	-	-	0.1327	0.062	-0.2360	0.088	-	-	0.0967	0.183
ECT, t-1	-0.2538	0.002	-0.2445	0.000	-0.1929	0.008	-0.3535	0.008	-0.0979	0.138	-0.1343	0.004
R^2	0.3783		0.3726		0.3029		0.3537		0.3015		0.1735	
F	4.728	0.000	6.994	0.000	5.070	0.000	5.124	0.000	5.036	0.000	2.184	0.024
N	115		116		115		115		115		115	

Notes: *coeff* stands for coefficient and *p-v* stands for the probability of rejecting the null hypothesis that the coefficient is equal to zero, F is the F-test of the null hypothesis that all coefficient are equal to zero.

Table A4: ECM models and price transmission for beans prices with Blantyre prices as exogenous

	Karonga		Mzuzu		Nkhotakota		Lizuli		Luchenza		Bangula	
Variables	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*
constant	0.0545	0.082	0.0676	0.049	0.0956	0.000	0.0106	0.838	-0.0655	0.239	-0.0399	0.266
Δp^i, t-1	-0.1735	0.105	0.0937	0.337	-0.3135	0.001	-0.2096	0.086	-0.2961	0.003	-	-
Δp^i, t-2	-0.2135	0.039	-0.1050	0.240	-0.1762	0.053	-0.2753	0.023	-	-	-	-
Δp^i, t-3	-0.2332	0.015	-0.0838	0.348	-	-	-0.1852	0.096	0.0666	0.481	-0.2101	0.007
Δp^i, t-4	0.1727	0.077	-	-	-	-	-	-	-0.0600	0.539	-0.0230	0.756
Q2	-0.0808	0.056	-0.0356	0.450	-0.0377	0.290	-0.1862	0.025	-0.0362	0.468	0.0176	0.643
Q3	-0.0297	0.444	0.0159	0.705	-0.0264	0.409	0.0799	0.242	-0.0640	0.196	0.0249	0.534
Q4	-0.0352	0.307	0.0740	0.056	-0.0479	0.130	0.0378	0.573	0.0241	0.601	0.0145	0.693
Δp^j, t	0.2004	0.001	0.2402	0.000	0.1824	0.001	0.5187	0.000	0.2218	0.006	0.0819	0.159
Δp^j, t-1	0.0146	0.858	-0.1052	0.150	0.0389	0.600	-	-	-0.0593	0.453	-	-
Δp^j, t-2	0.0368	0.625	-	-	0.0294	0.617	0.0941	0.439	-	-	-	-
Δp^j, t-3	-0.0057	0.935	-	-	-	-	0.0546	0.652	0.0826	0.254	0.0541	0.363
Δp^j, t-4	0.0525	0.384	-0.0053	0.930	-	-	-	-	0.0579	0.433	0.1150	0.065
ECT, t-1	-0.1994	0.006	-0.3500	0.000	-0.3169	0.000	-0.5025	0.000	-0.2557	0.003	-0.1045	0.004
R^2	0.3342		0.3296		0.3708		0.3815		0.3152		0.1772	
F	3.900	0.000	5.113	0.000	6.876	0.000	6.416	0.000	4.311	0.000	2.512	0.012
N	115		115		115		115		115		115	

Notes: *coeff* stands for coefficient and *p-v* stands for the probability of rejecting the null hypothesis that the coefficient is equal to zero, F is the F-test of the null hypothesis that all coefficient are equal to zero.

Table A5 : ECM models and price transmission for groundnuts prices with Blantyre prices as exogenous

	Karonga		Mzuzu		Nkhotakota		Lilongwe		Lizuli		Luchenza		Bangula	
Variables	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*	*coeff*	*p-v*
constant	0.2491	0.000	0.2215	0.000	0.2985	0.000	0.0557	0.173	0.0102	0.865	-0.0818	0.095	-0.0642	0.213
Δp^i, t-1	-0.1668	0.079	-0.1457	0.139	-0.2610	0.020	-0.0800	0.412	-0.1370	0.261	-0.3578	0.000	-0.2636	0.006
Δp^i, t-2	-	-	-0.0686	0.484	0.0551	0.613	-	-	-0.0894	0.421	-0.0806	0.412	-0.0457	0.550
Δp^i, t-3	-0.1367	0.101	-	-	-0.0850	0.371	-0.1427	0.110	-0.0653	0.537	-0.0364	0.693	-	-
Δp^i, t-4	-0.2504	0.004	-0.0918	0.300	-	-	-0.1431	0.093	0.1126	0.249	-	-	-	-
Q2	-0.1719	0.007	-0.1183	0.095	-0.1264	0.085	-0.0743	0.166	-0.1589	0.025	0.0105	0.857	-0.0091	0.828
Q3	-0.1154	0.067	-0.1454	0.037	-0.1786	0.017	-0.0989	0.062	-0.0837	0.271	0.0071	0.903	-0.0125	0.763
Q4	-0.1109	0.070	-0.1052	0.109	-0.0949	0.174	-0.0912	0.080	0.0502	0.469	0.1255	0.033	-0.0520	0.212
Δp^j, t	0.4784	0.000	0.3165	0.003	0.2878	0.011	0.3689	0.000	0.2189	0.046	0.2767	0.003	0.2460	0.000
Δp^j, t-1	0.2267	0.030	-	-	0.1715	0.182	0.1293	0.192	-0.0144	0.915	0.1327	0.243	0.1487	0.059
Δp^j, t-2	-	-	0.0869	0.420	0.0680	0.579	-	-	0.0052	0.970	0.1865	0.078	0.0728	0.311
Δp^j, t-3	-	-	-	-	0.0724	0.541	0.0947	0.273	-0.1042	0.393	0.2320	0.021	-	-
Δp^j, t-4	0.2346	0.018	0.0987	0.339	-	-	-	-	-0.0002	0.999	-	-	-	-
ECT, t-1	-0.2994	0.001	-0.2918	0.001	-0.3009	0.002	-0.3440	0.000	-0.3212	0.003	-0.1853	0.006	-0.1427	0.008
R^2	0.4540		0.2927		0.3761		0.3916		0.3075		0.3486		0.2601	
F	8.647	0.000	4.303	0.000	5.645	0.000	6.695	0.000	3.450	0.000	5.011	0.000	4.102	0.000
N	115		115		115		115		115		115		115	

Notes: *coeff*stands for coefficient and *p-v* stands for the probability of rejecting the null hypothesis that the coefficient is equal to zero, F is the F-test of the null hypothesis that all coefficient are equal to zero.