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Market liberalization and integration of maize markets in Malawi

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Abstract

The paper studies the extent of market integration of maize markets in Malawi in order to understand how it has been affected by market liberalization. Several measures of integration are introduced to analyze both the comovement of prices and the price adjustment process over time. Monthly retail prices of maize at eight main locations over the period January 1984 to December 1991 are considered. The main conclusion is that liberalization has increased market integration.

1. Introduction

High levels of production instability and large differences between import and export parity prices in southern Africa countries have often called for intervention in the form of price stabilization and stock holding of food surpluses (Pinckney, 1991). However, price stabilization efforts by releasing foods in good quantities in the areas of high price levels have often been thwarted by poor infrastructure and inadequate marketing institutions which could respond to the increased food availability. To improve the functioning of the markets and to reduce food insecurity, several measures have been taken in these countries through structural adjustment programmes. Market liberalization policies have formed a major component of structural adjustment in sub-Saharan Africa. The case of Malawi is typical.

The success of market liberalization and price stabilization policies depends on the strength of transmission of price signals among the markets in various regions of a country. In order to transmit the intended incentives of these policies to the beneficiaries, integration of these markets is essential. In this paper an attempt is made to understand the nature and extent of market integration among various markets with particular references to maize, the major staple food in Malawi. Information from the analysis of markets and their integration would be useful in several areas of food policy making in Malawi. Monitoring prices of food commodities in several markets is important to identify the chronically food deficit

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areas. However, given limited resources, it is not possible to monitor prices in all the villages. Thus it is essential to select markets for monitoring purposes. This could be done through an understanding of the markets which are not integrated with regional or central markets. The stabilization policies in Malawi through the use of strategic grain reserves have a national focus. Depending on the regional maize production and level of integration of maize markets among the north, central and southern regions, it may be necessary to consider regional grain reserves. It is also important to predict the changes in prices in various markets particularly in areas of chronic food deficit in order to formulate intervention strategies to prevent food insecurity. These efforts require information on the functioning of markets, which could be addressed through the specific objectives of this study. The specific objectives of the paper include:

(1) to study the extent of market integration and segmentation, and understand how it has been affected by liberalization;
(2) to test the central market hypothesis and thereby examine the appropriateness of radial models of price transmission for Malawi;
(3) to study the magnitude of price transmission and its dynamic impacts among various markets for maize;
(4) to study the speed of transmission of prices among various markets with a view of understanding the adjustment period in implementing food distribution and stabilization policies;
(5) to study the symmetry of price transmission and hence the nature of rigidity in upward and downward adjustment of prices.

The paper is organized as follows. The next section introduces the major policy issues and relates to past work. Section 3 gives information about the study area and the data used in the study. Section 4 uses cointegration techniques, to understand how liberalization has affected market integration, and the existence of central and regional markets. Section 5 explores issues related to dynamic adjustment, whereas the sixth section analyzes price rigidities. Section 7 gives the conclusions.

2. Major policy issues relating to market integration in Malawi and past work

One of the major policy reforms that Malawi has embarked on since 1987 is the liberalization of agricultural produce markets which provides a legal basis for the operation of private traders to participate in marketing activities. To enhance private trader activity, government of Malawi is also training the registered private traders to improve their planning and marketing skills. Several studies have been conducted to analyze the impact of market liberalization on the smallholder sector. Chilowa (1991) analyzed the security of rural households. He concluded that larger farmers have gained while smaller farmers have lost out due to market liberalization. According to his analysis, despite the liberalization, the constraints of land availability, low income, and inefficient distribution channels of both inputs and outputs and problems of transportation have prevented its benefits from reaching smallholder farmers.

As a result of market liberalization, Agricultural Development and Marketing Corporation (ADMARC), the only parastatal in crop procurement in Malawi, closed about 15% of its uneconomic markets (Kaluwa and Chilowa, 1990). In monitoring the effects of grain market liberalization on the income, food security and nutrition of rural households in Zomba, Peters (1992) found that private traders faced problems of competition, fluctuating prices, lack of capital for operation, and high cost of storage and transportation. According to her findings, in spite of market liberalization, ADMARC continues to be the major source for selling and buying maize from both traders and farmers. This is in contrast to the earlier expectation that the ADMARC's role as seller and buyer of the last resort will be reduced by market liberalization (Bowbrick, 1988; Scarborough, 1990). Private traders in remote areas sell their produce to the nearest ADMARC depots to maximize profits. This reduces their role in regional storage of maize (Kaluwa, 1991). To meet the seasonal shortage of food in remote areas, it has been suggested that prominent individuals should be assisted in constructing and

maintaining maize storage facilities (Kandoole and Musukwa, 1992). While these studies have attempted to understand the superficial impact of market liberalization policies, no concentrated attempt has been made to understand the factors that influence the successful implementation of market liberalization policies. Such an attempt would require, among other things, analysis of maize markets for their integration and segmentation (Silumbu, 1991).

The traditional tests of market integration have focused on correlation coefficients of spatial prices (see Lele, 1971, for India; Farruk, 1970, for Bangladesh; and Jones, 1972, for Nigeria). However, correlation coefficients mask the presence of other synchronous factors, such as general price inflation, seasonality, population growth, procurement policy, etc. Early criticism of this approach has been advanced by Blyn (1973), Harriss (1979) and Timmer (1974). More recently, contributions by Boyd and Brorsen (1986), Delgado (1986) and Ravallion (1986) have introduced time series methods in the study of market integration. Issues such as seasonality, the degree of market integration, and the short versus long-run adjustment process of prices could be precisely formulated. Further extensions of the time series methods using ARCH methods (see Engle, 1982) have been studied by Mendoza and Rosegrant (1991); a parallel line of research has introduced cointegration techniques to study long-term relations between non-stationary price series (see Engle and Granger, 1987; Ardeni, 1989; Palaskas and Harriss, 1991; Wyeth, 1992; Goodwin and Schroeder, 1991).

3. Study area and the data as they relate to market integration

Malawi is a land-locked country in southern Africa. The geography and physical structure of Malawi play an important role in the integration of its markets, partly due to the longitudinal nature of the country which has about 800 km between northern and southern most ends but only 260 km between the furthest points on east and west directions. Hills separate the country into two segments longitudinally and into four segments horizontally. The range of mountains in the north splits Karonga and Chitipa districts effectively. Again Karonga district and the rest of the country are effectively separated by the Chiweta mountain range. In the south, Chikwawa hills mountains separate Ngabu from the rest of the country. Between these two mountains the country is divided into east and west by the Dedza hills.

Agriculture generated 33% of GDP in 1990, providing 90% of all Malawians with a livelihood. The agricultural sector divides into estate and smallholder sectors. Smallholders, constituting about three quarters of the population, face poverty and increasing land pressure. Maize is the main subsistence crop for these smallholders.

The data used in the analysis are monthly

Table 1
Mean annual price margins of all markets with respect to Lilongwe (%)

Year	ADMARC	Blantyre	Lilongwe	Mzuzu	Zomba	Karonga	Nkhotakota	Msangu	Kamuzu
1984	79.7	97.0	100.0	88.6	98.7	128.0	105.4	85.3	94.4
1985	81.6	98.1	100.0	92.9	113.4	106.3	106.5	84.5	84.9
1986	70.2	103.4	100.0	83.1	93.9	99.1	72.4	80.7	73.9
1987	76.2	94.7	100.0	95.4	94.0	100.6	69.4	65.0	65.6
1988	79.9	98.0	100.0	100.0	92.8	101.2	84.0	84.5	87.8
1989	90.2	97.1	100.0	105.1	86.7	94.5	86.8	87.8	80.6
1990	76.0	108.8	100.0	93.1	96.4	77.8	86.5	117.9	92.7
1991	77.0	104.6	100.0	91.8	76.7	78.5	95.8	101.5	101.1
1992	79.1	112.6	100.0	98.1	81.4	73.1	102.4	101.3	104.6

Source: Computed based on data collected by IFPRI.
Cell (t, j) gives the average percentage difference between prices in location j and Lilongwe market at time t.

retail price data at the local markets for eight markets. The data have been put together from various sources. The National Statistical Office (NSO, 1992) collects price data for major city markets for the purposes of constructing consumer price index. These markets include Blantyre, Lilongwe, Zomba and Mzuzu cities. The data for the rural markets have been compiled from two different sources. The first is the Ministry of Agriculture's (MOA) market survey programme which collects data on 25 crop and livestock products in 18 rural markets throughout the country. This survey, which has been conducted since 1984, changed markets in 1988 by adding new markets and retaining some of the previous markets (Chidam'modzi, 1988). To have a longer time series, although data on the markets are available for the periods before and after this change, only the data from retained markets have been used in the analysis. They include data for Karonga and Nkhotakota. The second set of data collected by Ministry of Agriculture are the bi-weekly market price surveys undertaken by specific Agricultural Development Divisions (ADD). The Blantyre and Salima ADDs have been collecting data on food prices in selected rural markets. The data for Kamuzu Road and Msangu markets have been taken from the ADD records for this analysis (Salima ADD, 1992).

To gain a better understanding of the relationships of prices in different markets, we report mean annual percentage *price margins* between the capital, Lilongwe, and the other markets (see Table 1). Margins between the biggest city, Blantyre, and Lilongwe do not follow a discernable pattern over time. On average, Blantyre price margins with respect to Lilongwe have not exceeded 13% or fallen below 6%. Mzuzu-Lilongwe price margins also show no pattern. The Zomba maize price margin over Lilongwe peaked to 100% in late 1985. After 1985, however, average annual prices in Zomba remain below those in the capital. Karonga prices were on average 28% above those in Lilongwe in 1984. Between 1985 and 1988, average margins between these two cities were small. After 1989, Karonga prices fell to a level 27% below the capital. Prices in Nkhotakota are on average 18% lower than those in Lilongwe between 1986 and 1991. The Msangu-Lilongwe margin peaks in 1990 to a level showing Msangu prices to be double those in Lilongwe. Kamuzu Road prices are on average lower than Lilongwe from 1984 to 1990. Note that in 1987, prices at Nkhotakota, Msangu and Kamuzu are signifi-

Table 2
Correlation of price levels and differences

	Blantyre	Lilongwe	Mzuzu	Zomba	Karonga	Nkhotakota	Msangu	Kamuzu
Levels	1	0.916	0.867	0.84	0.814	0.849	0.797	0.833
Blantyre		1	0.908	0.838	0.853	0.837	0.807	0.865
Lilongwe			1	0.784	0.853	0.845	0.779	0.82
Mzuzu				1	0.696	0.655	0.68	0.73
Zomba					1	0.77	0.75	0.77
Karonga						1	0.813	0.844
Msangu							1	0.828
Kamuzu								1
Differences								
Blantyre	1	0.13	0.052	0.1860.059	0.101	0.029	0.026	
Lilongwe		1	0.079	0.169	0.073	−0.076	0.09	0.105
Mzuzu			1	0.239	0.081	0.139	0.106	−0.012
Zomba				1	0.012	0.08	0.105	0.056
Karonga					1	−0.013	0.117	0.066
Nkhotakota						1	0.391	0.102
Msangu							1	0.313
Kamuzu								1

Source: Computed based on data collected by IFPRI.

cantly below Lilongwe. Also note that in 1989, Lilongwe prices came closest to ADMARC than any other year in the study period.

The *correlations* of price levels and differences between the eight markets under study are reported in Table 2. The price level correlations are quite high; however, this may indicate spurious correlation due to time trends, inflation, and non-stationarity of the price series. As it will be shown in the next section, differencing will remove non-stationarity and common time trends. The correlation of price differences is much lower than the correlation of price levels suggesting a much lower degree of integration. An interesting problem is to see how close is the ranking of market links as measured by correlations of price differences and price levels. A rank correlation of 0.15 suggests that a taxonomy of market integration based only on correlations of levels is quite misleading. Markets that appear very integrated based on one measure of market integration are not integrated according to a second measure. This indicates that an exclusive reliance on one measure of market integration may be misleading and suggests the need of considering alternative measures that explore various aspects of the price transmission process.

4. Cointegration of markets

The intuitive idea behind the measurement of market integration is to understand the interaction among prices in spatially separated markets. In the extreme case of two markets A and B completely separated from each other, the prices of the same commodity should not be related to each other. If the areas where market A is located experiences a bad harvest, prices will suddenly increase. In market B, there is no reason to assume that a bad harvest has also occurred. In the absence of communication flows between the two markets, prices in B would not show any movement. On the other hand, if A and B were integrated, the price in B would also increase. This is because some food would flow from B to A decreasing the available supply in B. At the same time the price in A would be lower because of increased supply. Therefore, the co-movement of prices gives an indication of the degree of market integration. The econometric methods presented in this paper allow a detailed study of these co-movements.

The first issue is related to the *segmentation* of markets. This case would occur if price movements in market B are completely irrelevant to forecast price movements in market A. However, markets for the same commodity are rarely segmented. That may occur under situations of natural calamities or civil strife. Within the analysis of one commodity that is undertaken in this paper, a more relevant issue is to understand if there is a stable relation among prices in different localities. Prices move from time to time, and their margins are subject to various shocks, that may drive them apart or not. If in the long run they exhibit a linear constant relation then we say that they are *cointegrated.*

If two markets, A and B, are cointegrated, then there must be some sort of 'causality' running from one market to the other. The concept of causality here has to be interpreted in the limited meaning of contribution to predictability. This is the case when only the past movements of prices in one market are considered, and the issue of *Granger causality* becomes relevant (see Granger, 1969). The issue is whether lagged values of prices in market B can be used to forecast values in market A. If this is the case, then market B prices are said to Granger cause market A prices. If market B causes (in the Granger sense) market A, and market A causes market B, then there is *feedback relation* between the two markets. Only when the causation is unidirectional, then can we use the past prices of one market to forecast the prices in the other market. If the analysis can identify one market that causes other markets (in the Granger sense specified above), without being caused by them, that market can be interpreted as a *central* market. If there is only one central market, then there is a situation that is best described by a radial model. In a *radial model* of price transmission, prices in each market are dependent on their own past values and on current and past values of the central market price (see Ravallion, 1987). This

hypothesis is quite restrictive, since market networks may be organized around more than one center, for example regional centers, which may be the case when infrastructural or topographical reasons obstaculate trade flows among regions. Therefore, in the following estimation, no assumption of a central market is made.

4.1. Model

Market integration is concerned about linkages among markets. In order to study the interdependence of prices between any pair of markets i and j, it has been recently (see Palaskas and Harris, 1991; Goodwin and Scroeder, 1991; Ardeni, 1989) suggested to study if there is any relation among the prices series in the two markets, such as the one expressed by a linear relation of the type:

$$p_{i,t} = \alpha + \beta p_{j,t} + u_t \qquad (1)$$

where $p_{i,t}$ denotes the retail maize price at time t and at location i of a certain given quality, α and β are parameters to be estimated, and u_t is an error term.

Since the price series are generally nonstationary, this relation has interest only if the error term u_t is stationary, implying that price changes in regional market i do not drift far apart in the long run from regional market j. When this occurs the two series are said to be cointegrated. Engle and Granger (1987) proposed a two-step procedure for evaluating the properties of a pair of nonstationary economic time series.

In the first step, each series is taken separately and tested for the order of econometric integration, that is for the number of times the series needs to be differenced before transforming it into a stationary series. The test for integration is the Augmented Dickey–Fuller test (Dickey and Fuller, 1979). In the second step, the residual u_t of the OLS regression (1) between the two series is again tested for stationarity, with the Augmented Dickey–Fuller test.

The presence of cointegration between two series is indicative of interdependence between the two series. In other words, cointegration is indicative of non-segmentation between the two series. Cointegration analysis is a powerful tool to give a clear answer about the existence or not of relation between two economic time series. However, it is not powerful enough to highlight possible uses of market integration studies for policy analysis. This analysis is not able to tell anything about: (a) how strong is the relation between two markets; (b) how long does it take for a shock to be transmitted from one market to another; (c) if price transmission is symmetric or not.

Nevertheless, the analysis of cointegration allows to say something about *causality*. If two series are cointegrated, then Engle and Granger (1987) showed that they can be represented as an Error Correction Mechanism (ECM), as follows:

$$\Delta p_{i,t} = \gamma_0^i + \gamma_1^i p_{i,t-1} + \gamma_2^i p_{j,t-1} + \sum_{k=1}^{k=m_i} \delta_k^i \Delta p_{i,t-k} + \sum_{h=0}^{h=n_i} \phi_h^i \Delta p_{j,t-h} \qquad (2)$$

where Δ is the difference operator; m_i and n_i are the number of lags; and the γ's, δ's, and ϕ's are parameters to be estimated.

Causality from market j market i can then be tested as follows:

$$H_0: \gamma_2^i \neq 0 \qquad \phi_h^i = 0 \quad h = 1, 2, \ldots, n_i$$

A *central market* is one that causes all other markets unidirectionally, and is not caused by any

Table 3
Integration test for all samples

	Step 1		Step 2	
	No. of lags	t-statistics	No. lags	t-statistics
Blantyre	1	−0.51	2	−4.87
Lilongwe	2	−0.56	2	−5.32
Mzuzu	2	−0.88	2	−6.49
Zomba	2	−2.50	2	−5.89
Karonga	3	−1.01	2	−7.73
Nkhotakota	2	0	2	−7.74
Msangu	4	−1.62	2	−7.31
Kamuzu	4	−0.93	2	−8.78

Source: Based on data collected by IFPRI.
Step 1 is testing the hypothesis of integration of order 1 versus order 0 [I(1) versus I(0)].
Step 2 is testing the hypothesis of integration of order 2 versus order 1 [I(2) versus I(1)].
Augmented Dickey–Fuller critical value at 5% is −2.89.

of them. A weaker version of centrality involves causation within a certain region, so that a *regional center* can be defined as a market that is causing all markets in that region without being caused by them.

4.2. Results

The model has been applied to monthly retail prices of coarse maize in eight markets of Malawi spread all over the territory of the country, namely Blantyre, Lilongwe, Mzuzu, Zomba, Karonga, Nkhotakota, Msangu, Kamuzu Road. The period is January 1984 to December 1991 for a total of 96 observations.

The results of the integration test for all sample show that the series are non-stationary with their order of integration equal to one (see Table 3). Cointegration tests highlight that most of these markets have a stable long-term relations over the period of analysis, from 1984 to 1991 (see Table 4). Causality tests reveal further that Blantyre, Lilongwe and Zomba are major central markets, in the sense that their past values of prices are important to predict what happens in the remaining markets (see Table 5).

On one hand, cointegration analysis does not allow to say anything definite about the strength of market integration (see Palaskas and Harriss, 1991); on the other hand, it reveals how price relations among markets change over time. An example is to understand how liberalization in 1987 has affected market integration.

Table 4
Cointegration coefficient

	Blantyre	Lilongwe	Mzuzu	Zomba	Karonga	Nkhotakota	Msangu	Kamuzu
ALL SAMPLE								
Blantyre	0	−4.46	−5	−3.15	−2.89	−3.19	−3.74	−4.88
Lilongwe	−4.32	0	3.74	−2.95	−4.06	−3.08	3.46	−3.21
Mzuzu	−5.11	−4.09	0	−3.43	−5.49	−4.11	−2.99	2.46
Zomba	−4.35	−4.25	−4.26	0	−4.68	−3.87	−3.99	−4.45
Karonga	−3.23	−4.86	−6.08	−2.7	0	−3.87	−4.31	−5.09
Nkhotakota	−3.18	−2.94	−3.88	−2.7	−4.36	0	−0.22	−3.29
Msangu	−4.73	−4.13	−3.62	−3.78	−4.26	−2.02	0	−3.47
Kamuzu	−5.88	−5.33	−2.88	−4.39	−5.29	−4.67	−3.04	0
PRE-LIBERALIZATION								
Blantyre	0	−1.97	−1.92	−1.49	−1.83	−2.56	−0.89	−1.55
Lilongwe	−3.28	0	−1.93	1.85	−2.01	−2.49	−0.82	−1.52
Mzuzu	−2.89	−2.43	0	−1.83	−2.86	2.45	−1.94	−2.14
Zomba	−4.28	−4.08	−3.61	0	−3.6	−3.59	−4.37	−3.74
Nkhotakota	−3.65	−1.69	−2.77	−2.37	−0.02	0	−0.97	−0.96
Msangu	−3.57	−2.38	−3.1	−2.52	3.18	−3.16	0	−2.28
Kamuzu	−2.95	−2.77	−2.86	−2.95	3.16	−2.81	−3.51	0
POST-LIBERALIZATION								
Blantyre	0	−3.21	−4.25	0.33	−3.37	−3.03	−2.44	−3.46
Lilongwe	−2.32	0	−3.75	1.61	−1.9	−2.6	−2.1	−2.2
Mzuzu	−4.94	−5.04	0	−2.78	−1.87	−4.29	3.3	−4.81
Zomba	−2.48	−3.04	−2.87	0	−3.27	−3.53	3.64	−2.81
Karonga	−4.29	−3.34	−1.93	−4.16	0	−4.5	−3.5	−2.31
Nkhotakota	−3.1.	−3.33	−3.58	−1.63	−3.61	0	−2.76	−3.29
Msangu	−3.69	−3.23	−3.41	−3.02	2.81	−3.6	0	−2.44
Kamuzu	−4.5	−4.63	−3.36	2.32	−2.72	−3.83	−2.18	0

Source: Based on data collected by IFPRI.
The content of cell (i, j) gives the t − statistics to test the hypothesis that the error term in the OLS equation regressing price in market i on price of market j is stationary [I(1) versus I (0)].
Dickey–Fuller critical value at 5% level is −2.89.

Table 5
Causality tests

	Blantyre	Lilongwe	Mzuzu	Zomba	Karonga	Nkhotakota	Msangu	Kamuzu
ALL SAMPLE								
Blantyre	0	0.04	0.21	0.03	0.16	0.05	0	0.16
Lilongwe	0	0	0.17	0	0.45	0.08	0.86	0
Mzuzu	0	0	0	0.01	0.05	0.16	0.08	0.78
Zomba	0	0	0.17	0	0.13	0.19	0.46	0.13
Karonga	0	0	0	0	0	0.01	0.87	0.13
Nkhotakota	0	0	0.01	0.12	0.05	0	0.96	0
Msangu	0	0	0.2	0.01	0.08	0	0	0
Kamuzu	0	0	0.01	0	0	0.02	0.27	0
PRE-LIBERALIZATION								
Blantyre	0	0.24	0.19	0.6	0.94	0	0.19	0.25
Lilongwe	0	0	0.62	0.26	0.58	0.04	0.31	0.88
Mzuzu	0.03	0.07	0	0.58	0.81	0.71	0.2	0.09
Zomba	0.04	0.3	0.65	0	0.55	0.87	0.49	0.8
Nkhotakota	0.34	0.51	0.21	0.2	0.73	0	0.14	0.92
Msangu	0	0.17	0.49	0.08	0.94	0.1	0.0	0.3
Kamuzu	0.02	0.03	0.63	0.07	0.39	0.55	0	
POST-LIBERALIZATION								
Blantyre	0	0.17	0.15	0.46	0.52	0.16	0.02	0.32
Lilongwe	0	0	0.49	0	0.82	0.14	0.95	0.01
Mzuzu	0	0	0	0.01	0.26	0.09	0.06	0
Zomba	0.11	0.02	0.23	0	0.14	0.21	0.04	0.63
Karonga	0	0	0	0.03	0	0.02	0.25	0.02
Nkhotakota	0.4	0	0.27	0.26	0.21	0	0.84	0.03
Msangu	0	0.03	0.75	0.12	0.32	0.05	0	0.06
Kamuzu	0	0	0.08	0.01	0.14	0.07	0.54	0

Source: Based on data collected by IFPRI.
Content of cell (i, j) gives the probability of observinggreater value of the F-statistics associated to the test of the hypothesis that there is Granger-causality from market j to market i.

To study this problem the sample was divided into two subsample, the first Pre-Liberalization and the second Post-Liberalization. We see that the number of markets that were not cointegrated in the Pre-Liberalization period is much higher than in the Post-Liberalization period. That suggests that liberalization has improved the transmission of price signals among various regions of the country, strengthening the links between price series. Similarly, the analysis of causality before and after liberalization suggests that major markets such as Blantyre, Lilongwe and Zomba become more important centers in terms of their ability to predict prices in other markets when the process of price formation is progressively transferred in the hands of the private sector.

5. Dynamic adjustments

It is not enough to say that markets are integrated. One main question is to know the extent of integration. In the discussion above, segmentation occurs when there is no cointegration. *Perfect integration* would occur if the price in one market is just a translation of the price in the other market, implying that price changes are the same. The translation factor can be interpreted as a transfer cost between the two markets. However, it is only in extreme cases that perfect integration or segmentation occurs. Most of the time, intermediate degrees of integration occur. The effort of the analyst is then to make precise how to measure these different degrees. The main issue becomes that to measure the *magnitude* of price transmission. The immediate impact of price

shocks should be distinguished from the impact that is building over time. The process of price transmission usually takes time, as the result of complex dynamic adjustments. A short run and a long run can then be distinguished, and dynamic multipliers are computed.

The analysis of dynamic adjustments allows to study the *speed* of price transmission. That is, how many days, weeks, or months are needed for prices to be transmitted from one location to another? This is an issue of concern to policy makers for reasons related to planning of food distribution and price stabilization. Sometimes, the speed of the response of prices is related to the efficiency of the market system. However, rapid adjustments are just an indication of flexibility of the mechanism. They do not necessarily imply well functioning systems. Within the context of this discussion, it is important to consider the speed of adjustment as just another dimension of integration. Given two markets A and B with the same value of the magnitude of price adjustment with respect to a third market C, then the lower is the time to complete this adjustment, the better integrated the market. In other words, this suggests a new indicator of integration which is a combination of the magnitude and speed of adjustment. A ratio of the two would be an example of such and indicator; normalization of this indicator between 0 and 1, with 0 referring to minimum integration and 1 to maximum integration would allow cross country comparisons.

5.1. Model

Cointegration analysis offers a method to understand if there is any long-run relation between two markets i and j. Similarly, autoregressive processes can be used to study the dynamic process relating changes in i and j. First differences of logarithms of prices are taken because they offer an immediate interpretation in terms of percentage change; then, the coefficients of the autoregressive process measure how price changes in one location are related to price changes in another location. For every pair of market locations i and j, the following bivariate autoregressive process is estimated:

$$p_{i,t} = \sum_{k=1}^{k=m_i} \alpha_{i,k} p_{i,t-k} + \sum_{h=0}^{h=n_i} \beta_{i,h} p_{j,t-h} + X_{i,t}\gamma_i + \epsilon_{i,t} \qquad (3)$$

where $p_{i,t}$ is the percentage change of maize price in market i at time t, $p_{j,t}$ is the percentage change of maize price in market j at time t; $X_{i,t}$ are exogenous variables such as seasonal dummies and time trend; m_i and n_i are the number of lags; $\epsilon_{i,t}$ is an error term; $\alpha_{i,k}$, $\beta_{i,h}$, and γ_i are coefficients to be estimated.

In the estimation, problems of simultaneity may be encountered, related to the contemporaneous use of price in market i and in market j. Since both prices may respond to the same type of shocks, it is expected the error term $\epsilon_{i,t}$ be correlated with the percentage price change $p_{j,t}$. To overcome this problem, an instrumental variables estimation of $p_{j,t}$ has been used, taking lagged values of the prices of all markets included in the study. The three lags, one for prices in market i, one for prices in market j, and one for the instrumental variables, are determined simultaneously by application of the Akaike information criterion (see Akaike, 1969). Following Mendoza and Farris (1992), the error term of Eq. (3) is modelled as an autoregressive conditional heteroskedasticity (ARCH) process (see Engle, 1982). The ARCH model specifies the contemporaneous conditional variance as a function of past squared residuals. This specification captures the volatility clustering characteristics of time series describing asset prices, i.e., large residuals tend to be followed by large residuals and small residuals by small ones. In this formulation, the error term $\epsilon_{i,t}$ is supposed to be normally distributed with zero mean and variance h_t, where h_t is given by:

$$h_t = a_0 + \sum_{k=1}^{p} a_k \epsilon_{i,t-k}^2 \qquad a_k \geqslant 0 \quad k = 0, 1, \ldots, p \qquad (4)$$

The *extent* of market integration can be studied considering both the magnitude of price ad-

justment and the time needed to adjust. The *magnitude of price adjustment* is estimated with dynamic multipliers. Dynamic multipliers are interpreted as the effect of a price change due to a random shock or a shift in an exogenous variable. In the context of the model introduced above, the cumulative effect of a shock to price in market j on the price in market i, after k periods is:

$$\mu_k^{i,j} = \sum_{h=0}^{k} \frac{\partial E[p_i(t+h)]}{\partial p_j(t)} \tag{5}$$

The full adjustment of the dynamic process described by the model is given by the long-run dynamic multiplier, which corresponds to:

$$\mu_\infty^{i,j} = \lim_{k \to \infty} \mu_k^{i,j} \tag{6}$$

5.2. Results

Table 6 shows that the long-term multipliers, measuring the magnitude of the overall dynamic adjustment, vary very much across pairs of markets. Fifty percent of the long-term multipliers are not significantly different from zero. For the markets where the long-term adjustment is significantly different from zero, the mean of the adjustment is 0.49. Therefore, it can be concluded that overall the price adjustment is quite low. The notable exceptions are given by Mzuzu and Nkhotakota markets where prices adjustments to shocks originating in Zomba are extremely high, being above 100%. The dynamics of the adjustment is given by the interim multipliers, and may be quite complex. An initial overshooting can be

Table 6
Dynamic adjustment: Long-term multipliers, speed of adjustment, and composite indexes

	Blantyre	Lilongwe	Mzuzu	Zomba	Karonga	Nkhotakota	Msangu	Kamuzu
LONG-TERM MULTIPLIERS								
Blantyre	0.00	0.32 *	0.02	0.51 *	−0.16	0.24	0.92 *	0.46
Lilongwe	0.97	0.00	0.29 *	0.96 *	0.56	0.44	1.34	1.05
Mzuzu	−0.45	0.66	*	0.00	1.37 *	0.65 *		
Zomba	0.27	0.21 *	0.43 *	0.00	0.45 *	0.48 *	0.55 *	0.34 *
Karonga	−0.09	0.04	0.10	0.17	0.00	0.23	0.36	−0.22
Nkhotakota	0.44 *	−0.01	0.26 *	1.49 *	−0.09	0.00	0.46	0.37 *
Msangu	0.07	0.11	0.20	0.58 *	0.17 *	0.32 *	0.00	0.41 *
Kamuzu	−0.01	−0.03	0.61 *	0.38 *	0.05	0.63 *	0.33 *	0.00
SPEED								
Blantyre	0	6 *	14	5 *	10	5	10 *	8
Lilongwe	6	0	11 *	5 *	6	7	9	10
Mzuzu	2	5 *	0	5 *	3 *	6	12	8 *
Zomba	6	1 *	1 *	0	5 *	4 *	10 *	8 *
Msangu	5	4	7	2 *	10 *	1 *	0	5 *
Kamuzu	6	5	4 *	4 *	15 *	2 *	12 *	0
COMPOSITE INDEX								
Blantyre	0	0.053 *	0.001	0.103 *	0.016	0.048	0.092 *	0.058
Lilongwe	0.162	0	0.026 *	0.193 *	0.094	0.063	0.149	0.105
Mzuzu	0.227	0.132 *	0	0.275 *	0.405 *	0.117 *	0.036	0.082 *
Zomba	0.044	0.209 *	0.433 *	0	0.089 *	0.12 *	0.055 *	0.042 *
Karonga	0.029	0.009	0.01	0.025	0	0.019	0.026	0.027
Nkhotakota	0.109 *	0.002	0.037 *	0.213 *	0.011	0	0.033	0.053 *
Msangu	0.013	0.026	0.029	0.289 *	0.016 *	0.318 *	0	0.082 *
Kamuzu	0.002	0.006	0.153 *	0.094 *	0.004	0.314 *	0.027 *	0

Source: Computed based data collected by IFPRI.
* denotes that the corresponding long-term multiplier is significant at 95% level.

reversed and smaller fluctuations bring the system to the steady state. Most of the markets need a long time to complete their adjustment. The average mean adjustment is 5.7 months. Trend effects are not present; seasonal effects are detectable for all pairs of markets considered; and ARCH effects are present for several market links.

The analysis of the combined effects of magnitude and speed of adjustment is undertaken with the help of the ratios of the two measures, and is also reported in Table 6. Only for a very small number of markets this measure is significantly greater than 0.2, and the average over significant market links is 0.15, less than half the value in a country like Bangladesh (see Goletti, Ahmed and Naser, 1993). An interesting feature appears, that is the important position of Zomba market in the South, which appears well integrated with the central and southern region of the country. Lilongwe in the central region is not well integrated with the Northern region, whereas Karonga affects the neighboring Mzuzu. The surprising effect is that Blantyre in the South does not have a strong effect on other markets. Even though it has influence in predicting prices of other markets, since it is linked by causal relations with them, the overall effect, taking into consideration both magnitude and time to adjust is negligible, relative to other markets. In the design of policy, markets such as Zomba become critical to transmit the effects of price measures to the rest of the country.

6. Price asymmetry

Underlying the intuition of a well integrated marketing system is the capacity to transmit price changes across different localities. One important characteristics of this capacity is its flexibility. Flexibility of the price transmission mechanism can be specifically interpreted in terms of the *symmetry* of price adjustment. It is sometimes claimed that only price increases are transmitted to consumers, whereas traders are the main beneficiaries of price decreases. If the market system were well integrated, then price increases should be transmitted to the same extent as price decreases. This is an issue related to the rigidity of price adjustment in the marketing chain.

One of the notions widely held in developing countries is the idea that traders are able to exploit price movements to the detriment of farmers and consumers. One manifestation of such behavior is the asymmetric price response resulting from supply shocks being transmitted only in one direction. In the extreme case that would entail that when farmer's prices are low, because of a good harvest, retail prices do not go down accordingly; conversely, when farmer's prices are high retail prices go up even by a greater amount. In other words, traders would not allow the price changes to reflect changes in supply conditions. They would reduce the downward movement of prices, generating some rigidity in the market adjustment process damaging both consumers and farmers. In order to explore this issue, the framework of market integration can be extended by incorporating asymmetric price responses (see Kinnucan and Forker, 1987).

6.1. Model

In the following model some of the ideas of this literature are applied to study horizontal market integration. The main issue is whether or not price increases are transmitted across markets with the same intensity of price decreases.

Starting with the model of Eq. (3), reported here for convenience:

$$p_{i,t} = \sum_{k=1}^{k=m_i} \alpha_{i,k} p_{i,t-k} + \sum_{h=0}^{h=n_i} \beta_{i,h} p_{j,t-h} + X_{i,t}\gamma_i + \epsilon_{i,t}$$

the second term on the right-hand side can be decomposed as follows:

$$\sum_{h=0}^{n_i} p_{j,t-h}\beta_{i,h} = \sum_{h=0}^{n_i} \beta_{i,h}\left(p_{j,0} + p^{+}_{j,t-h} + p^{-}_{j,t-h}\right) \tag{7}$$

where for any variable x_t, x_t^+ is the *positive phase*, and x_t^- is the *negative phase*. Intuitively,

the positive phase associated to a time series is the cumulative sum of the positive changes of that variable. The negative phase is the cumulative sum of the negative changes. Clearly, the value of a variable can always be expressed as the sum of the positive and negative phase.

In order to define the positive and negative phase of x_t precisely, let proceed as follows. Let Px_t and Nx_t be the positive and negative increment of variable x_t, namely:

$$\begin{aligned} Px_t &= x_t - x_{t-1} \quad \text{if} \quad x_t > x_{t-1} \\ &= 0 \qquad\quad \text{otherwise} \end{aligned} \tag{8}$$

and

$$\begin{aligned} Nx_t &= x_t - x_{t-1} \quad \text{if} \quad x_t < x_{t-1} \\ &= 0 \qquad\quad \text{otherwise} \end{aligned} \tag{9}$$

Then, the positive phase is defined recursively as:

$$x_0^+ = 0$$

$$x_t^+ = x_{t-1}^+ + Px_t \tag{10}$$

The negative phase is similarly defined as:

$$x_0^- = 0$$

$$x_t^- = x_{t-1}^- + Nx_t \tag{11}$$

The initial model is then generalized, allowing the coefficients of the positive and negative phases to be different:

$$p_{i,t} = \sum_{k=1}^{n_i} a_{i,k} p_{i,t-k} + \sum_{h=0}^{m_i} \left(b'_{i,h} p^+_{j,t-h} + b''_{i,h} p^-_{j,t-h} \right) + x_{i,t} c_i + e_{i,t} \tag{12}$$

The symmetry price response hypothesis is then (see Kinnucan and Forker, 1987):

$$H_0: \sum_{k=0}^{m_i} b'_{i,k} = \sum_{k=0}^{m_i} b''_{i,k} \tag{13}$$

6.2. Results

Empirical results suggest that the price transmission mechanism in the maize retail market is characterized by symmetry. In 50 out of 56 cases examined, the hypothesis that the response of retail prices in market A to downward movements in market B is the same as the response to upward movements could not be rejected. Therefore, this result supports the belief that retailers benefit from decreases in retail prices to the same extent as they do from price increases. The symmetric price response hypothesis could not be rejected, even though some asymmetry in price response may occur at specific lags. The conclusion, however, is limited by the availability of retail prices only. When wholesale trade is considered, it is conceivable that by storing greater quantities traders can exploit price movements and generate an asymmetric price response.

7. Conclusions

This paper has examined several issues related to market integration for maize markets in Malawi. After presenting the major policy issues related to market integration in Malawi, it has introduced various models to analyze different aspects of market integration. The main limitation of the overall analysis is the lack of a framework general enough to admit the various models as special cases in the study of market integration. Cointegration coefficients and long-term dynamic multipliers have been computed, but their link needs further analysis. In spite of these limitations, several conclusions emerge.

First, almost all markets exhibit a long-term stable relation indicated by the existence of a stationary linear combination of the price series. In other words, the markets were cointegrated, suggesting a causal relationship among them. The hypothesis of market segmentation could then be excluded. Second, the number of markets that were cointegrated increased, after Liberalization took place in July 1987. Since traders were allowed to trade along with the ADMARC, prices reflected information more efficiently, and allowed the transmission of incentives along the marketing chain. Third, the pattern of causality in the Post-Liberalization period pointed out the existence of three major centers, namely Li-

longwe, Zomba and Blantyre, that are pivotal in the transmission of price signals to other markets. However, maize markets display a low level of integration, as measured by the comovements of price changes across spatially separated markets. The degree of integration is not perfect, in the sense that the adjustment of price changes to shocks originating elsewhere is not 100%. For most of the markets, this adjustment is below 50%. Fifth, the adjustment takes an average of 5.7 months. Finally, the analysis of the issue of asymmetry of price response showed that, contrary to most preconceptions, maize markets do not exhibit a downward rigidity of prices. Supply (and demand) shocks are transmitted equally, both when they tend to increase prices and when they put a downward pressure on prices.

The overall picture emerging from the analysis is that of a country where liberalization has enhanced market integration. An important lesson of the market liberalization experiment in Malawi has been the capacity of the private sector of responding to the new operating environment and improving the extent of price transmission across spatially separated markets. However, the extent of market integration is still very low. Market liberalization by itself cannot achieve a structural change in market integration unless investments in marketing infrastructure (transportation, communication, etc.) are undertaken.

References

Akaike, H., 1969. Fitting autoregressive models for prediction. Ann. Inst. Stat. Math., 21: 826–839.

Ardeni, P.G., 1989. Does the law of one price really hold for commodity prices? Am. J. Agric. Econ., 71: 661–669.

Blyn, G., 1973. Price series correlation as a measure of market integration. Indian J. Agric. Econ., 28: 56–59.

Bowbrick, P., 1988. An economic analysis of the impact of private traders on agricultural marketing. Ministry of Agriculture, Lilongwe, Malawi, 24 pp.

Boyd, M. and B.W. Brorsen, 1986. Dynamic price relationships for US and EC corn gluten feed and related markets. Eur. Rev. Agric. Econ., 13: 199–215.

Chilowa, W., 1991. Liberalization of agricultural produce marketing and household food security in Malawi. Working Paper 1991–2, Chr. Michelsen Institute, Fantoft, Norway.

Chidam'modzi, P., 1988. A note on implementing procedures for rural market price survey – agro-economic survey. Ministry of Agriculture, Lilongwe.

Delgado, C.L., 1986. A variance components approach to food grain market integration in Northern Nigeria. Am. J. Agric. Econ., 68: 970–979.

Engle, R.F., 1982. Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation. Econometrica, 50: 987–1007.

Engle, R.F. and C.W. Granger, 1987. Cointegration and error-correction: representation, estimation, and testing. Econometrica, 55: 251–276.

Farruk, M.O., 1970. The structure and performance of the rice marketing system in East Pakistan. Occas. Pap. 31, Department of Agricultural Economics, Cornell University, Ithaca, NY.

Goletti, F., R. Ahmed and F. Naser, 1993. Structural determinants of market integration. The case of rice markets in Bangladesh. International Food Policy Research Institute, Washington, DC.

Granger, C., 1969. Investigating causal relations by econometric models and cross spectral methods. Econometrica, 37: 424–438.

Goodwin, B.K. and T.C. Schroeder, 1991. Cointegration tests and spatial price linkages in regional cattle markets. Am. J. Agric. Econ., 73: 453–464.

Harriss, B., 1979. There is a method in my madness: or is it vice versa? Measuring agricultural product performance. Food Research Institute Studies, 17(2): 197–218.

Jones, W.O., 1972. Marketing staple food crops in tropical Africa. Cornell University Press, Ithaca, NY.

Kaluwa, B., 1991. Malawi food marketing: private trader operation and state intervention. In: J.B. Wyckoff and M. Rukuni (Editors) Food Security Research in Southern Africa: Policy Implications. Proc. 6th Annu. Conf. Food Security Research in Southern Africa, 28–30 October 1991.

Kaluwa, B. and W. Chilowa, 1990. Malawi: Food marketing liberalization and household food security. In: M. Rukuni and J.B. Wyckoff (Editors) Market Reforms, Research Policies and SADCC Food Security. Proc. 5th Annu. Conf. Food Security Research in Southern Africa, 12–14 November 1990.

Kandoole, B. and L. Musukwa, 1992. Household food security and the role of private traders. In: S.C. Babu, G.B. Mthindi and K.M. Mtawali (Editors) Food Security and Nutrition Monitoring in Southern Africa. Ministry of Agriculture, Lilongwe.

Kinnucan H.W. and O.D. Forkes, 1987. Asymmetry in farm-retail price transmission for major dairy products. Am. J. Agric. Econ., 69: 285–292.

Lele, U., 1971. Food marketing in India: private performance and public policy. Cornell University Press, Ithaca, NY.

Mendoza, M. and P.L. Farris, 1992. The impact of changes in government policies on economic performance (the ARCH model). J. Policy Modelling, 14: 209–212.

Mendoza, M. and M. Rosegrant, 1991. Marketing of corn in

the Philippines: market integration and the dynamics of price formation. In: M. Rosegrant and L.A. Gonzalez (Editors) The Philippines Corn Livestock Sector: Policy and Performance. IFPRI Mimeo, International Food Policy Research Institute, Washington, DC.

MOA, 1992. Area, production and yield of crops. Computer print out, Ministry of Agriculture, Lilongwe, Malawi.

Palaskas, T.B. and B. Harriss, 1991. Testing market integration: new approaches with case material from the West Bengal food economy. Institute of Economic Analysis, Oxford, UK.

Peters, P., 1992. Monitoring the effects of grain market liberalization on the income, food security and nutrition of rural households in Zomba South, Malawi. Report to N.S. Agency for International Development, Lilongwe.

Pinckney, T.C., 1991. Is market liberalization compatible with food security? Storage, trade and price policies maize in southern Africa. IFPRI mimeo, International Food Policy Research Institute, Washington, DC.

Ravallion, M., 1986. Testing market integration. Am. J. Agric. Econ., 68: 102–109.

Salima ADD, 1992. Bi-weekly market price data. Files of various years, Salima Agricultural Development Division.

Scarborough, V., 1990. Agricultural policy reforms under structural adjustment in Malawi. ADU Occas. Paper 12, Wye College, London.

Silumbu, E.B.D., 1991. Changing marketing environment: emerging pricing issues and policy in Malawi. In: J.B. Wyckoff and M. Rukuni (Editors) Food Security Research in Southern Africa: Policy Implications. Proc. 6th Annu. Conf. Food Security Research in Southern Africa, 28–30 October 1991.

Timmer, P.C., 1974. A model of rice marketing margins in Indonesia. Food Research Institute Studies, 13(2): 145–167.

Wyeth, J., 1992. The measurement of market integration and application to food security policies. Disc. Pap. 314, Institute of Development Studies, University of Sussex, UK.