MALAWI AGRICULTURAL COMMODITY EXCHANGE AND SPATIAL RICE MARKET INTEGRATION

BY

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B.Sc. Agric. (Agric. Econ.) (UNIMA)

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS OF MAKERERE UNIVERSITY

OCTOBER, 2009

DECLARATION AND APPROVAL

1. DECLARATION

I hereby declare that this thesis is my original work and effort and has not been presented in this or any other university for any award. All other sources of information have been duly acknowledged.

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2. APPROVAL

This Thesis has been submitted with our approval as supervisors.

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DEDICATION

To my darling late mum Alaida Kamkhwani, why so early mama why? I miss your love and care

May your soul rest in eternal peace

My grand parents the late Mr. and Mrs. Kamkhwani;

How I wish you were still alive to continue inspiring me. Thanks for the tears you made me shade every time I failed my exercises at kasanje primary school

My dear siblings;

Machitidwe, Daniel, Mwalisi, Anderson and Chifundo

thanks for being there for me

ACKNOWLEDGEMENTS

My sincere thanks to the Living God Almighty for all the successes granted unto me. He is always there even at a time I feel like I am alone. The study period has been a long way but He has been so faithful even when I was not faithful. I love you Lord Jesus!!!

I am deeply thankful to Dr B. Kiiza and Dr. L. Mapemba for tirelessly supervising this research work. Their guidance has been a key to the success of this thesis. I also gratefully acknowledge the invaluable support from members of staff of Makerere University and Bunda College.

Sincere gratitude also goes to the German Academic Exchange Service – Deutscher Akadamischer Austauscdienst (DAAD) for providing me with a scholarship through the African Economic Research Consortium (AERC) to pursue a Collaborative Master of Science Degree in Agricultural and Applied Economics (CMAAE) at Makerere University in Uganda.

I would also like to express my fond gratitude to my Uncles Mr. K. Kamkhwani and family and Mr. B. Kapoteza and family for indispensable financial, moral, and material support.

To my friends; Ssempa Barbara Namata, Eliam Kasambara, Robert Chirambo, Mike Chigowo, Rollins Chitika, Dorothy Tembo, Joel Mundua, Isoto Rosemary and Ruth Ssebagala thanks for the good times and your support during hard times. You have made a big difference guys.

Last but not least I am so grateful to Pastor Winter Chinamale and the entire Area 47 church of Christ and Kampala Church of Christ, your spiritual guidance has been key to my success.

ABSTRACT

There has been a growing debate regarding the role of the government and the effects of agricultural policies and interventions on agricultural markets. This therefore prompted this study to analyse the role of Malawi Agricultural Commodity Exchange (MACE) project as a market-enhancing intervention on aggregate market performance in Malawi using cointegration methods. MACE was introduced to improve agricultural market functioning through market information system. The study specifically examined the extent of spatial rice market integration, causality relationships among spatially separated markets and the dynamic adjustments of rice price series. The study used monthly price series data from 1994 to 2007 obtained from the ministry of agriculture. The data was divided into three sets; full sample, Pre-MACE and Post-MACE. Stationarity tests were done and it was noted that Salima and Bangula for full sample and Chitipa for Pre and Post-MACE price series were stationary in levels implying that these markets did not share the long-term trend with the major urban centres in Malawi in their respective samples.

Cointegration results have shown that spatial rice market integration in Malawi is on average marginally improving. Compared to Pre-MACE period, cointegration and interdependence among markets appeared to be increasing during the Post-MACE era. Cointegration has also revealed that rice markets have been operating as a unified market system over the period of study. However, the study left out other factors affecting market integration due to financial and time constraints hence this improvement can not be fully accredited to MACE intervention.

Nevertheless, since the aggregate picture observed in this study is an improvement of market integration the study recommends a promotion of MACE intervention to reach even more remote areas. The project needs to consider collecting and disseminating other market information such as trade flows, transaction costs and transfer costs. The study also recommends that further studies on market integration should take care of other structural determinants of market integration such as marketing infrastructure e.g. transportation, government policies and should consider application of the threshold autoregressive models (catering for transaction costs).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBRIVIATIONS

ADMARC	Agricultural Development and Marketing Corporation
APMB	Agricultural Production and Marketing Board
CCB	Cotton Control Board
EU	European Union
FMB	Farmers Marketing Board
ICT	Information and Communication Technologies
IDEAA	Initiative for Development and Equity in African Agriculture
KACE	Kenya Agricultural Commodity Exchange
MACE	Malawi Agricultural Commodity Exchange
MBC	Malawi Broadcasting Corporation
MCB	Maize Control Board
MIS	Market Information System
MoA	Ministry of Agriculture
NTB	Native Tobacco Board
TNM	Telecom Networks Malawi
STATA	Statistical Package for Professionals

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

There have been continued debates worldwide concerning the appropriate role of the government in the market place and the effects of agricultural policies and interventions on agricultural markets. This has therefore forced researchers to develop various methods in order to analyse market efficiency and its linkages to various agricultural policies and interventions (Galushko, 2003). Studies have observed that an intervention can only be justified if it does not enhance distortions into the market and, moreover, remedies the existing market imperfections. But how can one observe whether the policy proves to improve the functioning of the markets or results in even more inefficiency? One way to throw some light on this long-standing issue according to Uchezuba (2005) and Galushko (2003) is to analyse aggregate market performance by studying spatial market integration using co-integration methods.

Co-integration analysis is concerned with the existence of a stable relation among prices in different localities. Prices move from time to time, and their margins are subject to various shocks. When a long run linear relation exists among different series, these series are said to be co-integrated (Engle and Granger, 1987). The presence of co-integration between two series is indicative of interdependence; its absence indicates market segmentation. In particular, a segmented link is one where co-integration is rejected in both directions along which the link can be traced, where as an integrated link is one where co-integration is accepted in at least one direction (Goletti *et. al.* 1995 and Goletti and Babu, 1994).

Market integration measurement has been viewed by a number of authors as a basic tool for understanding how markets work (Ravallion, 1986). According to Barrett (1996), studies of market integration provide information on market performance which is necessary for proper policy formulation and macroeconomic modelling. If markets are not spatially or inter-temporally integrated it could be indicative that market inefficiencies exist as a result of, amongst others, collusion and market concentration which result in price fixing and distortions in the market. In such cases cross-sectional or intertemporal aggregation of demand and supply loses its logical foundation (Barrett, 1996). The result is that agricultural producers will fail to specialize according to long-run comparative advantages and gains from trade will not be realized (Baulch, 1997). This implies that if the assumptions of marketing integration hold, optimal allocation of scarce resources could be attained.

In Malawi, spatial market integration is increasingly becoming a popular and an important area of empirical research in food markets due to commencement of several policies and interventions that aim at improving food market performance. These policies and market-enhancing interventions include market liberalisation introduced in 1987 (Goletti and Babu, 1994) and Malawi Agricultural Commodity Exchange (MACE) initiated in 2004 (Phiri, 2006). The expectation from market liberalisation policies was that reduced government intervention would pave the way for well-functioning markets to emerge, providing better price and production incentives for the farmers (Rashid, 2004).

However, two decades of experience had shown unequivocally mixed results. Chirwa (2001, 1999) and Goletti and Babu (1994) reported that market liberalisation in Malawi had improved spatial market integration which implied improved market performance. On the other hand, Phiri (2006); Kherallah, *et. al*., (2002); and Chilowa (1998) noted that instead of boosting production, rapid liberalization policies resulted in output reduction in many developing and transition economies such as Malawi. This therefore revealed a shortfall in market liberalisation policies. Phiri (2006) and Goletti and Babu (1994) observed that the success of market liberalization policies depends on the strength of transmission of price signals among the markets in various regions of a country. This then necessitates the need for the development of a functional market information system. It is in this view then that MACE project was introduced to run a market information system in order to strengthen the liberalised markets (Phiri, 2006).

MACE project was specifically introduced to help farmers, especially smallholder poor farmers in remote rural areas, to access better markets and prices for their produce through a Market Information System (MIS). The successful market information system is believed to enable the price system to work as a mechanism for communicating information to both producers and consumers. For producers, prices direct resources and for consumers, prices reflect society's costs of production in a world of scarce resources (Galushko, 2003). This then has the capacity to improve market performance and efficiency. However, the success of this intervention to enhance market efficiency remains blurred as no study has been done. This therefore called for the need for this study on spatial market integration to give some light into it.

1.2 Problem Statement

In Malawi the performance of agricultural markets especially for staples remains a critical issue as it ensures that food is available and accessible to all. Agricultural markets play a vital role in food security initiatives especially in developing countries like Malawi. Therefore, any initiative that aims at enhancing the performance of the markets is an issue of concern by the majority. As such, any study that attempts to understand food-marketing performance to solve the problem of food insecurity is not only relevant but also necessary. This then implies that the study of spatial rice market integration in Malawi as it relates to Malawi Agricultural Commodity Exchange has a critical role to inform future food policy and food security initiatives.

The Malawi Agricultural Commodity Exchange is an institutional arrangement introduced to improve marketing performance in the agricultural sector by lowering transaction costs, improving market coordination, ensuring availability of price information and improving access of the poor to new input and output markets (IDEAA, 2004). By dissemination of pro-poor market information the project was expected to enhance market efficiency and competitiveness in the agricultural sector, improve bargaining power of smallholder farmers in the market place and provide a fair market price discovery mechanism (Phiri, 2006).

However, very little is known about how the agricultural markets, especially for staple food, are performing in the years following MACE intervention. There have been a lot of efforts to implement the project and enhance market efficiency and competitiveness, but its role on this area is not yet clear as no effort has been made to monitor the project and its activities. It still remains blurred as to whether there is an improvement in agricultural market performance especially for staples after MACE intervention. This study therefore attempts to fill this knowledge gap by analyzing how the extent and nature of rice market integration has improved with the genesis of the project. In this study spatial market integration is used as a proxy for market efficiency.

Studies of spatial market integration have been done in Malawi, but no study has specifically examined the role of MACE project on food market integration. As such, the extent to which spatial market integration has improved over time is not known. The nature of price transmission across markets which, implies causality relationships is also not clear. Again some important questions remain unanswered. First, if there is a price shock in one market, how much of that shock is being transmitted to the other market? Second, how long does it take for a price shock in one market to be transmitted to another market (Abdula, 2005)? Has MACE project had any impact in these areas? This study therefore attempted to provide solutions to these questions using rice markets. In Malawi, rice is the second most important food crop after maize and its role on the country's food security initiatives can not be overlooked. In Africa, rice and wheat followed by maize, yams and cassava constitute main food crops. In addition to that rice is a staple food for nearly half of the world's population.

This study was therefore essential as it helped to identify groups of integrated rice markets so that unnecessary government intervention in the agricultural markets in general and rice markets in particular may be avoided (Ghosh, 2003). Duplication of interventions to spatially separated markets can otherwise be undertaken at a higher cost (Goletti *et al.,* 1995). By giving a more detailed picture of the process of transmission of incentives across the marketing chain, knowledge of market integration is relevant to the success of policies such as market liberalization, price stabilization programmes and food security programmes (Amha, 1999).

The integration of food markets enhances regional food security by ensuring regional balance among food-deficit, food-surplus and non-food cash crop-producing regions (Goletti *et al.*, 1995). When, however, food markets are not integrated, local food scarcity will persist, as localized deficient markets fail to send the right signals to the surplus markets to attract supplies of food grains. As such, this study would help in food policy implementation to enhance the country's household food security initiatives. The study would also help policy makers to be cognizant of the fact that it takes some time for a price to be transmitted across regional markets, understand and consider the adjustment period, which might make the policy more successful. More importantly it would also aid MACE implementers to have an aggregate picture of the direction and progress of the project in meeting its objectives. This is one way of monitoring the project's impact. The results would be an indicator of performance which may be used to further refine implementation.

1.3 Objectives of the Study

The main objective of this study was to examine spatial rice market integration in Malawi following the commencement of the Malawi Agricultural Commodity Exchange project. Specific objectives were:

1) To characterise the rice markets in Malawi in terms of production trends and prices
2) To determine the extent of spatial market integration of the rice markets and understand how it has been affected by MACE intervention
3) To determine the causal relationships among spatial locations of the rice markets following the introduction of MACE intervention
4) To determine the dynamic adjustments to long-run equilibrium of spatial rice markets and understand how it has been affected by MACE intervention

1.4 Hypotheses of the Study

1) Malawi Agricultural Commodity Exchange project has had an effect on the extent of spatial integration of the rice markets
2) Malawi Agricultural Commodity Exchange project has had an effect on the long-run causality relationships among spatial locations of the rice markets
3) MACE project has had an effect on the dynamic adjustments to long-run equilibrium on spatial rice markets

CHAPTER TWO

2.0 MALAWI AGRICULTURE COMMODITY EXCHANGE (MACE) PROJECT

2.1 Background

The project became active on September 1, 2004 and is being implemented within the overall project framework of Initiative for Development and Equity in African Agriculture (IDEAA). IDEAA programme started in 1997 as a regional programme with an overall objective of improving productivity and income streams of smallholder farmers in Botswana, Lesotho, Malawi, Swaziland, South Africa and Zimbabwe with funding from the Rockefeller Foundation and Kellogg Foundation. The programme however underwent restructuring in August 2003, which was mainly influenced by the restructuring of the Kellogg Foundation and resulted into the closure of IDEAA as a regional programme in all the countries with the exception of Malawi, which was being wholly funded by the Rockefeller Foundation (IDEAA, 2004). During phase two Malawi had chosen to work on the commercialization of cassava through the development of stable cassava markets. While working on cassava, a need arose for a functional market information system to support cassava market development. This then led to the development of an agricultural Market Information System (MIS).

IDEAA-MIS aimed at providing market information and linking buyers and sellers of agricultural produce to address some problems associated with marketing of agricultural produce. The overall goal of the programme was to make markets work better for poor farmers and lower the huge risks and transaction costs that hinder market development in Malawi, working on the principle of an agricultural commodity exchange. This conceptualization of MIS then gave birth to Malawi Agriculture Commodity Exchange (MACE) to run a commodity neutral project and to ensure sustainability of the project beyond donor funding (IDEAA, 2005).

2.2 Specific Objectives of MACE

1. Facilitate linkages between sellers and buyers, exporters and importers of agricultural commodities;
2. Empower farmers, traders, processors, and other market participants with relevant and timely marketing information and intelligence that enhances their bargaining power and competitiveness in the market place;
3. Provide a transparent and competitive price discovery mechanism;
4. Harness and apply the power of information and communication technologies (ICTs) as a strategic tool for rural value addition and empowerment.

2.3 Components of MACE MIS

The Hub: The hub is the powerhouse of MACE activities and the secretariat of IDEAA. The hub receives all the information from the centres, processes it and sends it back to the centres and other interested users.

Market Information Centres (MIC): A MIC is established to manage and service a number of MIPs which are located in rural market centres. There are three MICs located in Mzuzu, Lilongwe and Blantyre. A MIC is equipped with Information and Communication Technologies (ICTs): landline and mobile phones, fax and computer with email and internet connectivity.

Market Information Point (MIP): A MIP is an information kiosk located at a rural market centre. A MIP serves as a source of marketing information and intelligence, and also as a trading floor to link buyers and sellers of commodities in a transparent and competitive manner. There are currently 10 MIPs in the following areas: Karonga, Rumphi, Jenda, Kasungu, Mitundu, Lobi, Lizulu, Liwonde, Muloza, and Mwanza.

2.4 Operations of MACE

The basic operation of MACE is to operate a Trading Floor at a MIP. This involves provision of writing boards for displaying offers and bids by sellers and buyers respectively. Other services include:

Mass media: MACE in collaboration with the Malawi Broadcasting Corporation (MBC), ICRISAT and Sasakawa global 2000 run a Radio program to disseminate price information. The MBC radio network covers the whole country even in remote areas, and is therefore widely listened to by the public, including smallholder rural farmers.

The Mobile Phone SMS: SMS is text messages sent and received with mobile phones. MACE is harnessing this technology to disseminate wholesale price market information in collaboration with Telecom Networks Malawi (TNM).

Regional and international market linkages: MACE is linked to some regional and international markets to facilitate export and import transactions. For example, Kenya Agricultural Commodity Exchange (KACE) limited.

2.5 Mace Project and Spatial Market Integration

Although MACE project is perceived as a market-enhancing strategy in Malawi to increase the performance of local markets its performance must be evaluated. Galushko (2003) observed that the study of spatial market integration is one way to measure the extent of market performance. Spatial market integration is defined by Uchezuba (2005) and Goletti (1995) as co-movement of prices, or in general, the smooth transmission of price signals and information across spatially separated markets.

In addition Ghosh (2003) described spatial market integration as a situation in which the prices of a commodity in spatially separated markets move together and price signals and information are transmitted smoothly. Uchezuba (2005) also observed that for markets to be integrated there must be free flow of goods between markets and the markets must be linked by efficient arbitrage. The efficient arbitrage condition is fulfilled when price spreads between markets are less than or equal to transaction costs. If markets are co-integrated there is evidence that the markets have a long-run relationship and that their prices in the long-run will not diverge from each other. This implies that the study of market integration usually tries to characterize the degree of co-movement of prices across spatially separated markets.

The issue of spatial market integration in Malawi is important because of its implications on household food security. Nkendah and Nzouessin (2006) observed that the concept of food security implies equilibrium between supply and demand on various markets. This however, is more effective when there is spatial integration between markets. The absence of such integration can constitute a signal of food insecurity because the technique of the arbitration which allows surplus areas to supply the deficit areas would be difficult to realize. More importantly, market integration is often used by economists as a proxy for market efficiency (Vinuya, 2003). As such, understanding of spatial rice market integration leads to understanding of the performance of rice markets and this is a pre-requisite to realisation of more effective and efficient market services. This perception according to RATES (2003) creates an incentive for boosting food production to realise sustainable household food security.

Spatial market performance may be evaluated in terms of a relationship between the prices of spatially separated markets (Uchezuba 2005). Meyer (2002) observed that spatial price behaviour in regional markets may be used as a measure of overall market performance.

Since prices are readily available and generally considered as the most reliable information on marketing systems in developing economies, market integration studies have been restricted to the interdependence of prices of spatially separated markets (Rashid, 2004). This study therefore evaluated spatial integration of rice markets in Malawi as a proxy to understanding how rice markets are performing since the commencement of MACE project.

2.6 Food Markets, Marketing Policies and Reforms in Malawi

In Malawi, during the pre-colonial era most commodity exchanges presumably took place informally with seller or buyer approaching the other when the exchange was needed. Around 1900s formal produce markets or market place started in some parts of the country notably; Blantyre, Zomba and Lilongwe. State marketing then came in around 1920s with the establishment of the Native Tobacco Board (NTB) in 1926, Maize Control Board (MCB) and the Cotton Control Board (CCB) in 1949. In 1956, all the three boards were incorporated into the Agricultural Production and Marketing Board (APMB) (Chirwa, 1999). In 1962 the Agricultural Production and Marketing Board was superseded by the Farmers Marketing Board (FMB) which was replaced by an Agricultural Development and Marketing Corporation (ADMARC) in 1971. The creation of ADMARC as a parastatal organization was meant to create a more effective and efficient market system for smallholder farmers (Nucifora, 2004).

Although ADMARC meant to reduce marketing problems in Malawi it was later recognized that state dominated enterprises were inefficient and impeded development and economic growth by severely limiting gains from specialization and trade (Phiri, 2006). Because of the importance of agriculture in the Malawian economy, Government then committed to far-reaching reforms between 1981 and 1994 of which liberalization of markets for agricultural inputs and products took a centre stage (Phiri, 2006; Chirwa, 1999 and Simler, 1997). Expectations were that reduced government intervention would quickly pave the way for well-functioning markets to emerge, providing better price and production incentives for farmers (Rashid, 2004).

However, two decades of experience with market liberalisation showed surprisingly mixed results. Instead of boosting production, empirical studies showed that rapid liberalization policies had resulted in output reduction in many developing and transition economies such as Malawi (Phiri 2006; Kherallah, et. al. 2002; and Chilowa 1998). These studies revealed that lack of efficient and effective market information system was one of the reasons for this unanticipated outcome (Phiri, 2006 and IDEAA, 2005). Goletti and Babu (1994) observed that the success of market liberalization policy depends on the strength of transmission of price signals among the markets in various regions of a country. As such development of a functional market information system becomes a pre-requisite to strengthen liberalized markets through transmission of timely and efficient market information.

This recognition saw Malawi establishing Agricultural Market Information System (MIS) as an institutional framework with an overall goal of providing market information in order to make markets work better for resource poor farmers (IDEAA, 2004). The conceptualisation of MIS gave birth to Malawi Agricultural Commodity Exchange (MACE) for sustainability of the market information system programme. MACE was intended to help farmers, especially smallholder poor farmers in remote rural areas, to access better markets and prices for their produce through market information system (MIS). It is argued that modern information and communication technology has a potential to deliver information to rural communities, and thus contribute to poverty alleviation (Mukhebi, 2004).

CHAPTER THREE

3.0 LITERATURE REVIEW

3.1 The Concept of Market and Price Analysis

In a market driven economy, the marketing system serves at both the micro and macro levels as mechanism to transmit to market participants, information that is useful in decision making. Transparent, accurate and timely price signals play a significant role in the conduct and performance of an efficient marketing system. In a competitive economy the pricing mechanism is expected to transmit orders and directions to determine the flow of market activities. Pricing signals guide and regulate production, consumption and marketing decisions over time, form and space (Kohls and Uhl, 1998). Identifying the causes of differences in prices in interregional or spatially separated markets has therefore become an important economic analytical tool to understand markets better. The next section explores this concept.

3.1.1 *Spatial Arbitrage Price Analysis*

According to Negassa *et.al.* (2003), the price relationships between spatially separated markets are generally analyzed within the framework of spatial price equilibrium theory developed by Enke (1951), Samuelson (1964) and Takayama and Judge (1964). The key assumption underpinning spatial price equilibrium theory is that price relationships between spatially separated competitive markets depend on the size of transaction costs. This implies that the principle underlying the differences between regions in a competitive market structure with homogeneous commodities is that price differences between any two regional markets that trade with each other should equal transaction cost, while in a situation of autarky price differences will be less than or equal to transaction costs (Tomek and Robinson, 1990). These are called spatial arbitrage conditions (Faminow and Benson, 1990).

When the price difference between different markets exceeds transaction costs, arbitrage opportunities will be created and profit seeking merchants will seek to exploit such opportunities, by purchasing commodities from a low-price surplus market and transferring them to a higher-priced deficit market.

Arbitrage opportunities occur only when the deviation in prices is substantial enough for potential profit to exceed the cost of trading. This will raise prices in the surplus region and reduce them in the deficit region (Tomek and Robinson, 1990). This concept of constant market price and arbitrage are consistent with the “law of one price” (LOOP). The "law of one price" states that, under competitive market conditions, all prices within a market are uniform after taking into consideration the cost of adding place, time and form utility to the products within the market (Kohls and Uhl, 1998). The LOOP is useful in determining the size of a market, predicting price changes within a market and evaluating the pricing efficiency of a market (Kohls and Uhl, 1998). Failure of one or more regions to adhere to the LOOP means that the regions may not be linked by arbitrage, or certain factors act as impediments to efficient arbitrage e.g. trade barriers, government intervention policy, imperfect information and risk aversion.

3.1.2 *Spatial Market Integration*

Spatial market integration refers to co-movement of prices across spatially separated markets (Uchezuba, 2005). In the case of two trading markets (A and B), market integration implies that price changes in one market are manifested to an identical price response in the other market (Vinuya, 2007 and Goletti *et al.*, 1995). The intuitive idea behind the measurement of market integration is to understand the interaction among prices in spatially separated markets. Figure 1 illustrates this concept and dynamics of integration between two markets.

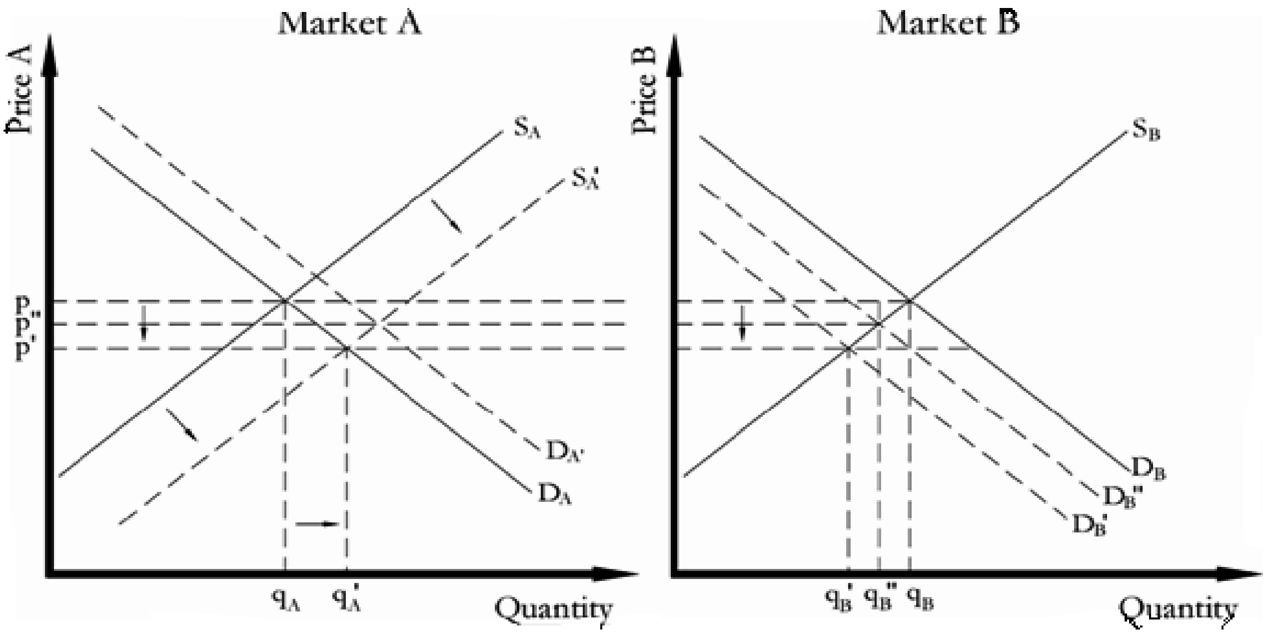


Figure 1: Interaction Between Two Markets; Source: Vinuya (2007)

Vinuya (2007) stated that if there are two markets A and B, which are completely separated from each other, the prices of the same commodity should not be related. If for example in an area where market A is located experiences a supply shock due to 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 information flows between the two markets, prices in B would not show any movement. However 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 than in the absence of market integration (Vinuya, 2007 and Goletti *et.al*., 1995). This co-movement of prices will equilibrate prices at p' in both markets and Vinuya (2007) calls this principle the Law of One Price (LOOP). Therefore, the co-movement of prices gives an indication of the degree of market integration.

Goletti *et.al*. (1995) further noted that for two pairs of markets (A, B) and (A′, B′) exhibiting the same price co-movement can show a different process of price adjustment. This suggests that the dynamics of price adjustment may also give important information about the integration of the two markets. If, for example, price shocks from A to B take longer to be transmitted than from A′ to B′, even though the index of price co-movement between A and B is the same as between A′ and B′, then the second pair is more integrated than the first one.

Market integration can also be defined as a measure of the extent to which demand and supply shocks in one location are transmitted to other locations (Negassa *et al.*, 2003). Barrett (1996) distinguished market integration into (i) vertical market integration involving different stages in marketing and processing channels, spatial integration relating to spatially distinct markets, and (ii) inter-temporal market integration which refers to arbitrage across periods of time. Based on the definition by Gonzalez-Revera and Helfand (2001), a market within a distinct location is considered integrated if physical flows of goods and services exist among the locations and there is evidence of a long run relationship. These criteria are important in identifying the sets of locations that are directly or indirectly spatially linked by trade. In light of these assertions several studies have attempted to provide a better understanding of how specific markets work through different measurements of market integration. Goletti *et. al*., (1995) and Goletti and Babu (1994) reported that the intuitive idea behind the measurement of market integration is to understand the interaction among prices in spatially separated markets.

3.2 Measures of Spatial Market Integration

3.2.1 *Bivariate Correlation Coefficients*

One simple way to study market integration is to consider the correlation of price series for different markets (Negassa *et. al.*, 2003). This is intuitively related to the idea that integrated markets exhibit prices that move together. Price correlations are the easiest way to measure these co-movements. However, the traditional tests of market integration focused on correlation coefficients of spatial prices mask the presence of other synchronous factors, such as general price inflation, seasonality, population growth, procurement policy, etc (Goletti *et. al.*, 1995).

Several researchers have therefore questioned the usability of bivariate price correlation to investigate the degree of market integration, for example:

- ✓ Negassa *et. al.* (2003) and Barrett (1996) found that bivariate price correlation may overstate the lack of price integration if a lag in market information produces a lag in the price response between markets.
- ✓ Barret (1996) argues that the bivariate approach is weak because it produces high correlation results even for markets with no physical linkage. In addition, price data of reasonably high frequency are often synonymous with the heteroscedasticity problem and a simple pair wise price correlation statistic will fail to recognize the presence of heteroscedasticity inherent in such price data series.
- ✓ Golletti *et. al.*, (1995) state that bivariate analysis masks the presence of certain factors such as general price inflation, effects of government policies, etc.
- ✓ Sexton *et. al.* (1991) and Ravallion (1986) state that bivariate price correlation assumes instantaneous price adjustment and cannot capture the dynamic nature of a marketing system. There is a high tendency of spurious market integration because the prices may tend to move together even though markets are not integrated.
- ✓ According to Delgado (1986), bivariate correlation coefficients have presented a distorted picture by indicating relatively low price correlation between the markets even in cases where evidence suggests competitive and rational behaviour by a large number of market participants. He argues that bivariate correlation analysis is a pair-wise analysis of two markets; difficulties arise when more than two markets are to be analyzed and compared.

One way to take care of some of these criticisms is to consider the correlation of price differences, which has the attractive property of interpreting market integration as interdependence of price changes in different markets. Moreover, price change would largely eliminate common trends that introduce spurious correlation (Goletti *et. al.*, 1995). Besides the problem of spurious correlation, there are other serious problems related to the often non-stationary nature of the price series involved. These problems are addressed by the co-integration analysis described in the following paragraphs.

3.2.2 *Co-Integration Analysis*

Co-integration analysis is an alternative procedure for evaluating spatial market linkage by taking the presence of stochastic trends in the price series into account. It was developed and applied in earlier work by Engle and Granger (1987) and also Engle and Yoo (1987). Co-integration analysis is concerned with the existence of a stable relation among prices in different localities. Prices move from time to time, and their margins are subject to various shocks. When a long-run linear relation exists among different series, these series are said to be co-integrated (Engle and Granger, 1987). The presence of co-integration between two series is indicative of interdependence; its absence indicates market segmentation. In particular, a segmented link is one where co-integration is rejected in both directions along which the link can be traced, whereas an integrated link is one where co-integration is accepted in both directions.

Co-integration has been regarded by many researchers as not absolute but a measure of degree of market integration (Gonzalez-Rivera and Helfand, 2001, and Goodwin and Schroeder, 1991). Spatial market prices that diverge from each other for a long time would have a weak long-run relationship while two prices that co-move are likely to be cointegrated. According to Goodwin and Schroeder (1991) various factors affect co-integration, e.g. transaction cost, risk associated in transacting business and influence of volume of trade. Low-volume markets have the tendency of large price variability and the distance between markets has a great influence on transaction costs. This idea is consistent with the findings of Goletti *et al.*, (2005) in describing the influence of structural factors in determining market integration.

According to Barrett (1996), co-integration is unfortunately not a sufficient tool for spatial market analysis. Negassa *et. al.,* (2003) and Barrett (1996) pointed out that, if transaction costs are non-stationary, a failure to find co-integration between two market price series may be completely consistent with market integration. In other words, co-integration may be assumed unnecessary, because price can be co-integrated without the market being integrated or efficient (Negassa *et. al.,* 2003; Baulch, 1997; Fackler, 1996, and Barrett, 1996). Barrett (1996) asserts that the insufficiency of co-integration as a tool for spatial market analysis stems from the fact that, if the coefficient of prices in the central market is negative, a negative relationship is observed, implying that prices move in the opposite direction rather than co-movement as indicated by the concept of market integration. The magnitude of the price co-integration coefficient may diverge far from one, contradicting the intuition behind market integration hypothesis.

Co-integration methodology has been used in Malawi by several authors. Notable ones include Chirwa (2001) whose results suggested that the markets for maize, rice, beans and groundnuts were integrated and price liberalization had enhanced the degree of market integration. Chirwa (1999) also used cointegration methods and reported that markets for rice a crop with complete price liberalization were more integrated than markets for maize in which the governments still imposed a price band for ADMARC. Goletti and Babu (1994) also applied co-integration technique and concluded that liberalization had increased market integration in Malawi. Co-integration tests highlighted that most of the markets had a stable long-term relations over the period of analysis, from 1984 to 1991. These studies, however, can not answer the question of how much MACE intervention has done to improve market integration. Much as studies have given empirical evidence that market liberalisation has improved food market integration, no study has been done in relation to the impact of MACE project.

3.2.3 *Granger Causality Analysis*

The existence of cointegration among a set of variables implies Granger causality, which, under certain restrictions, can be tested within Johansen's cointegration framework by standard Wald tests (Rashid, 2004). The Granger causality test is therefore used in order to assess the nature of price transmission across markets (and through different marketing levels). Basically, Granger Causality Test is accepted as another approach to test market integration (Abdula, 2005). Gujarati (2003) observed that a time series of prices in market *i* is said to "Granger cause" another time series of prices in market *j* if current and lagged values of prices in market *i* improve prediction of prices in market *j*. In simple words, Abdula (2005) reported causality as a basic measure of the predictability of prices, that is, price movements in one market can be used to forecast price changes in other markets.

Some empirical studies were done in Malawi applying the granger causality approach to test market integration. For example Chirwa (2001) on food pricing reforms and price transmission found Blantyre as central in the price transmission in the maize and groundnuts markets, Karonga was central in the rice markets and Blantyre and Lilongwe were central to the beans market. Chirwa (1999) also noted that Blantyre and Karonga were markets that drove prices of other markets for maize and rice, respectively. In 1994 Goletti and Babu (1994) also observed that Blantyre, Lilongwe and Zomba were the major central markets, in the sense that their past values of prices were important to predict what happens in the remaining markets. However, since the inception of MACE project no study has been done in this area, hence it is not known which markets are now influencing others.

3.2.4 *Dynamic Adjustments*

Often it is not enough to say that markets are integrated. One would like to know the extent of integration. Segmentation occurs when there is no co-integration. According to Goletti and Babu (1994) 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 (Goletti *et. al.*, 1995). However, it is only in extreme cases that perfect integration or segmentation occurs. Most of the time, intermediate degrees of integration occur. The task of the analyst is then to work out precisely how to measure these different degrees and measure the magnitude of price transmission. The immediate impact of price shocks should be distinguished from the impact that builds over time. The process of price transmission usually takes time as the result of complex dynamic adjustments. According to Ravallion (1986) a short run and a long-run can be distinguished and dynamic multipliers computed from the estimation of distributed lag equations.

The analysis of dynamic adjustments also permits the study of the speed of price transmission, i.e., 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 policymakers for reasons related to the planning of food distribution and price stabilization. Sometimes the speed of price response is related to the efficiency of the market system. However, this assumption is not always valid (Goletti *et. al.*, 1995). Rapid adjustments are just an indication of the flexibility of the mechanism. They do not necessarily imply well-functioning systems.

Chirwa (2001) applied this methodology to analysis of food pricing reforms and price transmission in Malawi. It was revealed that in the short-run, on average, the price changes in central markets explained between 18 percent (maize) and 70 percent (rice) of the variation in the price of peripheral markets. Between 15 percent and 47 percent of the price adjustment to the long-run equilibrium took place within a month. Applying the same methodology, Goletti and Babu (1994) observed that most of the markets in Malawi needed a long time to complete their adjustment period. The average mean adjustment period was found to be 5.7 months. However, it is not known whether the status is still the same since the commencement of MACE project into the market system. Hence this study was designed to fill this gap.

3.2.5 *Impulse Response Functions*

Impulse response function is a concept based on the notion that the economy's dynamic behaviour can be well explained by random impulse generated over time by a constant linear structure (Potter, 1998). This is a useful approach in giving additional information about dynamic interrelationships among market price pairs which can be used to examine the responses of prices and price pairs to shocks (Uchezuba, 2005). The concept of Impulse response functions is used to analyze the impact of price shocks and the way in which shocks are transmitted among market prices. Gallant, Rossi and Tauchen (1993) extended this notion to a non-linear time series. The standard linear technique was further improved to the non-linear case by defining a generalized impulse response function as a random variable on the underlying space of the time series (Potter, 1998).

According to Kooper *et.al.*, (1996), impulse response functions can be applied to both univariate and multivariate time series. In the case of univariate or symmetric adjustment models, the response to a price shock is independent of the history of the time series and the sign and magnitude of the postulated shock. However, Goodwin and Piggott (2001) and Potter (1995), reported that asymmetric adjustment models produce impulse response functions that are functions of the history of the price series and the sign and magnitude of the shock implying that the size and sign of the shock will influence the nature of response. In addition, Baum, Barkoulas and Mustafa (2001) observed that shocks of different magnitude have disproportionate effects and that positive and negative shocks of the same magnitude have different dynamic effects due to asymmetry based on the sign of the shock.

3.3 Empirical Applications of the Co-Integration Test

A number of authors have used co-integration analysis in the study of market integration. This section therefore reviews studies that have applied this concept of co-integration with the aim of comparing various ways the concept is used in relation to spatial market analysis. Liu and Wang (2003) used Johansen's multivariate co-integration to test for egg market integration of six Pacific states in the US using annual price data from 1960 to 1996. They found that there were physical flows among the six pacific states which indicate integration. However, the law of one price was rejected by testing linear combinations of co-integrating vectors. Due to transaction costs, the LOOP was also rejected in many other studies using the integration test involving non-stationary series (Asche *et. al.*, 2004 and Baffles 1991; Ardeni, 1989).

Thapa (2002) also used the co-integration technique to analyze the impact of Real Effective Exchange Rate (REER) on economic activities in Nepal. Based on the standard theories of aggregate demand and aggregate supply in an economy, the author tested the relationship between REER and the Gross Domestic Product (GDP). ADF test revealed that the time series data used for the study were not stationary at log levels but at first log differences and that the series had a significant time trend. The results further showed that interest rate is not important to boost economic activities while international competitiveness and labour costs are more significant variables in influencing economic activities in Nepal.

Asche *et. al*., (1999) applied the concept of co-integration and the law of one price to test for product aggregation, market integration and relationships between prices in the world salmon market from 1986 to 1996. The objective of the study was to investigate whether different species of salmon compete in the same market. The Johansen multivariate test was used to conduct tests for law of one price (LOOP) and co-integration. The results indicate that the markets were co-integrated implying that five species of salmon used in the analysis compete in the same market. They also found out that the LOOP and the composite commodity theorem hold. These findings have implications for trade restraining policy measures. The analysis supports the claims that all salmon prices move together in the long-run (co-integrate) with some short term deviations.

Diakosavvas (1995) used co-integration analysis based on the ordinary least square approach and the time varying parameter estimation approach to examine the market integration between Australian and United States (US) beef prices at the farm gate. Using monthly time series data from 1972:1 to 1993:2 co-integration was found between Australian and U.S. beef prices. The time varying convergence analysis indicates that the degree of convergence between the various price pairs has not increased over time. The result implies that Australian prices cannot be adopted as the world price in empirical analysis.

Golleti and Bapu (1994) also used the same co-integration technique in their analysis of market integration in Malawi. The authors worked with data that covered both the period before and after market reforms. The Augmented Dickey Fuller (ADF) test revealed that all series were I(1)[1] and that most of the markets were integrated with the period after reform having more integrated markets than the period before.

Goodwin and Schroeder (1991) used a co-integration test of regional price series to evaluate spatial linkages in regional cattle markets in the U.S. The aim was to determine the impacts of co-integration of several regional markets characteristics. Weekly price series were used from January 1980 through September 1987. Co-integration tests were conducted on spatial price

[1] Integrated of order one

relationships among eleven regional markets. The result was that several markets were not integrated over 1980 through 1987. Market volume, industrial concentration ratio, and distance between markets were found to significantly influence co-integration.

The concept of Impulse response functions was employed by Bekkerman *et.al.* (2009) in examining the effects a decision to build an ethanol-fuel production facility near one of the corn markets Northampton county, North Carolin on prices. Due to the proximity of the ethanol plant site to the two corn processor sites, it was expected that a rise in the demand for corn would trigger an associated rise in prices, which may have impacted, through market linkages, prices in other North Carolina corn markets. The study reported that for corn, the shock responses end between 10 and 20 weekdays while all of the shock responses in the soybean markets lasted under one week. Additionally, five of the six market pairs exhibited a movement back toward the original price parity relationship while one market pair, the resulting price pair relationship was greater than the initial shock amount.

Goodwin and Piggott (1999) utilised the nonlinear impulse response functions to evaluate the dynamic paths of adjustments to exogenous, localised shocks. The responses confirmed equilibrating responses to be consistent with price equalisation and integration of markets. Adjustments were complete after 15 days. Though modest asymmetries were revealed, positive and negative shocks generally yielded symmetric responses. However, Bekkerman *et.al.* (2009) noted that impulse response functions that use the asymmetric variable threshold model parameters indicate that the magnitude of the shock as well as the time-to-price-parity-equilibrium in the linked markets may be underestimated if a constant thresholds specification is implemented.

Bamba and Reed (2004) also used impulse response functions to trace the effect of monetary shocks on current and future values of coffee and cocoa prices in the United States. The study results indicated that a shock in money supply has a negative and immediate impact on coffee prices. Baum *et.al*. (2001) used an impulse response function to support evidence of non-linear dynamic structure to purchasing power parity (PPP). Convergence to log-run PPP in the post-Bretton Wood era was found to be low. Goodwin and Piggott (2001) used an impulse response function to study asymmetric price response to shock in U.S. corn and wheat markets. Strong evidence to support market integration was found. In their findings, responses to shocks were complete after fifteen days. Abdulai (2000) applied an impulse response function to study price transmission in Ghanaian maize markets. Wholesale maize prices in Accra and Bolgatanga were found to respond more quickly to increases than to decreases in central market prices.

In South Africa, Uchezuba (2005) also employed an impulse response function to evaluate the response in the Johannesburg market due to shocks in other local markets. The study utilised the non-linear impulse response approach of Potter (1995) also adapted by Koop *et.al.* (1996). Due to the non-stationary nature of Johannesburg prices and some other market prices, shocks emanating from Johannesburg were expected to produce either temporary or permanent responses in the alternate local market. The outcome of the analysis indicated that both positive and negative shocks lead to almost a similar pattern of adjustment. For example, it took about six to twelve months for other fresh produce markets (FPMs) to adjust completely in response to a price shock in the Johannesburg FPM. The positive and negative shocks converged to equilibrium and did not show any tendency to deviate from equilibrium in the long run. These responses were found to be consistent with long-run market integration.

Franken and Parcell (2003) used impulse response functions derived from Vector Autoregressive modeling to investigate the Law of One Price and price relationships among four Missouri grain/oilseed markets. The results were consistent with the Law of One Price, supporting the ideology that markets work, and implying that localized structural change may not significantly affect research shelf-life. The impulse response functions also illustrated little evidence that pricing patterns and linkages may have changed, following the structural changes. In most cases, the duration of a response for one market location to a shock in another market location was nearly the same length prior to and following the structural change events although some improvements were observed during the period following the structural change. For example, the duration of responses to shocks prior to the merger appeared to last 60 days, while following the merger the responses had been completed in closer to 50 days for Hannibal and Kansas City soybean markets. Thus, the Hannibal and Kansas City soybean markets responded to shocks in each other by returning to a long-run equilibrium quicker following the merger than prior.

3.4 Weaknesses and Strengths of Co-Integration Methods

Due to several criticisms levelled against conventional approaches to testing for market integration, there have been remarkable improvements and extensions over the past three decades on these methods (Rashid, 2004). However, despite these improvements Rashid (2004) and Chirwa (2001) observed that the conventional methods of market integration analyses continue to have limitations in capturing the complex intricacies of the way markets work, particularly in the developing countries. The co-integration method for example is criticized as being unreliable if: i) the transaction costs are non-stationary or are ignored (Goodwin, 2002 and Barrett, 1996) and ii) there are reversals in trade flows across markets (Barrett and Li, 2002 and Goodwin, 2002).

The argument behind non-stationarity of transaction costs is that if transaction costs are non-stationary, failure to find co-integration between two price series may be consistent with market integration (Barrett, 1996). In other words, rejection of co-integration hypothesis according to Rashid (2004) may not necessarily mean lack of market integration; it can just be a reflection of transfer costs being non-stationary. As such Barrett (1996) concluded that while co-integration 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.

Nonetheless, despite this criticism of the co-integration approach, Rashid (2004) and Chirwa (2001) observed that the conclusions of many available co-integration-based studies tend to refute this contention. Several co-integration-based studies from countries of different development levels have concluded in favour of market integration instead of finding no co-integration. For example; Heman and Fateh (2006) in Pakistan; Rashid (2004) in Uganda; Ghosh (2003) in India; Dawson and Dey (2002) in Bangladesh; Chirwa (2001) in Malawi, Gonzalez-Rivera and Hafland (2001) in Brazil and Chirwa (1999) in Malawi, found co-integration among the markets. Nonetheless, Rashid (2004) noted a few cases, such as Alexander and Wyeth 1994, where one or two locations in a given set of markets lack integration, but noted that it is hard to attribute them entirely to the non-stationarity of transaction costs.

Baulch (1997) and Barrett (1996) also raised concerns on conventional tests of market integration on the basis of ignoring transfer costs. Baulch (1997) argued that conventional methods 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 have differed with Baulch (1997) on the aptness of PBM. For example, Chirwa (2001) argued that the use of the parity bounds model rely on best estimates of transaction costs, and the model falls short of telling whether trade flows occur.

Zanias (1999) concurred with Chirwa and noted that using proxy transport costs or transaction costs may create more problems than they intend to solve. Timmer (1996) also observed that in spite of sophistication in econometric techniques the understanding of market integration requires real data on transaction costs and trade flows between spatially separated markets.

A failure of co-integration approach to distinguish various arbitrage conditions, such as autarky, efficient arbitrage, and arbitrage failure is another criticism levelled against the co-integration method (Rashid, 2004). In co-integration characterization, efficient arbitrage and arbitrage failures are reflected through integration and non-integration of markets. The autarkic conditions, however, are not distinguishable. For example, if ‘A’ and ‘B’, are two surplus markets whose price differential is less than transfer costs, then the markets will not engage in trade. But if both markets supply to a major urban location, say ‘C’, with which price differentials are large enough to cover the transfer costs, and ‘A’ and ‘B’ are integrated to ‘C’, then prices in these markets are likely to co-move over time, as price shocks in ‘C’ will be transmitted to the other two markets. In this situation, the co-integration results might indicate that all three markets are integrated, although there is no trade flow between ‘A’ and ‘B’. The failure to make this distinction is a limitation of co-integration method.

Nevertheless, Rashid (2004) argued that for a small country such as Uganda, this is hardly a problem, as neither local experts nor available market survey data suggests autarky across markets.

CHAPTER FOUR

4.0 METHODOLOGY

4.1 Field Methods

4.1.1 *Study Area*

The study focused on nine selected markets across Malawi where rice prices are collected by both the Ministry of Agriculture and Food Security and IDEAA Malawi. The markets under study are: Chitipa, Karonga and Mzuzu from Northern region; Salima, Lilongwe and Chimbiya from the Central region; Ntaja, Lunzu, and Bangula from the South and are shown in Appendix 4. Selection of the markets was based on availability of the data. Mzuzu, Lilongwe and Lunzu are the major urban markets in the northern, central and southern region respectively.

4.1.2 *Data Collection and Handling*

The study used secondary data of monthly rice prices from 1994 to 2007. The data were from the Ministry of Agriculture and Food Security supplemented by data from IDEAA Malawi. The data were cleaned by means of adjusting the prices that were two standard deviations from the yearly means as suggested by Goetz and Weber (1986). Missing values were approximated by linearly interpolating where there were one to three missing values. Where there were more than three missing values, prices from nearby market were placed for missing values because it is hypothesized under spatial arbitrage theory that prices of the same commodity in adjacent markets tend to move in unison and that they do not divert much from each other according to Tomek and Robison (1990).

The data were split into three sets; full sample (January 1994 – December 2007), Pre-MACE (January 1994 – August 2004) and post-MACE (September 2004 – December 2007) period. The data were deliberately divided into these periods in order to extract the relative importance of MACE project on spatial rice market integration in Malawi.

4.2 Analytical Methods

4.2.1 *The Concept of Market Integration*

The concept of co-integration states that if a series P_{it} (rice price in market *i* at time t) is non-stationary but its first difference is stationary, then it is said to be integrated of order one or simply integrated, and can be represented as $P_{it} \sim I(1)$. Otherwise, if P_{it} is stationary in levels it is said to be integrated of order zero and denoted as $P_{it} \sim I(0)$. If two series P_{it} and P_{jt} are both $I(1)$ then in most cases the linear combination $P_{it} - a - bP_{jt} = \varepsilon_t$ is also $I(1)$. But it is possible that ε_t is stationary, or $I(0)$. This will only happen if the trends in P_{it} and P_{jt} are said to be co-integrated with *b* as the co-integration parameter or coefficient. In general a pair of series P_{it} and P_{jt} is said to be co-integrated if they are individually I(d), *d* is the order of integration, but there exists a linear combination of them, $\varepsilon_t = P_{it} - a - bP_{jt}$, that is $I(0)$ (Greene, 2000). The task in cointegration analysis is therefore two fold. The first part is to find out if each of the pair of a time series is stationary and secondly, to difference the series until stationarity is achieved (Edriss, 2003).

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 (Uchezuba, 2005). 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-movement 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. 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 (LOOP) (Richardson, 1978), the Ravallion model (Ravallion, 1986), and the application of new econometric techniques of co-integration and Granger causality (Palaskas and Harriss-White, 1993; Alexander and Wyeth, 1994).

Given that only price information from private traders is collected in Malawi (Chirwa, 2001), this study tests the existence of long-run equilibrium relationships among the main markets using the co-integration analysis. Co-integration analysis is concerned with the existence of a stable relation among prices in different localities (Goletti *et. al.*, 1995). Prices move from time to time, and their margins are subject to various shocks. When a long-run linear relation exists among different series, these series are said to be co-integrated. The presence of co-integration between two series is indicative of interdependence; its absence indicates market segmentation. In particular, a segmented link is one where co-integration is rejected in both directions along which the link can be traced. Following Engel and Granger (1987), the co-integration model is composed of two steps: non-stationarity test using the ADF test and co-integration analysis.

4.2.1.1 Stationarity Tests of the Data

The first step in co-integration analysis involves the test for non-stationarity of the series using Augmented Dickey Fuller Test (ADF) (Vinuya, 2007; Uchezuba, 2005 and Niemi, 2003). Most economic time series data tend to exhibit non-stationary processes which imply existence of unit roots (Dawson and Dey 2002) that is, the mean is not constant and the variance is time dependent (Enders, 1995).

When a time series is non-stationary, regression in levels often display first-order serial correlation and this implies spurious or dubious regression results (Vinuya, 2007 and Niami, 2003). A time series is said to be stationary if its mean fluctuates around a constant long-run mean and the variance is finite. The ADF test which also tests for economic order of integration is therefore performed by running the regression model specified as (Gujarati, 1995):

$$P_t = \delta + \rho P_{t-1} + \varepsilon_t \qquad (1)$$

Where P_t is the rice price at time t,

P_{t-1} is the lagged rice price

δ is a constant drift,

ρ is the coefficient of lagged rice prices and

ε is error term.

Subtracting P_{t-1} from both sides of equation (1) gives:

$$\begin{aligned} P_t - P_{t-1} &= \delta + \rho P_{t-1} - P_{t-1} + \varepsilon_t \\ \Delta P_t &= (\rho - 1)P_{t-1} + \varepsilon_t \\ \Delta P_t &= \alpha P_{t-1} + \varepsilon_t \end{aligned} \qquad (2)$$

Where ΔP_t is the price difference (P_t - P_{t-1}), and α is equal to (ρ-1)

The ADF Test can also be used for testing a unit root in the presence of a drift and/or trend Vinuya (2007). According to Ghosh (2003) the test is based on the statistics obtained from applying the ordinary least squares (OLS) method to the following regression equation:

$$\Delta P_{it} = \alpha + \beta P_{it-1} + \delta T + \sum_{\gamma=1}^{k_i} \varphi_\gamma \Delta P_{it-\gamma} + \varepsilon_t \qquad (3)$$

Where: T = time trend

P_{it} = Rice price in market i at time t

Δ = (I – L) and L is a lag operator

β & φ = n x n matrices of coefficients

α & δ = vectors of constants and trend coefficients

k = lag length

The regression can be run with or without a time trend (T) depending on the nature of the price series (Dawson and Dey, 2002). Trend term is only included to make sure that the apparent lack of stationarity is not due to the presence of a deterministic trend (Bopape, 2002). *k* represents the number of lags of the price variable included and ε_t contains no autocorrelation. The lag length (k) in this study is determined using the Akaike Information Criterion (AIC).

The null hypothesis is that the particular price series is nonstationary (i.e. $H_0 : \delta=\beta=0$). Failure to reject the null hypothesis, it is assumed that there is a unit root and hence the data has to be differenced before running a regression to come up with white noise series. If the null is rejected the data are stationary and can be used without differencing. The procedure is repeated for the first differences of the price series. Once the price series are confirmed to be integrated of degree one with the rejection of the null hypothesis on the first differences, the series are deemed possible candidates for co-integration (Vinuya, 2007). The number of times needed to difference each price series to turn it stationary gives the order of integration of the series. For instance, if a price series is differenced once to turn it stationary, this series is integrated of order one and is symbolized as $I(1)$ (Uchezuba, 2005 and Niemi, 2003).

4.2.2 *Co-Integration Analysis*

Co-integration focuses on the long-run relationships between bivariate or multivariate price series. Thus, co-integration 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. If P_{it} denotes the price at market *i* at time t, and P_{jt} denote the price in market *j* at time t, the coefficient β_1 in the regression model (4) below gives the long-run relationship between these two markets only if the error term (ε_t) in the same regression model is stationary.

This can be done by applying OLS regression on one of the price series, say P_{it} on P_{jt} plus a constant. This can be represented as follows:

$$P_{it} = \delta_0 + \beta_1 P_{jt} + \varepsilon_t \qquad (4)$$

This tests whether in equation (4) (β=1) is the test of the Law of One Price. It implies that price changes in one market will be transmitted on a one-on-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 (4) are spurious. However, if the price series are integrated of the same order, then equation (4) can be used to test for co-integration using the Johansen vector autoregression (VAR) method.

Co-integration implies that there is a linear long-run relationship between price series in spatially separated markets, and is interpreted as a test that (β≠0). If (β≠0), then the price series are co-integrated and a long-run equilibrium relationship exists between the prices, and hence there exist a co-integration vector (1, -β). Co-integration 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.

4.2.3 *Johansen's Trace Tests for Co-integrating Vectors*

The Johansen VAR-based procedure (Johansen, 1988) of testing co-integration 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 co-integration vectors that exist between two or more integrated time series. The Johansen procedure can be used to test for the presence of a co-integration 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 modeled as a vector auto regression (STATACORP, 2005 and Rashid, 2004) given in 5 below:

$$\Delta P_t = \alpha + \delta t + \beta P_{t-1} + \sum_{i=1}^{k-1} \varphi_i \Delta P_{t-i} + \varepsilon_t \qquad (5)$$

Where P_t is an $n \times 1$ vector containing the series of interest (spatial prices), β and φ are n x n matrices of coefficients; $\Delta = (I - L)$ and L is a lag operator; k is lag length; α and δ are vectors of constants and trend coefficients respectively. ε_t is an identically and independently distributed n-dimensional vector of residuals with zero mean and variance matrix, Ω_ε. Since P_{t-1} is I (1), but ΔP_t and ΔP_{t-i} variables are I (0), equation (5) will be balanced if $\beta P_{t\text{-}i}$ is I(0), i.e. $\beta P_{t-1} \sim I(0)$. The β matrix is the one to convey information about the long-run relationship among variables in P_t (Ghosh, 2003).

As such Rashid (2004) noted that, the hypothesis of co-integration will be formulated as a reduced rank of β written as $H(r): \beta = \chi\pi$, where r is the rank of β that determines how many linear combinations of P_t are stationary, χ and π are n x r matrices of full rank. If $r = n$, then the variables are stationary in levels but if $r = 0$, then no linear combination of P_t is stationary. Two methods for testing reduced rank of β as reported by Uchezuba (2005), Rashid (2004) and Ghosh, (2003) are maximum eigenvalue test, known as λ_{max} test, and trace test. The null hypothesis is that there is r co-integrating vectors and is presented as:

$$H_0: \lambda_i = 0 \qquad i = r + 1 \ldots, n \qquad (6)$$

where λ_i is a measure of the strength of correlation between the co-integrating relations for $i = 1 \ldots r$.

The maximal-eigenvalue (λ – max) statistics test the null hypothesis of at most r co-integrating vectors against the alternative of r+1 and is given by:

$$\lambda_{\max} = -T \log(1 - \tilde{\lambda}_{r+1}) \qquad r = 0, 1, 2, \ldots, n - 1 \qquad (7)$$

where T is the sample size, and $(1-\tilde{\lambda}_{r+1})$ is the max-eigenvalue estimate.

The trace statistic test the null hypothesis of *r* co-integrating vectors against a general alternative hypothesis of more than *r* co-integrating vectors and is computed as:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \log(1-\tilde{\lambda}_i) \quad r = 0,\ 1,\ 2,\ \ldots,\ n\text{-}1 \qquad (8)$$

4.2.4 *Granger Causality Tests*

In order to assess the nature of rice price transmission across markets and causal relationships among spatially separated markets, the Granger causality test is used. Basically, Granger Causality Test is another approach to test market integration. A time series of prices P_{it} (rice price in market *i* at time t) is said to "Granger cause" another time series of price P_{jt} (rice price in market in *j* at time t) if current and lagged values of P_{it} improve prediction of P_{jt} (Gujarati, 1995). In other words, causality is basically a measure of the predictability of prices, that is, price movements in one market can be used to forecast price changes in other markets (Minten and Mendonza, 1998). The existence of co-integration among a set of variables implies Granger causality (Rashid, 2004), which, according to Dawson and Dey (2002), follows the Granger-causality approach and can be tested within Johansen's co-integration framework by standard Wald tests (Rashid, 2004). For a pair-wise causal relationship, this is determined by re-writing (5) in the following equivalent form:

$$\begin{bmatrix} \Delta P_{1t} \\ \Delta P_{2t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{i=1}^{k-1} \begin{bmatrix} \varphi_{i,11} & \varphi_{i,12} \\ \varphi_{i,21} & \varphi_{i,22} \end{bmatrix} \begin{bmatrix} \Delta P_{1t-i} \\ \Delta P_{2t-i} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \end{bmatrix} \begin{bmatrix} \beta_1 & \beta_2 \end{bmatrix} \begin{bmatrix} P_{1t-k} \\ P_{2t-k} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \qquad (9)$$

where subscripts denote markets and all other notations remains the same as in (5).

Causation can occur in two ways, unidirectional– where shocks in one market affect another market but not the reverse – and bidirectional where shocks in one individual market are transmitted both ways. Therefore, based on models 9, four hypotheses of causality can be tested:

1. Unidirectional causality from P_{it} to P_{jt} if the coefficients $\beta_{j,h}$ are statistically different from zero ($\beta_{j,t} \neq 0$) and the coefficients $\beta_{i,t}$ are not statistically different from zero ($\beta_{i,t}$=0)
2. Unidirectional causality from P_{jt} to P_{it} if coefficients $\beta_{j,h}$ are not statistically different from zero and the coefficients $\beta_{i,t}$ are statistically different from zero
3. Bilateral causality (both P_{it} and P_{jt} cause each other) if all coefficients α_i, δ_i, $\beta_{i,t}$ and β_{jt} are statistically different from zero.
4. Independent causality (both P_{it} and P_{jt} do not cause each other) if all coefficients α_i, δ_i, $\beta_{i,t}$ and $\beta_{j,t}$ are not statistically different from zero.

4.2.5 *Dynamic Interrelationships among Prices at Different Markets*

4.2.5.1 Short-Run Price Relationship between the Markets

Co-integration analysis is very important in understanding if a long-run relationship exists between two markets. However, the analysis does not answer two important questions. First, if there is a shock in one market, how much of that shock will be transmitted to the other market? Second, how long does it take for a price shock in one market to be transmitted to another market (Abdula, 2005)? The magnitude of the influence between markets and the speed of adjustment to shocks can be measured to determine strength (or weakness) of the market linkage, and rapidity (or sluggishness) by which markets responds and adjust to shocks. The short-run dynamics of the price series can be investigated by estimating the following error correction model for each of the price series between the peripheral and central market (Chirwa, 2001):

$$\Delta \ln P_{it} = \alpha_0 + \sum_{k=1}^{3} \partial_k S_k + \sum_{l-1}^{q-1} \alpha_l \Delta \ln P_{it-l} + \sum_{l=0}^{q-1} \varphi_l \Delta \ln P_{jt-l} + \theta ECT_{t-1} + \varepsilon_t \qquad (10)$$

where S_k are seasonal dummies (quarterly), P_{it} is the price of rice in a dependent market *i*, P_{jt} is the price of rice in independent markets *j*, ECT_{t-1} is the lagged error correction term, ε_t is the error term. The most relevant parameters according to Chirwa (2001) are the short-run parameter (φ) and the adjustment parameter (θ). The significance of the short-run parameters and the adjustment parameter has implications for causality and co-integration (Enders, 1995). If θ 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 φ_l are zero, then the price in market *j* does not Granger cause price in market *i*. In addition, the price series are co-integrated if one or both of the coefficients are significantly different from zero.

4.2.5.2 Nonlinear Impulse Response Functions

A concept of impulse response function gives additional information about the long-run dynamic interrelationships among prices. The study used nonlinear impulse response functions to analyse the dynamic paths of adjustment to localized exogenous shocks in the Malawian rice markets for the pre- and post-MACE periods. In the impulse response functions analysis it is necessary to note the nonstationarity of price data as well as the error correction properties. Due to these factors, shocks may elicit responses that are temporary, such that there is a return to the initial time path of the variables, or permanent, causing a persistent shift in the time path (Goodwin and Piggott, 2001).

The study adopted the non-linear response function following Potter (1995) which defines responses denoted as I_{t+k} basing on observed data (zt, zt-1, …), a shock, v and E[.] as the expectation operator in the following equation:

$$I_{t+k}(v, Z_t, Z_{t-1},...) = E[Z_{t+k} \mid Z_t = z_t + v, Z_{t-1} = z_{t-1,}...] - E[Z_{t+k} \mid Z_t = z_{t,} Z_{t-1} = z_{t-1,}...] \qquad (11)$$

This was done by adjusting the last observation in the time series for the Lilongwe market by one-half standard deviation to represent positive and negative shocks and the impulse was produced by estimating E[.].

CHAPTER FIVE

5.0 RESULTS AND DISCUSSION

The concept of market integration is modelled within the framework of the spatial price equilibrium model of inter-market linkages, in the point-space tradition of Samuelson (1952) and Takayama and Judge (1964). This theory is subject to production shocks and general price information. Two markets are said to be spatially integrated if, when trade takes place between them, price spreads between them are less than or equal to transaction costs. This implies that markets must be linked by efficient arbitrage conditions (Chirwa, 1999). If markets are co-integrated there is evidence that the markets have a long-run relationship and that their prices in the long-run will not diverge from each other (Uchezuba, 2005). This notion is presented in this chapter which has utilized both bivariate and multivariate error collection models.

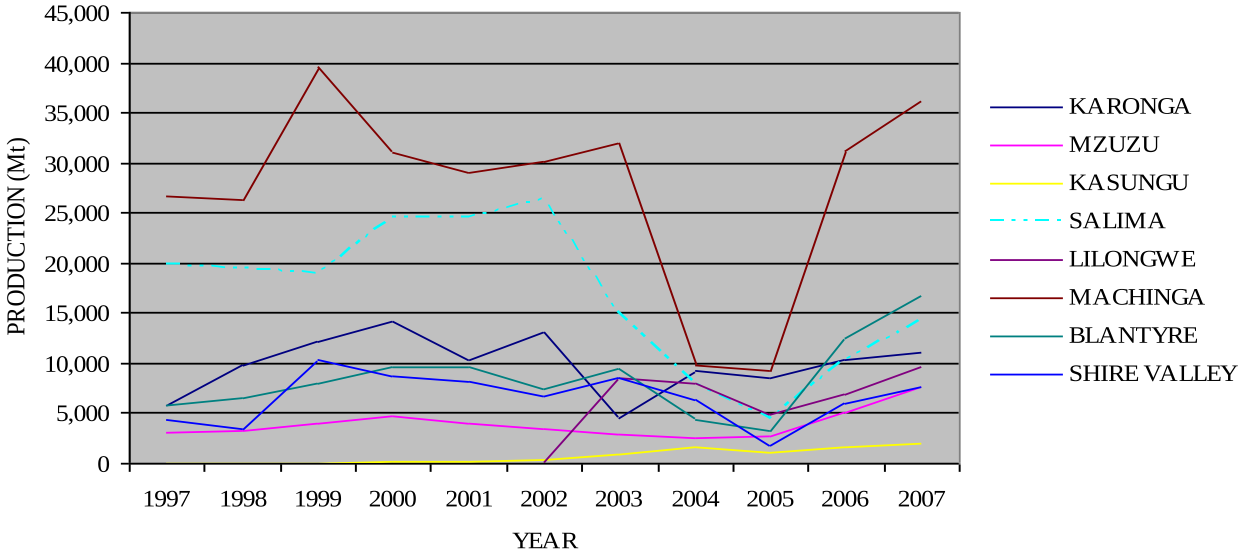
5.1 Characterising Rice Markets in Malawi

5.1.1 *Rice Production in Malawi*

The theory of market integration is highly influenced by production trends of the commodity under study (Abdula, 2005). As such it is essential to characterise rice markets in Malawi based on rice production trends. In Malawi all rice is grown by smallholder farmers, either under irrigation or rain-fed in upland areas. It is the second most important food crop after maize (RATES, 2003). Unlike maize, rice production is concentrated in specific areas which are mainly along the lakeshore due to the fact that rice requires significant amounts of water (USAID, 2008). Figure 2 shows production trends of smallholder agriculture in Malawi by Agricultural Development Division (ADD). As shown in figure 2, Machinga ADD is the largest rice producer followed by Salima ADD while Kasungu and Mzuzu are the least rice producing areas.

The figure also portrays fluctuations in production across ADDs and according to Ng'ong'ola *et. al.,* (2003) these fluctuations are attributed to erratic rainfall, drought and changes in commodity marketing. With reference to the markets in this study it is shown that in the northern region Karonga and Chitipa markets which falls under Karonga ADD are the surplus markets unlike Mzuzu market which is under Mzuzu ADD. In central region Salima market falls under Salima ADD where as Lilongwe and Chimbiya falls under Lilongwe ADD. In southern region Ntaja market falls under Machinga ADD which reports highest rice production, Lunzu falls under Blantyre ADD while Bangula falls under Shire Valley ADD. This then implies that Mzuzu, Lilongwe, Chimbiya and Lunzu markets are the major deficit markets while the rest are the surplus markets.

Figure 2: Rice Production by ADD in Malawi



5.1.2 *Price Variability*

Prices for agricultural products in different markets are largely influenced by seasonality in production, fluctuations in production and the general economic growth of the country. As such price variability becomes a common phenomenon in agricultural outputs due to stochastic nature of the products. The stochastic nature of agricultural outputs is heavily linked to natural factors such as weather and economic factors such as structural transformation in markets, length of different marketing channels, transport and other marketing infrastructure. Demand factors such as consumer habits, substitution between products and per capita income also influence prices. The consumers and other market participants can be affected by a host of daily events such as shocks that affect their behaviour and their response to prices. In turn their reactions have repercussions on other agents and the ensuing dynamic process leads to determination of prices at each point in time. As such it is of particular importance to understand the variability in prices over time and space in order to give an insight of price behaviour within the period of study. Table 1 shows the descriptive statistics and coefficient of variation of the prices of the markets.

Table 1: Descriptive Statistics of Nominal Rice Prices in Malawi Kwacha for the Period 1994 to 2007

Market	Observations	Min	Max	Mean	Std. Deviation	Std. Error	Coefficient of variation (%)
Chitipa	168	4.98	159.47	43.32	32.88	2.54	75.89
Karonga	168	3.35	144.53	40.68	33.11	2.55	81.39
Mzuzu	168	4.14	139.00	47.98	31.69	2.44	66.04
Salima	168	4.34	115.00	42.55	30.45	2.35	71.57
Lilongwe	168	5.63	128.00	49.53	33.00	2.55	66.62
Chimbiya	168	3.82	152.38	45.86	34.78	2.68	75.83
Ntaja	168	3.05	120.00	36.21	25.59	1.97	70.67
Lunzu	168	4.50	120.27	42.06	28.04	2.16	66.66
Bangula	168	3.67	123.33	40.89	30.94	2.39	75.67

Source: Survey Data

As reported in Table 1, the highest nominal price of rice across markets was observed in Chitipa with a maximum of Mk159.47 and Ntaja reported a minimum nominal price of Mk3.05. On average Lilongwe and Mzuzu reported the highest mean prices of Mk49.53 and Mk47.98 respectively. Lilongwe and Mzuzu are the two major urban centres in Malawi in addition to Blantyre. The study however, dropped Blantyre market due to data inconsistency. However, the inclusion of Lunzu which is one of the major markets in the city of Blantyre shows a highest mean price of all the southern region markets (Ntaja, Lunzu and Bangula).

Lilongwe, Mzuzu and Blantyre are major demand centres for rice and hence higher prices (Chirwa, 1999). The lowest mean nominal rice prices are reported in Ntaja, Bangula, and Karonga. These areas were observed by Chirwa (2001) as main rice producing areas in Malawi. The rice prices show high variability across markets. As shown in table 1 the highest variability is observed at Karonga with a coefficient of variation of 81.39% and lowest variability of 66.04% is observed at Mzuzu market. This then implies that the rice prices have been more variable over the years. This phenomenon can be attributed to fluctuations in rice production and more importantly due to inflation.

5.1.3 *Seasonality and Trend*

Agricultural commodity prices vary annually and portray trends and cycles or seasonal patterns. This behaviour in time series data can be depicted graphically as suggested by Tomek and Robinson (1990). In this study figures; 3, 4 and 5 are a graphical representations showing these annual variations in nominal rice prices in the markets under study for the Northern, Central and Southern regions respectively.

Figure 3: Nominal Rice Price Levels and Time in the Northern Region

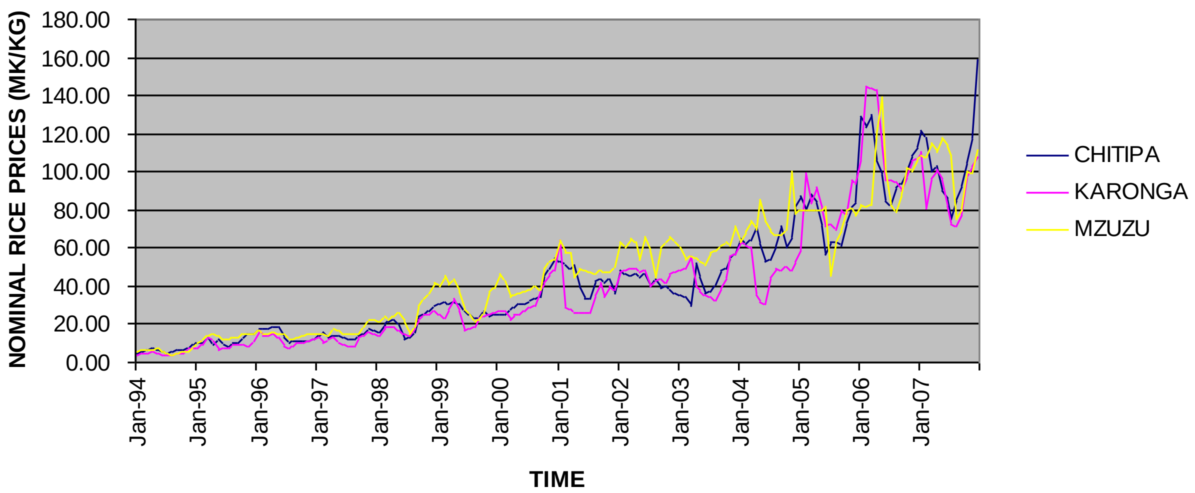


Figure 4: Nominal Rice Price Levels and Time in the Central Region

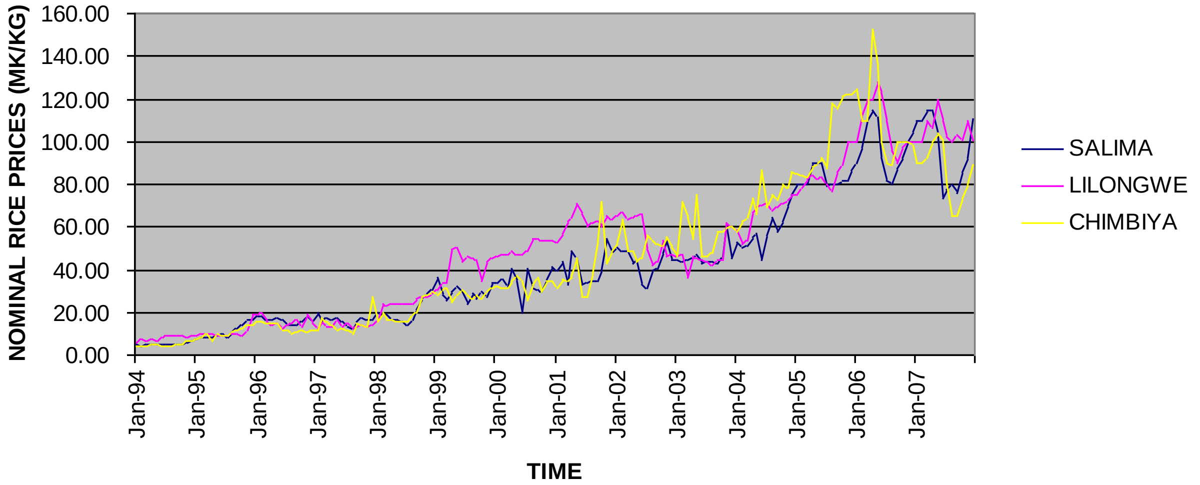
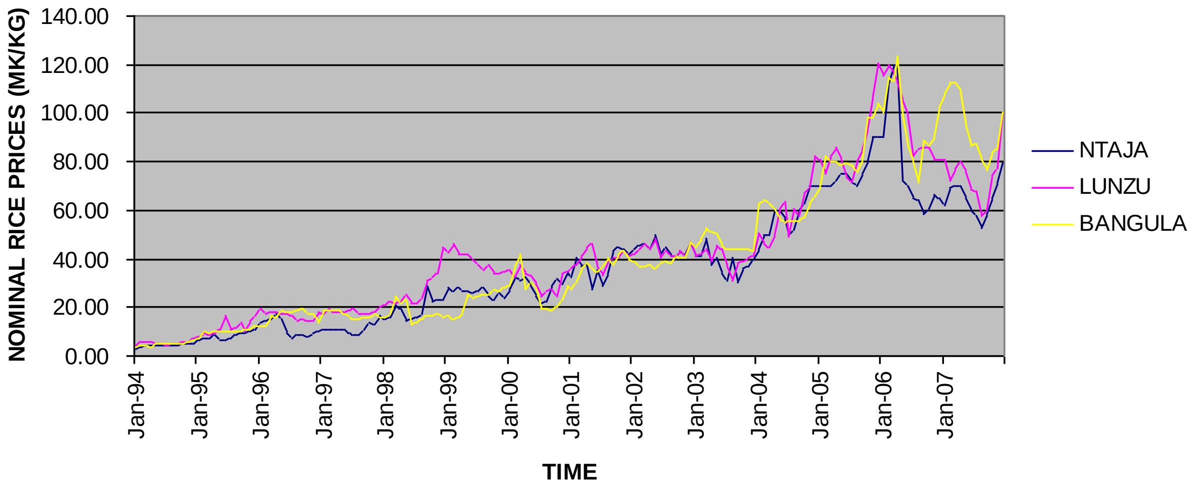


Figure 5: Nominal Rice Price Levels and Time in the Southern Region



All the three figures show that on average the rice prices move in the same direction (co-move) for the period understudy. As can be seen from figure 3, 4 and 5 prices were very high in 2006 in all the markets. Mzuzu reports highest price in the northern region, Lilongwe in the central region and Lunzu from the southern region. Overall, southern region reported the lowest price while central region has the highest mean price. This could be explained due to the fact that southern region is the main producing area of rice unlike the central region.

5.1.4 *Seasonal Variation*

A further analysis of variability of monthly rice prices for each month of the year was carried out in order to arrive at the seasonality of price variability. Seasonal variation occurs in agricultural products such as rice over a production cycle which is normally within a period of twelve months. Crop prices tend to follow a general seasonal pattern, which is a function of relative changes in supply and demand as the marketing year progresses. Generally crop prices set their seasonal low at harvest followed by a post harvest rally. Post-harvest rallies occur because the supply of the crop is fixed and consumption gradually uses up that supply, causing prices to rise. A variability analysis on rice prices therefore helps to arrive at a seasonal index of price variability. Figure 6 is a graphical presentation of seasonal indices over the twelve months period of the year.

Figure 6: Rice Seasonal Price Index by month, 1994 through 2007 (2000=100)

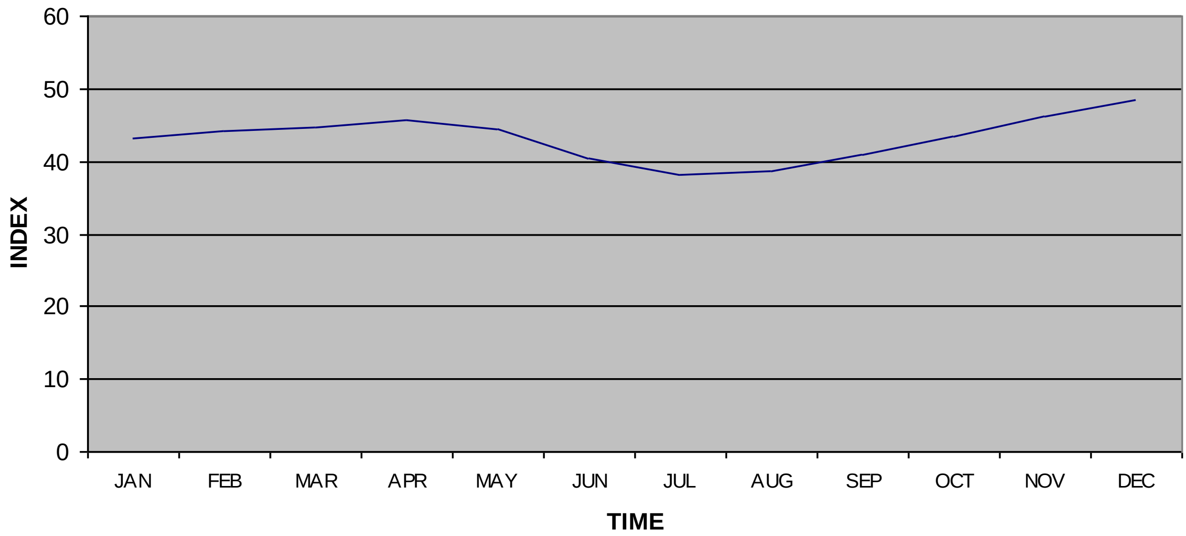


Figure 6 depicts the seasonal pattern of rice prices across the country. Typical of agricultural commodities, the lowest prices are reported between June and July, which happens to be rice harvesting period. These prices start increasing from August and reach its peak in December. Overall the prices are high until May and this could be as a result of scarcity of the crop as this is the growing season in most parts of the country.

5.1.5 *Trend Analysis*

Trend Analysis in time series data captures gradual, long-term changes in crop markets that can have powerful influence on markets which may significantly alter seasonal patterns. This analysis as suggested by Goodwin (1994), Goez and Weber (1986) involves calculation of trend factor by performing an OLS of the time series on a time dummy variable, which increases by 1 each consecutive time period (month). The time variable is taken as an independent variable used as a surrogate for other variables, which may change by the same amount each period, or for variables such as technological change that may readily be subject to measurement. The regression results of price series on time variable are presented in Table 2.

Table 2: Results of Regressing Price Series on Trend Variable

MARKET	*Real Price Trend Coefficient*	*t-statistic of linear trend*	*R-squared of the Trend Equation*
Chitipa	0.0400	3.18	0.0575
Karonga	0.0850	6.53	0.2046
Mzuzu	0.0282	2.47	0.0355
Salima	0.0385	4.03	0.0893
Lilongwe	0.0214	1.44	0.0124
Chimbiya	0.1104	8.89	0.3223
Ntaja	0.0451	4.75	0.1195
Lunzu	-0.0210	-1.66	0.0980
Bangula	0.0487	4.13	0.0931

Source: Survey Data

This analysis determines the influence of time trend on the price levels. Goodwin (1994) noted that a trend is of enough significance if the trend analysis suggests that time alone explains as much as 15 percent of the variation in the price series and that probably should not be ignored. The results in Table 2 above show that all trend coefficients are positive except for Lunzu. This implies that the prices have been increasing throughout the study period. However, it is only in two markets; Karonga and Chimbiya where trend explains 15% or more of the variations. The rest of the markets their R-squared are less than 15%. This implies that the time trend has less influence in most of the price levels in these markets such that inclusion or exclusion of the trend can not change the outcome of the results.

5.2 Determining the Extent of Spatial Market integration

5.2.1 *Stationarity Test*

The price series from the nine selected markets under study were tested individually for stationarity, thus, the price series were tested for presence of unit roots. The study applied Augmented Dickey Fuller (ADF) test to carry out this test. The Akaike Information Criterion (AIC) was used to determine the lag length. The resulting residuals follow white noise process. Results of the ADF tests are presented in Table 3 and show the markets and ADF test statistics.

Table 3: Stationarity Test Results Using ADF Test for Unit Roots

	LEVELS			FIRST DIFFERENCE				CRITICAL VALUES	
FULL SAMPLE (1994:O1 - 2007:12)									
Market	**Coefficient**	**t-statistic**	**No. of Lags**	**Coefficient**	**t-statistic**	**No. of Lags**	**Order of Integration**	**1%**	**5%**
Chitipa	-0.017	-3.130	10	0.585	-6.178	9	I(1)	-4.021	-3.442
Karonga	-0.017	-2.579	11	-0.038	-5.011	10	I(1)	-4.021	-3.442
Mzuzu	-0.024	-3.447	10	-3.462	-7.430	9	I(1)	-4.021	-3.442
Salima	-0.024	-3.735	9	-	-	-	I(0)	-4.022	-3.443
Lilongwe	-0.021	-2.298	2	-4.410	-10.212	1	I(1)	-4.018	-3.441
Chimbiya	-0.027	-2.622	5	-10.340	-9.362	2	I(1)	-4.019	-3.442
Ntaja	-0.025	-3.158	1	-3.832	-13.909	3	I(1)	-4.019	-3.441
Lunzu	-0.024	-2.663	2	-1.187	-9.751	1	I(1)	-4.018	-3.441
Bangula	-0.011	-3.747	1	-	-	-	I(0)	-4.021	-3.443
PRE-MACE (1994:01 - 2004:08)									
Chitipa	-0.033	-3.847	2	-	-	-	I(0)	-4.031	-3.447
Karonga	-0.042	-2.063	1	-0.912	-6.620	9	I(1)	-4.034	-3.448
Mzuzu	-0.028	-3.159	10	-0.883	-5.436	9	I(1)	-4.034	-3.448
Salima	-0.037	-3.332	9	-1.301	-5.854	12	I(1)	-4.035	-3.448
Lilongwe	-0.028	-2.012	2	-1.197	-9.064	1	I(1)	-4.033	-3.447
Chimbiya	-0.035	-3.319	3	-1.355	-8.085	2	I(1)	-4.034	-3.448
Ntaja	-0.033	-3.146	1	-1.123	-8.127	1	I(1)	-4.033	-3.447
Lunzu	-0.036	-2.193	2	-1.246	-9.406	1	I(1)	-4.032	-3.447
Bangula	-0.033	-3.274	1	-1.103	-12.404	0	I(1)	-4.031	-3.447
POST-MACE (2004:09 - 2007:12)									
Chitipa	-0.115	-3.921	3	-	-	-	I(0)	-4.260	-3.556
Karonga	-0.208	-3.011	0	-0.993	-5.952	0	I(1)	-4.279	-3.556
Mzuzu	-0.360	-2.749	2	-1.123	-6.657	0	I(1)	-4.260	-3.548
Salima	-0.226	0.797	1	-0.649	-5.472	11	I(1)	-4.362	-3.592
Lilongwe	-0.122	-1.821	1	-0.904	-5.370	0	I(1)	-4.260	-3.548
Chimbiya	-0.209	-2.286	2	-0.835	-4.439	2	I(1)	-4.279	-3.556
Ntaja	-0.182	-2.401	2	-0.820	-4.861	0	I(1)	-4.260	-3.548
Lunzu	-0.163	-2.051	4	-0.734	-4.759	2	I(1)	-4.279	-3.556
Bangula	-0.188	-2.039	6	-0.854	-4.965	0	I(1)	-4.260	-3.548

Notes: All variables are in natural logarithm. The ADF tests H_0:: $P_i \sim I$ (1) against H_0: $P_i \sim I$ (0).

The results, presented in Table 3, indicate that for full sample database all price series are *I* (1) (i.e. integrated of order 1), except for Salima and Bangula which are stationary in levels. However, for the periods; Pre and Post-MACE, Chitipa price series are *I* (0) (i.e., stationary in levels) while the rest of the markets are *I*(1). This implies that Salima and Bangula for full sample and Chitipa for the two periods did not share the common trend with dominant central markets, such as Lilongwe and Mzuzu in their respective periods. Therefore these markets were excluded from co-integration and causality analyses, as inclusion of them would increase the number of co-integrating vectors (Rashid, 2004).

5.2.2 *Co-integration Test*

Co-integration tests in this study are based on Johansen's method and the results presented are for both Bivariate and Multivariate models. Co-integration is based on the notion that if the log likelihood of unconstrained model that includes the co-integrating equations is significantly different from the log likelihood of constrained model that does not include the co-integrating equations, the null hypothesis of no co-integration is rejected (STATACORP, 2005). Co-integration test results are presented in Tables 4, 5 and 6. The co-integration results presented in Table 4 are for bivariate models and highlight that most of the markets under study have a stable long-term relations over the period of analysis, from 1994 to 2007 for full sample. However, co-integration analysis does not allow us to say anything definite about the strength of market integration (Goletti and Babu, 1994) but rather it helps to reveal how price relations among markets change over time. An example is to understand how MACE has affected market integration.

To study this problem the sample was divided into two sub-samples, the first Pre-MACE and the second Post-MACE. The study shows that the number of cointegrated markets during the Pre-MACE period is much smaller than that of the Post-MACE period. That suggests that MACE improved the transmission of price signals among various regions of the country, strengthening the links between price series. For example, results show that in the Pre-MACE period, out of the 56 market links presented 33 of them were significant, representing 58.93%. On the other hand 73.21% of market links were significant during the Post-MACE period. This difference in proportion of integrated markets between the two periods is statistically significant at 1% level (*p-value* = 0.0006, see Appendix 3).

Table 4: Co-integration Test Results (Bivariate Analysis)

Market(i,j)	*Chitipa*	*Karonga*	*Mzuzu*	*Salima*	*Lilongwe*	*Chimbiya*	*Ntaja*	*Lunzu*	*Bangula*
					FULL SAMPLE (1994: 01 - 2007:12)				
Chitipa	**0.000**	16.711*	22.412**		15.870*	20.388*	15.034	15.124	-
Karonga	27.617*	**0.000**	26.258*	-	25.331**	40.388*	27.617*	15.769*	-
Mzuzu	38.028*	42.934*	**0.000**	-	23.444*	31.298*	36.311*	18.230*	-
Salima	-	-	-	**0.000**	-	-	-	-	-
Lilongwe	24.997*	25.920*	25.546*	-	**0.000**	22.207**	30.737**	19.545**	-
Chimbiya	12.325	21.448*	21.121*	-	35.258**	**0.000**	25.231**	14.235	-
Ntaja	15.325	18.771*	24.356*	-	15.687*	34.538**	**0.000**	23.214*	-
Lunzu	12.721	29.376*	13.486	-	14.365	18.098*	40.091*	**0.000**	-
Bangula	-	-	-	-	-	-	-	-	-
					PRE-MACE (1994:01 - 2004:08)				
Chitipa	**0.000**	-	-	-	-	-	-	-	-
Karonga	-	**0.000**	10.154	14.523*	09.032	39.872*	17.880*	14.325	14.012
Mzuzu	-	41.588*	**0.000**	26.351*	23.452*	36.475*	31.309*	18.642*	17.085*
Salima	-	13.52	23.124*	**0.000**	25.321**	38.553*	41.169**	15.354	11.516
Lilongwe	-	22.245*	18.110*	16.048*	**0.000**	16.051*	26.448**	10.993	14.900
Chimbiya	-	08.961	08.654	09.852	25.124**	**0.000**	14.234	14.572	20.541*
Ntaja	-	15.234	14.289	28.578*	24.239**	25.752*	**0.000**	23.785*	22.139**
Lunzu	-	15.395	12.965	19.871*	14.234	14.903	31.638**	**0.000**	17.675*
Bangula	-	13.875	09.685	10.568	15.586*	24.759*	37.582**	23.254**	**0.000**
					POST-MACE (2004:09 - 2007:12)				
Chitipa	**0.000**	-	-	-	-	-	-	-	-
Karonga	-	**0.000**	28.694**	12.337	25.876*	21.445*	13.998	17.475*	15.206
Mzuzu	-	19.003*	**0.000**	18.240*	39.542**	19.675*	18.040*	15.825*	17.585*
Salima	-	12.853	25.42*	**0.000**	23.421*	15.712*	17.584*	17.523*	16.722*
Lilongwe	-	17.082*	16.809*	23.666*	**0.000**	20.735*	15.968*	13.514	31.561*
Chimbiya	-	15.089	15.958*	18.754*	19.524*	**0.000**	28.245*	12.542	11.654
Ntaja	-	14.587	17.582*	19.752*	25.475*	15.536*	**0.000**	27.562*	15.577*
Lunzu	-	23.435*	13.296	20.574*	15.812*	21.585*	17.244*	**0.000**	21.474*
Bangula	-	12.322	09.254	23.123*	12.542	14.582	15.289	23.241*	**0.000**

The critical values for rejection of a null hypothesis of no co-integration are 20.04 and 15.54 for $P \le 0.01$ and $P \le 0.05$ respectively. An integrated link is the one whose Trace statistic is above the critical value.
*, ** Significant at 5% and at 1% level of significance respectively
-Salima and Bangula are $I(0)$ for full sample and Chitipa is also $I(0)$ for Pre and Post-MACE samples. See table 5

These results confirm the hypothesis that MACE intervention through the market information system played a critical role in market functioning. This is in agreement with Mabota *et. al.* (2003) who observed that agricultural market information is important for economic efficiency, performance, and equity. According to KACE (2004) the provision of market information enables smallholder resource-poor farmers to access better markets and better prices for their produce. In addition this enlightens them to better market opportunities that exist elsewhere in liberalized markets. As such the services of MACE could be improving market performance in Malawi through increasing of knowledge of buyers and sellers about quantities available for sales and purchase and other factors that affect commodity prices.

Mabota *et. al.,* (2003) also observed that in Mozambique public information about new opportunities helped to provide incentives to greater participation in the market. There was a significant relationship between households with information and their participation in the market. In regions where people had access to market information, they also participated more in the marketing of cereals, beans and peanuts. In addition, there was complementarity between access to information and access to extension services; that is, those who benefited from extension services had also an access to information. In Mali Mabota *et. al.,* (2003) also noted that the right information helped to shift surpluses to areas with shortages without resorting to foreign aid. This has led Mali to self-sufficiency for basic grain need.

However, the improvement observed in this study can not be attributed to MACE intervention alone as market integration is a function of so many factors. For example, Goletti *et.al.,* (1995) observed that marketing infrastructure (e.g. roads and communication), volatility of government intervention, and the degree of self-sufficiency in production are the major determinants of market integration. This study only focused on MACE as a market-enhancing intervention. MACE project as per its objectives is trying to improve market information system through collection and transmission of price information (IDEAA, 2004). It is however, interesting to note that other market information such as transaction costs and trade flows are not well disseminated by the project. This study therefore, calls for MACE implementers to consider collecting and disseminating such important and valuable market information. In addition further studies on the subject matter should consider such factors affecting market integration.

The importance of other factors significantly impacting spatial market integration is equally manifested by the fact that some links show no co-integration despite the prospects of improved market integration over time after the introduction of MACE project into the market system. The results show that most links involving Bangula are not well integrated. This could be attributed to lack of proper infrastructures such as roads in the area. Bangula market is situated in Nsanje district of which there have been no good roads for many years. The absence of proper and well functioning infrastructure such as roads means that it is difficult to transfer the commodity from surplus regions to deficit areas. This also masks the presence of high transaction costs which is a key factor in efficient arbitrage conditions (Uchezuba, 2005).

5.2.3 *Co-integration Test (Multivariate Analysis)*

Another approach to testing spatial marketing integration utilised the multivariate co-integration technique and results are presented in Table 5. The trace test results reveal the existence of four, five and six co-integrating vectors for full sample, Pre-MACE and Post-MACE price series, respectively. The results show that the markets for rice in Malawi have been operating as a unified market system over the period of study. In terms of the number of significant co-integrating vectors, the extent of market integration is higher for Post-MACE price series. These results are consistent with Chirwa (1999) who observed that maize and rice markets in Malawi operate as a unified market system. Chirwa (2001) also had similar findings on food market integration. It was observed that food market integration in Malawi had been improving over time due to market liberalization policies that were introduced in 1987 (Goletti and Babu, 1994). This therefore implies that introduction of market-enhancing interventions and policies such as market liberalization and Market Information System has the capacity to significantly improve market performance in Malawi.

Table 5: Co-integration Test (Multivariate Analysis)

Trace Test Ho: rank=r	FULL SAMPLE (1994:01-2007:12)		PRE-MACE (1994:01-2004:08)		POST-MACE (2004:09-2007:12)	
	Trace Statistic	Critical Values (5%)	Trace Statistic	Critical Values (5%)	Trace Statistic	Critical Values (5%)
r = 0	183.392	124.240	324.788	156.000	316.451	156.000
r ≤ 1	116.348	94.150	221.917	124.240	224.471	124.240
r ≤ 2	76.790	68.520	159.860	94.150	157.325	94.150
r ≤ 3	48.089	47.210	101.610	68.520	98.886	68.520
r ≤ 4	25.578	29.680	60.172	47.210	60.931	47.210
r ≤ 5	10.246	15.410	29.326	29.680	32.797	29.680
r ≤ 6	3.317	3.760	14.789	15.410	15.240	15.410
r ≤ 7			2.715	3.760	3.416	3.760

5.2.4 *Johansen's Trace Tests for Co-integrating Vectors*

A further test on the extent of rice market integration was done through a sequential search for *n−1* co-integrating vectors. The Johansen's λ_{Trace} test results for this sequential search are presented in Table 6. The results indicate that full sample had a maximum of four co-integrating vectors, Pre-MACE had four while Post-MACE reported a maximum of six co-integrating vectors. Thus, the extent of spatial rice market integration improved in Post-MACE period.

Table 6: Johansen's Likelihood Ratio Test for the Number of Co- Integrating Vectors

Markets	r	Trace Statistics	Critical Values
FULL SAMPLE (1994:01 - 2007:12)			
Lilongwe + Mzuzu	0	25.546	15.41
	1	3.609	3.76
Lilongwe + Mzuzu + **Lunzu**	1	19.265	20.04
	2	4.138	6.65
Lilongwe + Mzuzu + Karonga	1	30.308	15.41
	2	3.360	3.76
Lilongwe + Mzuzu + Karonga + Ntaja	2	30.899	20.04
	3	3.986	6.65
Lilongwe + Mzuzu + Karonga + Ntaja + Chimbiya	3	27.117	20.04
	4	4.192	6.65
Lilongwe + Mzuzu + Karonga + Ntaja + Chimbiya + Chitipa	4	24.906	15.41
PRE-MACE (1994:01 - 2004:08)			
Lilongwe + Mzuzu	0	18.110	15.41
	1	3.218	3.76
Lilongwe + Mzuzu + **Lunzu**	1	10.285	15.41
	2	2.293	3.76
Lilongwe + Mzuzu + Karonga	1	23.168	15.41
	2	3.327	3.76
Lilongwe + Mzuzu + Karonga + Ntaja	2	23.490	15.41
	3	3.593	3.76
Lilongwe + Mzuzu + Karonga + Ntaja + Chimbiya	3	20.036	15.41
	4	3.372	3.76
Lilongwe + Mzuzu + Karonga + Ntaja + Chimbiya + Salima	4	20.215	15.41
	5	3.403	3.76
Lilongwe + Mzuzu + Karonga + Ntaja + Chimbiya + Salima + **Bangula**	5	15.216	15.41
POST-MACE (2004:09 - 2007:12)			
Lilongwe + Mzuzu	0	16.809	15.41
	1	3.131	3.76
Lilongwe + Mzuzu + Lunzu	1	21.474	15.41
	2	3.217	3.76
Lilongwe + Mzuzu + Lunzu + Karonga	2	23.642	15.41
	3	4.681	3.76
Lilongwe + Mzuzu + Lunzu + Karonga + Ntaja	3	23.389	15.41
	4	4.530	3.76
Lilongwe + Mzuzu + Lunzu + Karonga + Ntaja + Chimbiya	4	19.060	15.41
	5	3.863	3.76
Lilongwe + Mzuzu + Lunzu + Karonga + Ntaja + Chimbiya + Salima	5	19.605	15.41
	6	0.498	3.76
Lilongwe + Mzuzu + Lunzu + Karonga + Ntaja + Chimbiya + Salima + Bangula	6	15.740	15.41
	7	3.416	3.76

Notes: The critical values for rejection of a null hypothesis of n-2 are 20.04 and 15.54 for $P \leq 0.01$ and $P \leq 0.05$ respectively.

Applying the same sequential methodology on Post-MACE data set, the results suggest that the extent of spatial rice market integration in Malawi has substantially improved. All markets including Lunzu and Bangula, except Chitipa which was tested stationary in levels are found to have shared a common trend during this period. These results are consistent with Rashid (2004) in Ugandan maize markets where it was observed that some markets which did not share a common trend with major markets like Kampala improved with market liberalisation policies.

A significant implication of co-integration approach is that, while individual price series may wander extensively, certain pairs should not diverge from one another in the long-run. Another implication of co-integration and representation is that co-integration between two variables implies existence of causality between them in at least one direction (Gujarati, 1995). As such co-integration itself cannot be used to make inferences about the direction of causation between the variables and the causality tests are therefore necessary.

5.3 Determining the Causality Relationships among Spatial Rice Markets

As earlier stated, to determine whether there are any causal relationships in prices among cointegrated markets, Granger causality test was carried out following regression equation (9). Again, like the ADF tests, of importance in the causality test is the specification of lag length in the equation. Gujarati (1995) concedes that Granger causality test is very sensitive to the number of lags used in the analysis. He suggests that to have confidence in the results of the test, we should use more rather than fewer lags. As such the Akaike Information Criterion (AIC) was also used to determine the appropriate lag length to be included in the regression equations. The causality tests are tested by the significance of β_1 and β_2 as specified in equation (9). Granger causality test results are presented in Table 7 and only cover the causality results between the major urban markets (Mzuzu, Lilongwe and Lunzu) and the peripheral markets.

Table 7: Pair wise Granger Causality Tests by Regional Centres

Market *i*	Market *j*	β_i	P_i-value	β_j	P_j-value	Direction of Causality
			FULL SAMPLE (1994:01-2007:12)			
Lilongwe	Mzuzu	-0.127	0.000	0.102	0.019	Bidirectional
	Lunzu	-0.090	0.107	0.074	0.029	Unidirectional
	Chimbiya	-0.127	0.000	0.112	0.032	Bidirectional
	Ntaja	-0.138	0.000	0.152	0.001	Bidirectional
	Chitipa	-0.152	0.000	0.091	0.151	Unidirectional
	Karonga	-0.088	0.390	0.181	0.000	Unidirectional
Mzuzu	Chitipa	-0.271	0.000	0.084	0.110	Bidirectional
	Karonga	-0.263	0.000	0.065	0.277	Bidirectional
	Chimbiya	-0.242	0.000	0.129	0.450	Unidirectional
	Ntaja	-0.217	0.000	0.131	0.013	Unidirectional
	Lunzu	-0.127	0.005	0.080	0.290	Unidirectional
Lunzu	Chitipa	-0.099	0.007	0.066	0.193	Unidirectional
	Karonga	-0.133	0.000	0.196	0.120	Unidirectional
	Chimbiya	-0.117	0.022	0.131	0.272	Independent
	Ntaja	-0.235	0.000	0.142	0.014	Bidirectional
			PRE-MACE (1994:01-2004:08)			
Lilongwe	Mzuzu	-0.143	*0.001*	0.057	*0.198*	Unidirectional
	Lunzu	-0.079	*0.094*	0.059	*0.121*	Unidirectional
	Chimbiya	-0.122	*0.004*	0.123	*0.035*	Bidirectional
	Ntaja	-0.133	*0.007*	0.189	*0.210*	Unidirectional
	Salima	-0.096	*-0.296*	0.100	*0.001*	Unidirectional
	Karonga	-0.096	*-0.096*	0.194	*0.000*	Bidirectional
	Bangula	-0.096	*-0.196*	0.085	*0.181*	Independent
Mzuzu	Karonga	-0.234	*0.000*	0.282	*0.002*	Bidirectional
	Chimbiya	-0.297	*0.000*	0.268	*0.352*	Unidirectional
	Ntaja	-0.204	*0.004*	0.287	*0.000*	Unidirectional
	Lunzu	-0.099	*0.351*	0.143	*0.001*	Unidirectional
	Salima	-0.166	*0.164*	0.234	*0.000*	Unidirectional
	Bangula	-0.064	*0.292*	0.117	*0.010*	Unidirectional
Lunzu	Karonga	-0.163	*0.000*	0.185	*0.320*	Unidirectional
	Chimbiya	-0.143	*0.120*	0.082	*0.328*	Independent
	Ntaja	-0.246	*0.000*	0.136	*0.037*	Bidirectional
	Salima	-0.164	0.010	0.187	0.065	Unidirectional
	Bangula	-0.073	*0.282*	0.111	*0.106*	Independent
			POST-MACE (2004:09-2007:12)			
Lilongwe	Mzuzu	-0.056	*0.091*	0.304	*0.001*	Bidirectional
	Lunzu	-0.183	*0.214*	10.081	*0.235*	Independent
	Chimbiya	-0.146	*0.012*	0.251	*0.075*	Bidirectional
	Ntaja	-0.123	*0.003*	0.029	*0.712*	Unidirectional
	Salima	-0.053	*0.029*	0.206	*0.003*	Bidirectional
	Karonga	-0.231	*0.007*	0.214	*0.327*	Unidirectional
	Bangula	-0.389	*0.000*	0.047	*0.732*	Unidirectional
Mzuzu	Karonga	-0.481	*0.000*	0.092	*0.047*	Bidirectional
	Chimbiya	-0.269	*0.013*	0.272	*0.000*	Unidirectional
	Ntaja	-0.305	*0.014*	0.211	*0.005*	Bidirectional
	Lunzu	-0.299	*0.110*	0.185	*0.003*	Unidirectional
	Salima	-0.508	*0.001*	0.040	*0.667*	Unidirectional
	Bangula	-0.260	*0.490*	0.201	*0.002*	Unidirectional
Lunzu	Karonga	-0.020	*0.803*	0.339	*0.004*	Unidirectional
	Chimbiya	-0.091	*0.126*	0.431	*0.230*	Independent
	Ntaja	-0.196	*0.016*	0.379	*0.018*	Bidirectional
	Salima	-0.018	*0.034*	0.019	*0.014*	Unidirectional
	Bangula	-0.012	*0.045*	0.098	*0.034*	Bidirectional

Pre-MACE database, presented in Table 7, suggest that out of 18 market links, the study failed to reject the null hypothesis of unidirectional causality for 11 market links. Unidirectional causality implies that either coefficient β_2 is statistically different from zero ($\beta_2 \neq 0$) and the coefficients β_1 is not statistically different from zero ($\beta_1 = 0$) or vice-versa. For example, for Lilongwe-Mzuzu link, the hypothesis that β_2 is not statistically different from zero ($\beta_2 = 0$) can not be rejected at 5% level of significance. This implies that the causality is unidirectional, with prices in Mzuzu market Granger causing the prices in Lilongwe market. For Post-MACE period, unidirectional causality is found in nine of the 18 links.

Both way causalities are found to exist in four of the 18 market links (i.e. 22.22%) during the Pre-MACE period. For example; Mzuzu-Karonga and Lunzu-Ntaja are among the markets which indicate interdependence between them. In other words, price in one market reacts to any deviations of price in the other market from its equilibrium path. This bi-directional causality is more pronounced in the Post-MACE database where out of 18 market pairs reported in Table 7, causal feedbacks are found to exist in seven pairs representing 38.89%. These results also indicate increased integration of the markets in the Post-MACE period and the difference in percentages of bi-directional causalities between the two periods is significant at 5% level (P = 0.0147, refer Appendix 1). Independent causality where both P_{it} and P_{jt} do not cause each other manifest itself in three and two market links during the Pre-MACE and the Post-MACE price series, respectively.

It is important to note that although co-integration between two price series implies Granger causality in at least one direction, the opposite is not necessarily true as stated by Abdulai (2006). In this case, as noted in the earlier discussion about co-integration, lack of co-integration between the two trading price series may indicate that market integration is absent, as other factors such as transaction costs determine the movements of one of the price series.

However, Granger causality may exist, indicating that, although the two price series drift apart due to other factors such as non-stationarity and transaction costs, some price signals are passing through from one market to another. On the other hand, lack of Granger causality may not imply an absence of transmission, as price signals may be transmitted instantaneously under special circumstances, which are expected for a staple food commodity like rice (Abdulai, 2006).

Granger causality results however, as noted by Rashid (2004), point to the limitations of bivariate market integration analyses, where a central location is assumed to be exogenous, i.e., to dominate the long-run price movements. The notion of central market being exogenous implies that, if Lilongwe for example is indeed such an exogenous location, then all other $\beta_{i,t}$'s would have been statistically zero, which is not the case in this study. As such the study fails to identify a central rice market that is exogenous in the rice markets in Malawi. These results however, contradict the findings of Chirwa (2001) who found that Karonga was weakly exogenous in rice market. Nevertheless, the findings of this study are similar to those of Rashid (2004) who also failed to find a central market in the Ugandan maize markets.

5.4 Determining Dynamic Adjustments to Long-run Equilibrium of Spatial Rice Markets

5.4.1 *Short-Run Price Relationship between the Markets*

The study further modelled the short-run price relationship between the markets under study using Lilongwe as an independent market expected to have an influence on other peripheral markets. The selection of Lilongwe was done based on the fact that Lilongwe is one of the major urban centres in the country and is situated in the centre where its impact is expected to be transmitted to all the three regions of Malawi. However, the fact that rice produced mainly from Southern and Northern Malawi, the impact of Lilongwe is expected to be minimal.

Two lags for the markets in estimating equation (10) were used in the short-run regression as determined by the Akaike Information Criterion. The study included quarterly seasonal dummies, with the first quarter (Q1) coinciding with the rice 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 (Chirwa, 2001).

The most important parameters in equation (10) were the coefficient of the contemporaneous change (β) in Lilongwe market and the coefficient of the lagged error correction term (θ). The error correction term (ECT) is derived from the residual from the co-integration vector of the dependent and independent market in the bivariate analysis. Based on the results of the coefficients of the current change in Lilongwe 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 revealed that both causality and co-integration have increased over time, further confirming the hypotheses of co-integration and market integration.

Table 8: Short-run and Adjustment Speed Coefficients

	FULL SAMPLES (1994:01-2007:12)		**PRE-MACE (1994:01-2004:08)**		**POST-MACE (2004:09-2007:12)**	
Market *j**	**β**	**θ**	**β**	**θ**	**β**	**θ**
Chitipa	0.145	-0.290	-	-	-	-
	(0.049)	*(0.016)*	-	-	-	-
Karonga	0.192	-0.281	0.226	-0.298	0.094	-0.452
	(0.071)	*(0.021)*	*(0.096)*	*(0.027)*	*(0.023)*	*(0.001)*
Mzuzu	0.191	-0.322	0.179	-0.321	0.153	-0.462
	(0.015)	*(0.021)*	*(0.057)*	*(0.012)*	*(0.012)*	*(0.012)*
Salima	-	-	0.211	-0.322	0.358	-0.374
	-	-	*(0.025)*	*(0.014)*	*(0.003)*	*(0.004)*
Chimbiya	0.294	-0.335	0.257	-0.282	0.242	-0.386
	(0.034)	*(0.025)*	*(0.036)*	*(0.004)*	*(0.008)*	*(0.006)*
Ntaja	0.129	-0.384	0.141	-0.252	0.164	-0.452
	(0.046)	*(0.019)*	*(0.062)*	*(0.003)*	*(0.090)*	*(0.076)*
Lunzu	0.221	-0.318	0.126	-0.299	0.224	-0.419
	(0.077)	*(0.024)*	*(0.078)*	*(0.021)*	*(0.078)*	*(0.090)*
Bangula	-	-	0.103	-0.263	0.396	-0.421
	-	-	*(0.978)*	*(0.023)*	*(0.000)*	*(0.003)*
Average	**0.195**	**-0.322**	**0.177**	**-0.291**	**0.233**	**-0.424**

* Lilongwe market was taken as a dependent market. Figures in parenthesis are critical p-values

The results in Table 8 showed that the contemporaneous change in Lilongwe market prices significantly affected the price change in the other markets with the coefficients ranging from 0.129 to 0.294, resulting in an average impact of 19.5% for full sample data set. During the Pre-MACE the coefficients ranged from 0.126 to 0.257, resulting in an average impact of 17.7% with Bangula being insignificant. The impact of price changes in Lilongwe to other markets improved during the Post-MACE era with the coefficients ranging from 0.094 to 0.396 and, on average contemporaneous changes in rice prices in Lilongwe explained around 23% of changes in the other markets. However, Chirwa (2001) who reported Karonga as a central rice market observed that, on average, changes in rice prices in Karonga explained around 70 percent of changes in the peripheral markets. Nevertheless, the difference between Pre and Post-MACE was found to be significant at 5% level of significance (p= 0.0448, see Appendix 3) which implies that the MACE programme had an impact.

With respect to the speed of adjustment parameter the coefficient of the lagged error correction term shows that the speed of adjustment to long-run equilibrium is slowest for Karonga (-0.281) and highest for Ntaja (-0.384), and about 32.2% of the price adjustment to the long-run equilibrium takes place within a month for the full sample price series. During the Pre-MACE period the speed of adjustments to long-run equilibrium was faster in Salima (-0.322) and slowest in Ntaja (-0.252) with an overall average of 29.1%.

The study noted increased speed of adjustments during the Post-MACE period whereby the slowest speed of adjustment was reported as -0.374 in Salima and the fastest is -0.462 in Mzuzu. On average, about 42.2% of the price adjustments to the long-run equilibrium took place within a month for the Post-MACE period. These findings were also slightly different from Chirwa (2001) where the coefficient of the lagged error correction term showed that the speed of adjustment was slowest for Lilongwe (-0.33) and highest for Mzuzu (-0.67), and about 47 percent of the price adjustment took place within a month. However, the difference between the period before and after commencement of the MACE project was found to be statistically significant at 1% (p=0.0068, see Appendix 3).

5.4.2 *Long-Run Price Relationships: Impulse Response Functions*

Considering all markets, the time plot shows that both positive and negative shocks lead to almost a similar pattern of adjustment. Figure 7 below and figures 8 to 13 presented in the Appendix 1 illustrate the responses to positive and negative shocks of the price parity relationships between Lilongwe market and an auxiliary market *j* for rice market prior to and after the MACE programme. For example, Figure 7 shows the response for the Karonga market to both positive and negative price shocks in Lilongwe. The diagram shows that the speed of response by the Karonga rice market to shocks in Lilongwe rice market was nine weeks in the pre-MACE period and seven weeks in the post-MACE period.

Figure 8 represents how Mzuzu rice market responded to a one half standard deviation shock in Lilongwe rice market prior to and after the MACE intervention. It takes 7.5 weeks for Mzuzu market to respond to price shocks in Lilongwe market during the pre-MACE period and 6.5 weeks during the post-MACE period. Figure 9 show little change in speed of response between Lilongwe and Salima markets for the pre- and post-MACE periods, both responses appear to be relatively complete by 7.5 weeks.

Figure 10 shows the response of Chimbiya rice market to a one half standard deviation shock in Lilongwe rice market. The responses are generally complete after seven weeks during pre-MACE period and 6.5 weeks during post-MACE period. The rest of the Figures 11, 12 and 13 also show improvement to the responses of auxiliary markets to the central market in the post-MACE period. It takes 8.5 weeks for Ntaja, 7.0 weeks for Lunzu and 9.0 weeks for Bangula to respond to Lilongwe shocks during the pre-MACE period while the figures for the post-MACE period are 8.0 weeks for Ntaja, 6.0 weeks for Lunzu and 8.0 weeks for Bangula markets to respond to shocks in Lilongwe central market.

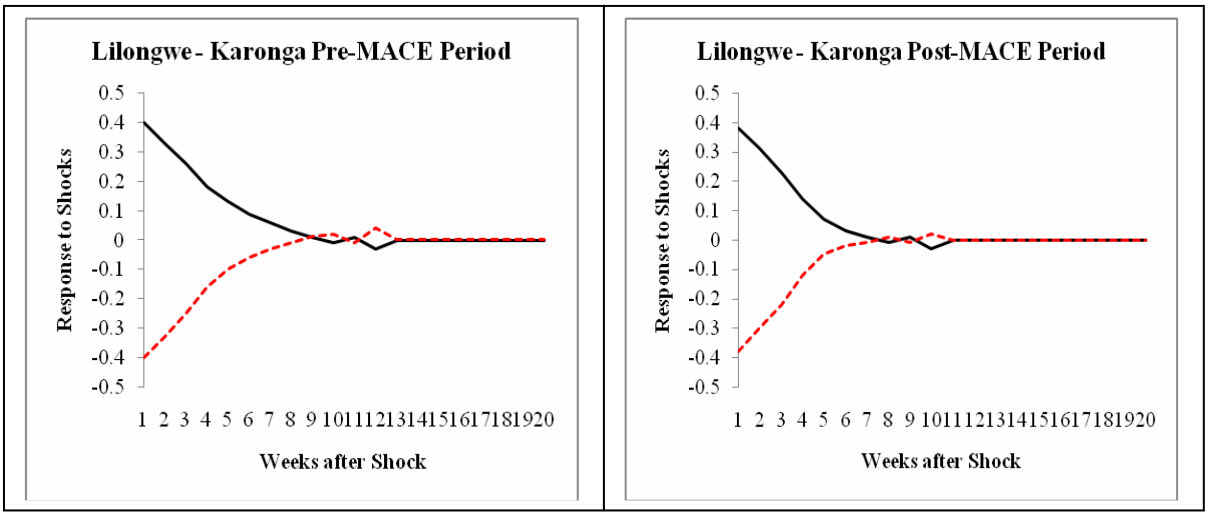


Figure 7: Response of Karonga Rice market to positive/negative price shocks in the Lilongwe Rice market

A general picture portrayed by this impulse response analysis in this study is that it took an average of about eight weeks for auxiliary markets to adjust completely in response to a price shock in Lilongwe rice market during the Pre-MACE period. An improved is observed for Post-MACE era where an average of seven weeks was reported. Another key observation is that the positive and negative shocks converge to equilibrium and do not show any tendency to deviate from equilibrium in the long run. These responses are consistent with long-run market integration. It should, however, be noted that these responses are conditional on the size of the shock due to asymmetric price relationships among the markets.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary and Conclusion

It is increasingly recognized that the formulation of market-enhancing policies and initiatives to increase the performance of the markets requires a better understanding of how the market functions. Aggregate market performance is better understood by studying the level of market integration that exists. In the context of this study market performance was investigated by studying the impact of MACE on average market prices in the rice markets in Malawi. A review of the literature showed that no study had been specifically done to measure the extent of market integration in this area. The primary objective of this study was to examine spatial rice market integration in Malawi and understand how it has been affected by MACE project.

The study used monthly price data from 1994 to 2007. The study noted that typical of agricultural products, rice prices varied both in space and over time. The main rice producing areas such as Ntaja and Karonga reported lowest mean rice prices where as the main consuming regions such as Lilongwe and Mzuzu reported highest mean rice prices. The study further observed the existence of seasonal variations which occur over the production cycle which is normally a period of twelve months. Seasonal variation is a function of relative changes in supply and demand as the marketing year progresses. It was therefore observed that rice prices are low during harvest and start rising thereafter, reaching the peak during the growing season.

Co-integration test results have shown that compared to the period before MACE project, the extent of spatial rice market integration in Malawi appear to be improving in years following the commencement of the project. For example, market locations, such as Lunzu and Bangula, which did not share the common trend with the main consumption markets (Mzuzu and Lilongwe) in Pre-MACE period, were integrated during the Post-MACE era.

In addition, trace tests revealed the existence of four, five and six co-integrating vectors for full sample, Pre-MACE and Post-MACE price series respectively, which is also an indication of improved market integration. These results provide empirical support to the hypothesis that provision of market information has the capacity to improve market performance.

More over the analysis of market integration using the vector autoregression co-integration approach and the test for the existence of valid co-integration vectors reveal that markets for rice given the price information are highly integrated in Malawi. Of particular importance is the fact that there are more integrated market links during the Post-MACE than the Pre-MACE period. For example, Pre-MACE period reported 58.93% integrated links while Post-MACE reported 73.21% integrated links and this proportional difference was found to be significant at 1% level (P=0.0006). It can therefore be concluded that the market information system advanced by the project is on average increasing spatial market integration. However, the fact that other links show no co-integration especially those involving Bangula market is an indication that the government need to invest a lot in other sectors such as infrastructure like roads.

The causality test results also indicated improved rice market integration in recent years. For example, feedback relationships were found to be more manifested during the Post-MACE era. The study noted 22.22% bi-directional causalities during the Pre-MACE and 38.89% during the Post-MACE. This proportional difference was found to be significant at 5% level. Furthermore, the pattern of causality in the Post-MACE period pointed out to the existence of two major centres, namely Mzuzu and Lilongwe that are pivotal in the transmission of price signals to other markets. However, these causality results have reinforced the shortcomings of bivariate market integration models, where a central location is assumed to be exogenous, i.e., to dominate the long run price movements.

In our analyses, if Mzuzu and Lilongwe were indeed exogenous locations, then the causal relationship would have been unidirectional, which is not the case in this study. As such the study failed to identify a central rice market in Malawi.

On the dynamic adjustments the study also noted an improvement in spatial rice market integration in Malawi. The study observed that price changes in Lilongwe explained about 23.00% of the changes in other markets during the Post-MACE relative to 17.70% Lilongwe price changes explained during the Pre-MACE period. This difference was significant at 5% level (*P*=0.0448) which implies that MACE intervention is significantly improving the impact Lilongwe market is having on other markets in influencing price changes. The study further observed that the speed of the adjustment parameter had also improved with the genesis of MACE project. About 42.20% of the price adjustments took place within a month during Post-MACE era compared to 29.10% for Pre-MACE period. This proportional difference was significant at 1% (*P*=0.0068). This implies that more price changes in the major urban markets were transmitted to peripheral markets within a shortest time possible.

The overall picture emerging from this analysis is that Malawi Agricultural Commodity Exchange project is enhancing spatial rice market integration. As such an important lesson that can be learnt from the MACE experiment is that market information system has the capacity to improve the extent of price transmission across spatially separated markets and that serious initiatives should be undertaken. This then may be translated to improving of market performance and efficiency in agricultural sector which is a key to sustainable household food security realisation. However, it should be noted that MACE by itself can not achieve a structural change in market integration unless investments in marketing infrastructure such as transportation, communication, etc. are undertaken.

6.2 Recommendations

Based on the findings of this study, the study makes the following recommendations:

- ✓ Much as MACE project is perceived to be improving market integration in Malawi serious investments need also to be made in infrastructure development such as roads and communication in order to realise significant structural change in market performance through reduction of transaction and other transfer costs.

- ✓ The identification of Lilongwe and Mzuzu markets as pivotal in the transmission of price signals to other markets implies that government can influence the prices of rice and other food crops in the rural markets through market operations that can influence supply and demand in these markets. The government can also facilitate price stabilisation efforts through the market mechanism, by targeting markets that are highly integrated.

- ✓ This study has also shown that market-enhancing interventions are working well, as such; MACE project needs to be promoted and be expanded to cover a wider area of the country. It should be able to reach even the remotest areas of the country.

- ✓ MACE needs further improvements in systematic collection, compilation and storage of price and structural information on trade flows, transaction and other transfer costs. Availability of this data will enable further understanding of factors contributing to market integration of not only rice markets but also other agricultural commodities.

- ✓ MACE also needs to consider timeliness of widespread dissemination for this information: if market participants have accurate and timely information on market conditions, rice and in general, food markets may be able to respond more quickly to market shocks, and market linkages can efficiently and effectively distribute food from surplus to deficit areas.

REFERENCES

Abdula, D. C. 2005. "Improving Maize Marketing and Trade Policies to Promote Household Food Security in Southern Mozambique." MS Thesis. Michigan State University.

Abdulai, A. 2006. "Spatial Integration and Price Transmission in Agricultural Commodity markets in Sub-Saharan Africa." In: Saris, A. & Hallan, D ed. *Agricultural Commodity Markets & Trade*: *New Approaches to Analysis Market Structure and Instability*. FAO. Rome, Italy.

Alexander, C. and J. Wyeth. 1994. "Cointegration and Market Integration: An Application to the Indonesian Rice Market." *The Journal of Development Studies* 30(2):303-328.

Amha, W. 1999. "Maize Market in Ethiopia: Liberalization and Price Integration Issues." *Ethiopian Journal of Development Research* 21(1):79-110.

Asche, F., H. Bremnes, and C. Wessels. 1999. "Product Aggregation, Market Integration, and Relationship between Prices: An Application to World Salmon Market." *American Journal of Agricultural Economics* 81:568-581.

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.

Baulch, B. 1997. 'Transfer Costs, Spatial Arbitrage, and Testing for Food Marketing Integration." *American Journal of Agricultural Economics* 79:477-487.

_______ and Li. 2002. "Distinguishing Between Equilibrium and Integration in Spatial Price Analysis." *American Journal of Agricultural Economics* 84(2):292-307.

Blyn, G. 1973. "Price Series Correlation as a measure of Market Integration." *Indian Journal of Agricultural Economics* 28(2).

Bopape, L. E. 2002. "Analysis of Price Relationships among Spatially Differentiated Potato Markets in South Africa." MS Thesis. Cornell University.

Chilowa, W. 1991. "Liberalization of Agricultural Produce Marketing and Household Food Security in Malawi." Working Paper, Chr. Michelsen Institute, Fantoft, Norway.

Chirwa, E. W. 2001. "Food Pricing Reforms and Price Transmission in Malawi: Implications for Food Policy and Food Security." Working Paper, University of Malawi, Zomba, Malawi.

______ 1999. "Food Marketing Reforms and Integration of Maize and Rice Markets in Malawi." Working Paper, University of Malawi, Zomba, Malawi.

Dawson, P. J. and P. K. Dey. 2002. "Testing For the Law of One Price: Rice Market Integration in Bangladesh." *Journal of International Development J. Int. Dev* 14:473–484.

Delgado, C.A. 1986. "Variance Components Approach to Food Grain Market Integration in Northern Nigeria." *American Journal of Agricultural Economics* 68(4):970-979.

Diakosavvas, D. 1995. “How integrated are beef markets: The case of Australian and US beef markets.” *Journal of Agricultural Economics* 12:37-53.

Edriss, A. K. 2003. “*A* passport to Research Methods: Research Skills-Building Approach.” International Publishers and Press. Las Vegas, USA.

Enders, W. 1995. “Applied Econometric Time Series, first edition.” John Wiley & Sons, New York.

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

Engel, R., and B. S. Yoo. 1987. “Forecasting and testing in co-integrated systems.” *Journal of Econometrics* 35:143-159

Enke, S. 1951. “Equilibrium among spatially separated markets: solution by electric analogue.” *Econometrica* 19(1):40-47.

Fackler, P. 1996. “Spatial price analysis: A methodological review.” Mineo. North Carolina State University.

Faminow, M. and B. Benson. 1990. “Integration of spatial markets.” *American Journal of Agricultural Economics* 72:49-62.

Galushko, V. 2003. “Has Spatial market Integration Increased over Time: The Evidence from the Ukrainian Food Markets?” MS Thesis. National University of Kyiv-Mohyla Academy

Goetz, F., and M.T. Weber. 1986. “Fundamentals of Price Analysis in Developing Countries’ Food System: A Training Manual to Accompany the Micro Computer Soft Ware Programme “MSTAT”.” Working Paper, Michigan State University. [on-line] Available at http://www.aec.msu.edu/fs2/papers/ordr/idwp29.pdf.

Ghosh, M. 2003. “Spatial Integration of Wheat Markets in India: Evidence from Cointegration Tests.” *Oxford Development Studies* 31(2):159 – 171.

Goletti, F. and S. Babu. 1994. “Market liberalization and integration of maize markets in Malawi.” International Food Policy Research Institute, Washington, DC, USA Bunda College of Agriculture, Lilongwe, Malawi. *Agricultural Economics* ll:31 l-324.

Goletti, F., R. Amed and N Farid. 1995. “Structural Determinants of Market Integration: The Case of Rice Markets in Bangladesh.” *The Developing Economies* XXXIII-2.

Goodwin, J.W. 1994. “Agriculture Price Analysis and Forcasting.” John Wisley and Sons Inc. New York, Toronto, Singapore.

Gonzelez-Revera, G., and S.M. Helfand. 2001. “The extent, pattern, and degree of market integration: A multivariate approach for the Brazilian rice market.” *American Journal of Agricultural Economics* 83:576-592.

Goodwin, B. K. 1992. "Multivariate Cointegration Tests and Law of One Price in International Wheat Markets". *Review of Agricultural Economics* 14:117-24.

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

Govindan, K. and M. Kherallah. 1997. "The Sequencing of Agricultural Market Reforms in Malawi: Mssd Discussion Paper, Market and Structural Studies Division; International Food Policy Research Institute; Washington, D.C. U.S.A.

Green, W. H. 2003. "Econometrics Analysis." 5th Edition. Prentice Hall.

Gujarati, D. N. 2003. "Basic Econometrics." 4th Edition. International Edition. McGraw-Hill.

Harriss, B. 1979. "There is method in my madness: Or is it vice versa. Measuring agricultural market performance." *Food Research Institute Studies* 17:197-218.

Heman D. L., and F. M. Mari. 2006. "Testing Market Integration in Regional Onion Markets of Pakistan: Application of Error Correction Model in the Presence of Stationarity." *International Research Journal of Finance and Economics* ISSN 1450-2887(1):89-97.

IDEAA. 2005. "Malawi Agriculture Commodity Exchange (MACE) Launch Report." ideaa Malawi Project; Lilongwe; Malawi. Available at http://www.ideaamis.com.

______2004. "Initiative for Development and Equity in African Agriculture." Lilongwe; Malawi. Available at http://www.ideaamis.com.

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

Jones, W. O. 1972. "Marketing Staple Food Crops in Tropical Africa." Ithaca and London, Cornell University Press.

KACE, 2004. "Strategies for Pro-Poor Sustainable Agricultural Knowledge Centres in East Africa." Available at http://www.kacekenya.com.

Kherallah, M., C. Delgado, E. Gabre-Madhin, N. Minot, and M. Johnson. 2002. "Reforming Agricultural Markets in Africa." Baltimore: The Johns Hopkins University Press.

Kohls, R.L. and J.N. Uhl. 1998. "Marketing of agricultural products." 5th Edition, New York. Macmillan.

______ 1985. "Marketing of agricultural products." New York. Macmillan Publishing Company.

Lele, U. 1972. "Food Marketing in India: Private Performance and Public Policy." Ithaca, New York. Cornell University Press.

Liu, Q. and H.H. Wang. 2003. "Market integration test for pacific egg markets." Paper presented at the American Agricultural Economist Association annual meeting, Montreal, Canada.

Mabota, A., P. Arlindo, A. Paulo and C. Donovan. 2003. "Market Information: A Low Cost Tool for Agricultural Market Development?" Available at http://www.aec.msu.edu/agecon/fs2/mozambique.

Meyer, J. 2002. **"**Measuring Market Integration In The Presence Of Transaction Costs - A Threshold Vector Error Correction Approach." Department of Agricultural Economics, Göttingen, Germany.

Ministry of Agriculture, 1999. "Review of Malawi Agricultural Policies and Strategies." Ministry of Agriculture and Irrigation, Lilongwe; Malawi.

Minten, B. and M.S. Mendonza. 1998. "Price Behaviour and Market Integration." In: *Structure and Conduct of Major Agricultural Input and Output Markets and Response to Reforms by Rural Households in Madagascar.* Part 3. Final Report. IFPRI.

Mount, P. R. 1969. "Exploring the Commodity Approach in Developing Marketing Theory." *Journal of Marketing* 33(2):62-64. Available at http://www.jstor.org/about/terms.html.

Mukhebi, A. 2004. "Kenya Agricultural Commodity Exchange Limited (KACE); Reaching the Poor in Rural Kenya with Market Information: A Case Study of a Market Information System." A Paper presented at the CTA Seminar, Maputo, Mozambique, 8-12 November.

Muyepa, F. 2002. "The role of Agricultural Information in Poverty Monitoring in Malawi." A Paper presented at the Poverty Monitoring Stakeholders Workshop. 24-26 July.

Negassa, A., Meyers, R., and E. Gabre-Maldhin. 2003. "Analyzing the grain market efficiency in developing countries: Review of existing methods and extensions to the parity bound model." Market trade and institutions division**.** *Discussion paper*, 63.

Ngo'ong'ola, H.D., R.N. Kachule and P.H. Kabambe. 1997. "The Maize Market in Malawi." Lilongwe: APRU.

Ngugi, D.M.G. 1997. "The Implications of Agricultural Market liberalization for Market Efficiency and Agricultural Policy in Kenya: The Case of Maize." MS Thesis. Bunda College, Lilongwe, Malawi.

Niemi, J. 2003. "Cointegration and Error Correction Model of Agricultural Commodity Trade: The Case of Asian Agricultural Exports to EU." Academic Dissertation; University of Helsinki; Helsink.

Nkendah, R. and C. B. Nzouessin. 2006. "Economic Analysis of the Spatial Integration of Plantain Markets in Cameroon." African Economic Research Consortium (AERC).

Nucifora, A. 2004. “Lessons in Managing Policy Dialogue in Malawi: Reforming the Agricultural Development and Marketing Corporation (ADMARC).” The World Bank, Washington D.C.

Onyuma, S.O., E. Icart, T. Wambua and G. Owuor. 2005. “Testing for Market integration for Kenyan Pineapples.” *Eastern African Journal of Rural Development* 21(1):23-33.

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

Phiri, MAR. 2006. “Malawi Agriculture Commodity Exchange Baseline Survey.” Bunda College of Agriculture, Lilongwe, Malawi.

RATES. 2003. “Maize Market Assessment and Baseline Study for Malawi.” RATES Center, Nairobi, Kenya. Available at rates@ratescenter.org

Ravallion, M. 1986. “Testing market integration.” *American Journal of Agricultural Economics* 68:102–109.

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

Samuelson, P. 1964. “Spatial equilibrium and linear programming.” *The American Economic Review* 42(3):283-303.

Sexton, R.J., C.L. Kling and H.F. Carman. 1991. “Market integration, Efficiency of Arbitrage, and Imperfect Competition: Methodology and Application to U.S. Celery.” *American Journal of Agricultural Economics* 73:568-580.

Shahidur, R. 2004. “Spatial Integration of Maize Markets in Post-Liberalized Uganda. International Food Policy Research Institute (71). Available at http://www. ifpri.org.

Simler, K. R. 1997. “The Transition to a Market-Based Agricultural Economy in Malawi: A Multi-Market Analysis.” Cornell Food and Nutrition Policy Program; New York. Cornell University Ithaca.

STATACORP lp. 2005. “Stata time-series reference Manual release 9.” a stata press publication.

Takayama, T. and G.G. Judge. 1964. “Equilibrium among spatially separated markets: A reformulation.” *Econometrica* 32(4):510-524.

Thapa, N.B. 2002. “An Econometric Analysis of the Impact of Real Exchange Rate on Economic Activities in Nepal”. Occasional Paper. Kathmandu: NRB

Timmer, C. P. 1996. “Liberalized Agricultural Markets in Low-Income Economies: Discussion.” *American Journal of Agricultural Economics* 78(August):830-832.

Tomek, W.G. And K.L. Robinson. 1981. “Agricultural product prices.” Ithaca, New York, Cornell University press.

Uchezuba, D. I. (2005). “Measuring Market Integration for Peoples on the South African Fresh Produce Market: A Threshold Error Correction Model.” MS Thesis. University of the Free State Bloemfontein.

United Nation Development Program (UNDP), Human Development Report. 2004: *Cultural Liberty in Today's Diverse World,* UNDP, New York, NY. Available on (http://hdr.undp.org/reports/global/ 2004).

USAID, 2008. *Malawi Food Security Update*. FEWSNET. Available at http://www.fews.net/docs/Publications/malawi_2008_02_final.pdf

Vinuya, F. D. 2007. “Testing For Market Integration and the Law of One Price in World Shrimp Markets.” *Aquaculture Economics & Management* 11(3):243– 265.

Wyeth, J. 1992. “The measurement of Market Integration and Application to Food Security Policies.” *Discussion Paper 314*. Brighton: Institute of Development Studies, University of Sussex.

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

Appendix 1: Impulse Response Functions

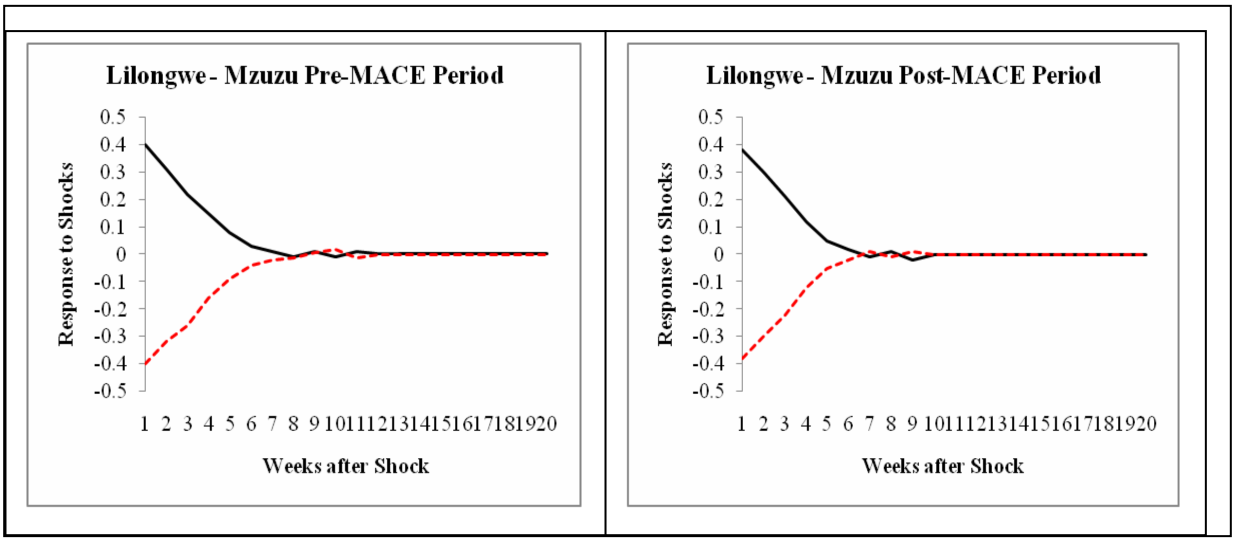


Figure 8: Response of Mzuzu Rice market to positive/negative price shocks in the Lilongwe Rice market

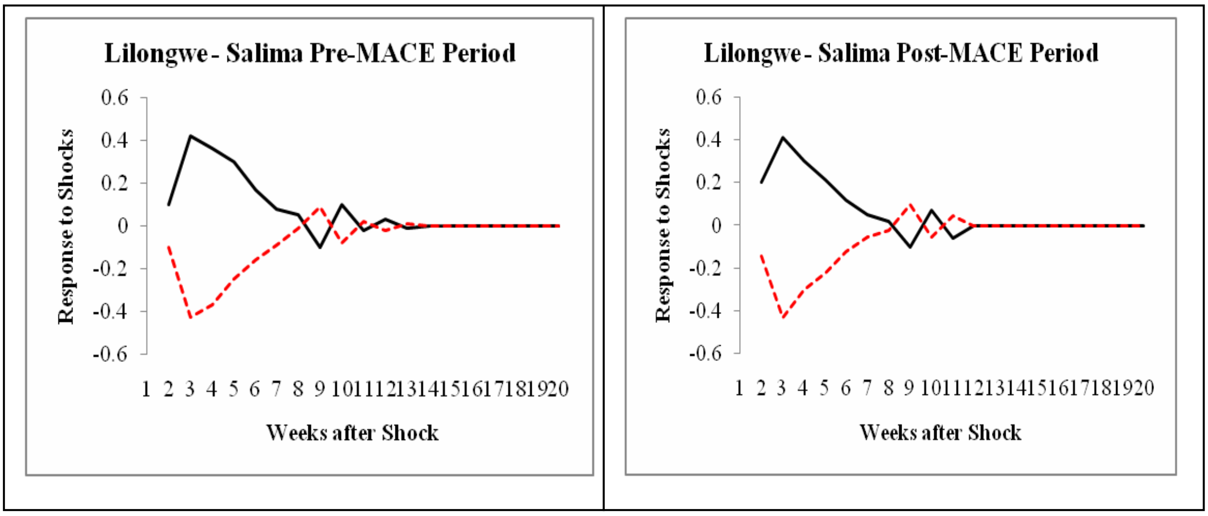


Figure 9: Response of Salima Rice Market to positive/negative price shocks in the Lilongwe Rice market

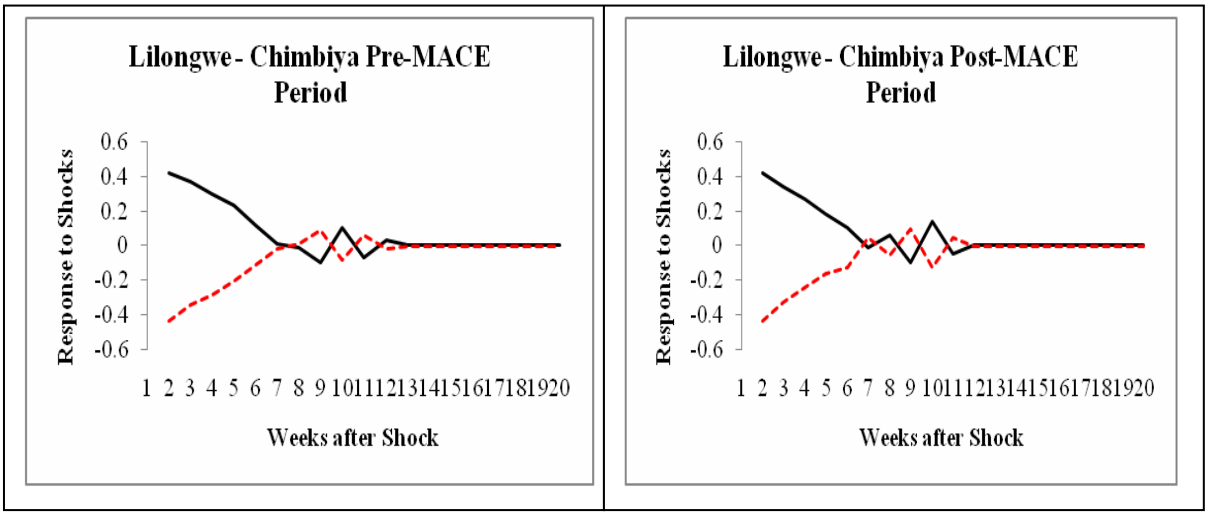


Figure 10: Response of Chimbiya Rice market to positive/negative price shocks in the Lilongwe Rice market

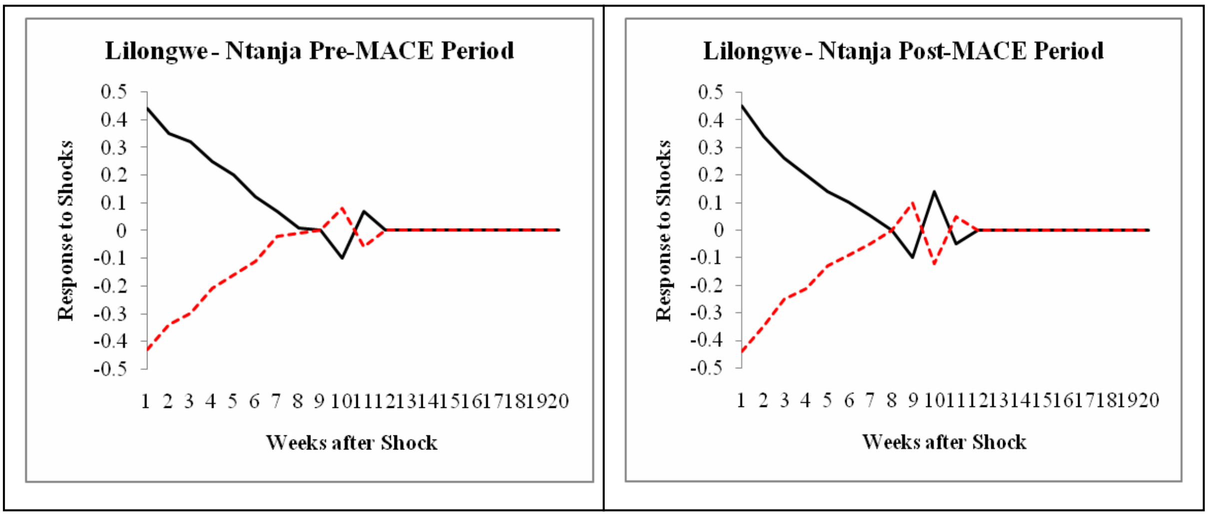


Figure 11: Response of Ntaja Rice Market to positive/negative price shocks in the Lilongwe Rice market

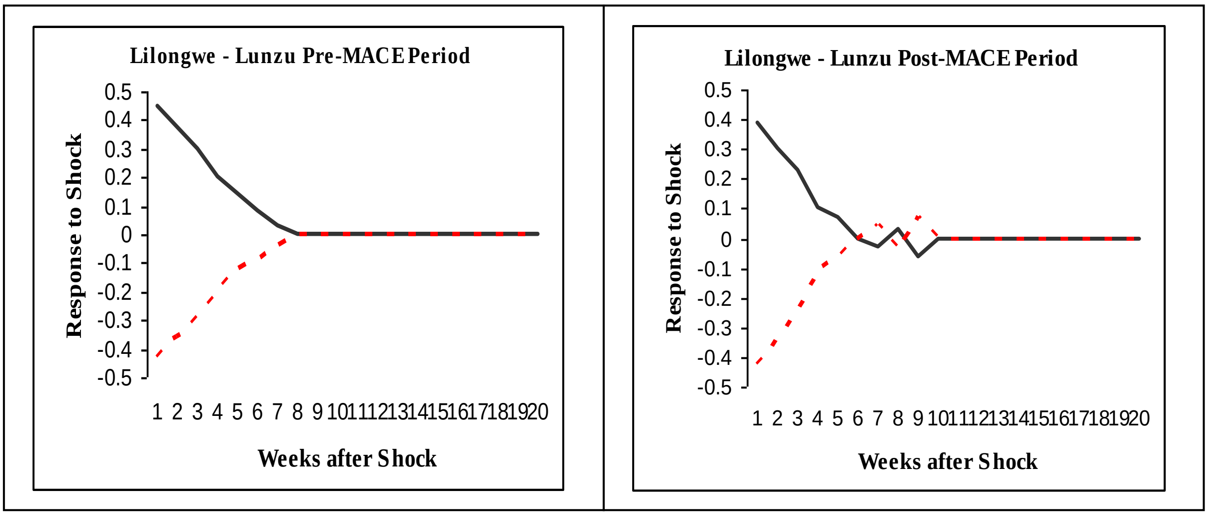


Figure 12: Response of Lunzu Rice Market to positive/negative price shocks in the Lilongwe Rice market

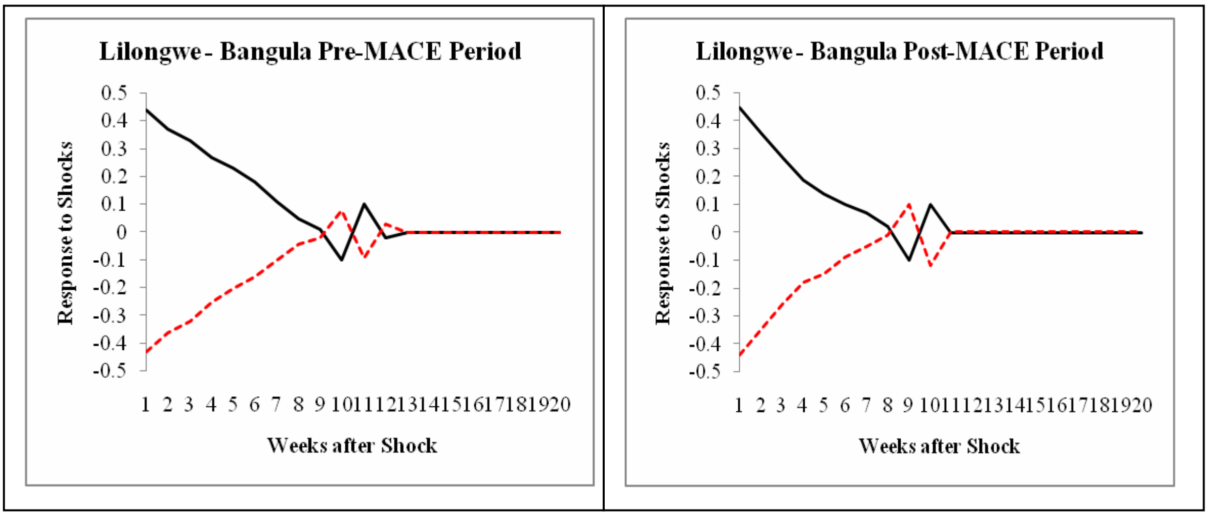


Figure 13: Response of Bangula Rice market to positive/negative price shocks in the Lilongwe Rice market

Appendix 2: Proportional Difference Test

To test for proportional difference for Pre-MACE and Post-MACE periods for a given co-integration parameter, Z-test was performed as follows.

$H_0 : p_i = p_j$

$H_0 : p_i \neq p_j$

$$z = \frac{p_i - p_j}{\sqrt{\frac{p_c\left(1-p_c\right)}{n_i} + \frac{p_c\left(1-p_c\right)}{n_j}}}$$

where, $p_c = \frac{x_i + x_j}{n_i + n_j}$

z = Standard normal cumulative probabilities

p_i = Proportional of Pre-MACE

p_j = Proportional of Post-MACE

p_c = Pooled estimate of p_i and p_j

x_i = Number of co-integrated markets during the Pre-MACE

x_j = Number of co-integrated markets during the Post-MACE

n_i = Total number of markets during the Pre-MACE

n_j = Total number of markets during the Post-MACE

Appendix 3: Test for Significant Differences between Pre and Post-MACE Periods

	PRE-MACE (%)	***POST-MACE (%)***	***P-VALUE***
Co-integrated Markets	58.93	73.21	0.0006
Unidirectional Causality	61.11	50.00	0.7486
Bi-directional Causality	22.22	38.89	0.0147
Independent Causality	16.67	11.11	0.6844
Magnitude of Price Shock Transmitted from Market *i* to Market *j*	17.70	23.00	0.0448
Average Speed of Adjustment for Price Shocks	29.10	42.20	0.0068

Appendix 4: Map of Malawi showing the Markets under Study