INTERCOMMODITY PRICE TRANSMISSION: AN ANALYSIS OF TANZANIAN MAIZE AND RICE MARKETS

MUHIDINI SALEHE ZUNGO

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO, TANZANIA.

2017

ABSTRACT

The overall objective of the present study was to examine price linkages between maize and rice to inform food policy in Tanzania. The specific objectives were: i) to analyze trends in monthly wholesale prices for maize and rice in selected markets; ii) to determine the degree of price transmission between maize and rice; iii) to determine the direction of causality between maize and rice prices. A purposive sampling was used to draw a sample of ten (10) markets /regions. The study used monthly wholesale prices for maize and rice from July 1992 to December 2012. The data were obtained from the Ministry of Industry and Trade in Tanzania. The study employed descriptive and econometric (Co-integration and causality techniques) analyses. Microsoft Excel, SPSS and STATA were used during the analyses. Prices of the considered commodities follow an upward trend with frequent fluctuations in specific periods. This trend displays some co-movement. Seasonal indices follow the cropping cycle for the commodities under investigation. Price variation for the two commodities is consistently high in all markets. Moreover, many of these are connected. ECM reveals that many of the market pairs denied price transmission between the two commodities in the short-run with three (3) months lags. In many cases, bidirectional causality was observed between the two commodities rather than unidirectional causal reference. The study recommends that (i) the government should make efforts to reduce price instability in agricultural markets (ii) The government should improve transportation infrastructures including where the crops are produced so as to ensure movement of crops in all weather conditions (iii) Also more researches on intercommodity price transmission should be conducted and the analysis should exploit factors like information on marketing and transfer costs.

DECLARATION

I, **Muhidini Salehe Zungo,** do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Muhidini Salehe Zungo Date

(M.Sc. Candidate)

The above declaration is confirmed by:

Prof. F. T. M. Kilima Date

(Supervisor)

COPYRIGHT

ACKNOWLEDGEMENT

It is my honour to express my sincere gratitude to my parents (Mr. Salehe Mzee Zungo and Mrs. Ghalie Mwamvua Zungo) for having sponsored my studies at Sokoine University of Agriculture. Special thanks are due to Professor M. M. A. Mtambo of the Department of Veterinary Medicine and Public Health, Sokoine University of Agriculture for advising and initially encouraging me to pursue the M.Sc. (Agricultural Economics) course at the University.

Many people helped the author to complete this work. The help rendered to me by all my fellow M.Sc. Agricultural Economics students and all staff at the Ministry of Industry and Trade is highly appreciated. The author would like to acknowledge the support of the Statistician of the Ministry of Industry and Trade Mr. Genya Charles Genya for his effort to provide me with data required for the study and devoting much of his invaluable time to compile the dataset.

My grateful thanks are due to my supervisor Professor Freddy T. M. Kilima from the Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture for his invaluable assistance in form of comments, criticisms, suggestions and editorial work which eventually led to the completion and form in which this dissertation appears. Acknowledgement is made to the same Department specifically to the Head of the Department and other member of academic staff for their support during my studies.

DEDICATION

This work is dedicated to all members of my family namely Salehe M. Zungo (father), Ghalie M. Zungo (mother), Kuruthum Abdulrahman Ismail (Lovely wife), Ashraf S. Zungo (brother), Hijah S. Zungo (young brother) and Saudat S. Zungo (sister) for their kindness and support during my studies. ***"I love you very much".***

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND SYMBOLS

ADF	Augmented Dickey Fuller
AR	Arusha
CV	Coefficient of variation
DOM	DODOMA
DSM	Dar es Salaam
ECM	Error Correction Model
ECT	Error correction term
FAO	Food and Agriculture Organization
GC	Granger Causality
IMC	Index of Market Connection
IR	Iringa
MBY	Mbeya
MIT	Ministry of Industry and Trade
MORO	Morogoro
MWZ	Mwanza
N	Total number of observations
NBS	National Bureau of Statistics
NFRA	National Food Reserve Agency
NSCA	National Sample Census of Agriculture
PBM	Parity Bound Models
PSNP	Productive Safety Net Program
SGR	Strategic Grain Reserve
SHY	Shinyanga
SONG	Songea

SPSS	Statistical Package for Social Science
SURE	Seemingly unrelated estimation
TAR	Threshold Autoregressive
TBR	Tabora
VAR	Vector Autoregressive
VECM	Vector Error Correction Model

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The staple food basket of many households in developing countries consists of more than one substitutable cereal (Rashid, 2011). FAO (2009a) cited by (Minot *et al.*, 2010) indicates that this food basket for households in Tanzania includes maize, cassava, rice, wheat, and sorghum. However, maize and paddy/rice are the most preferred and the marketing of these two crops involve a wide range of stakeholders (Ashimogo and Mbiha, 2007). Indeed, this is the reason to justify government interventions in maize and rice markets (Ashimogo and Mbiha, 2007). These two crops are close substitutes. Substitutability typically implies that their prices are likely to have a long-run relationship, and price shocks to one commodity are likely to be transmitted to another commodity across space and time, if markets are integrated. Therefore, price transmission study focusing on these crops can potentially draw specific lessons to inform food policy and influence the production, marketing and utilization of maize and rice.

Also production and consumption of maize and rice are characterised by seasonal and spatial variation attributable to occurrences of periodic surpluses and deficits in different regions or districts within Tanzania. For instance, in years when there is maize shortage, the government releases grain stock from its National Food Reserve Agency (NFRA) formally known as Strategic Grain Reserve (SGR) (Nyange, 1999). Furthermore, private traders and relief agencies also import food and these imports affect food supply.

Owing to substitutability of maize and rice, an understanding of the degree of price transmission between these staple grains is crucial to ensure effective design and implementation of food policy in Tanzania. Literature shows that price transmission may affect the speed of traders' response to move food to deficit areas, especially during emergencies such as drought, floods or pestilence (Nyange, 1999).

1.2 Problem Statement and Justification

Prices of staple foods in Tanzania have been fluctuating due to reasons such as poor harvest leading to food shortage. Furthermore, this fluctuation affects the welfare of both producers and consumers. Producers are affected once there is a decrease in prices of their produce especially during bumper harvest while consumers in deficit regions are affected when there is an increase in food prices (Dawe and Opazo, 2009). Price instability continues to receive policy attention in many developing countries in general and Tanzania in particular. Price stabilization through either buffer stock or trade have been sought to reduce price fluctuation. Whichever approach is adopted, the cost of stabilization is reduced if internal markets are well integrated in the sense that price movements are transmitted across all spatially dispersed markets and commodities (Rashid 2011; Sadoulet and de Janvry, 1995). However, what appears to be important is the cost effectiveness of the approach adopted and a least cost approach would be preferred.

Food markets in Tanzania, like many other developing economies, are likely to be segmented due to several reasons such as poor transportation infrastructure (Onyuma *et al.*, 2006; Basu and Bell, 1991; Nyange, 1999). Therefore, market integration studies are important to measure marketing efficiency, and hence identifying means for improving market performance.

Price integration studies conducted in developing countries have analysed the price relationships for single commodities across markets (Alderman, 1993). Studies on price linkages in Tanzania such as Ashimogo (1995) and Gjolberg *et al.* (2004) have assessed price integration between pairs of segmented regions within the country.

These studies have generated useful information on spatial price transmission for a single commodity and the findings of these earlier studies provide useful insights into the degree of price integration in local markets and highlight policy intervention measures needed to improve market efficiency (Kilima, 2006). An understanding of inter-commodity price relationships and transmissions is particularly important for developing countries, where cereals account for a large share of agricultural commodities and value-added products.

In these countries prices are generally volatile, social safety net programs are common and modern and traditional Production technologies coexist (Rashid, 2011). This implies that success of cash based social safety net programs, which are perceived to be ideal are likely to be affected by the instability of cereal prices. Rashid and Lemma (2011) found that all beneficiaries of productive safety net program (PSNP) in Ethiopia preferred food over cash as the value of cash transfers declined drastically at the time of food price hike. Thus, farmers have to be food self-sufficient in terms of basic staples to hedge against food price risks (de Janvry *et al.*, 1991). These farmers are not likely to invest in cash crops if cereal prices are volatile (Fafchamps, 1992), and will make less risky crop choices (Dercon 1996; Murdoch, 1995). This avoidance is common when there are market failures such as inadequate infrastructure, incomplete credit and insurance markets and information asymmetry. These failures are widely acknowledged as the basis for public interventions in the cereal markets (Timmer, 1989). However, market interventions can potentially distort commodity prices and affect price transmission within and between commodities traded in different markets. In general, it is crucial to understand price transmission for agricultural commodities.

However, to the best knowledge of the author, little is known about inter-commodity price transmission in Tanzania. Thus, more studies are needed to assess relationships that exist among related commodities particularly cereal crops. This study was conducted to fill this knowledge gap. The study examined price linkages between domestic market prices for maize and rice in a number of selected regions/markets in Tanzania. The study has generated new knowledge on price linkages that is crucial in making decisions related to food policy.

1.3 The Study Objectives

1.3.1 The overall objective

The overall objective of the present study was to examine price linkages between maize and rice to inform food policy in Tanzania.

1.3.2 The specific objectives

The specific objectives of the study were:

i. To analyse trends in monthly wholesale prices for maize and rice in selected markets.
ii. To determine the degree of price transmission between maize and rice.
iii. To determine the direction of causality between maize and rice prices.

1.4 Hypotheses

i. There is no price transmission between maize and rice.
ii. There is no causality between maize and rice prices.

1.5 Organization of the Dissertation

The present study has five chapters. The first chapter provides a general background to the study with a particular emphasis on the main problem addressed, study objectives and hypotheses tested. The second chapter presents a thorough review of literatures relevant to the study. The third chapter presents a detailed description of the methodology employed by the present study. The fourth chapter presents the main findings while the last chapter gives concluding remarks and recommendations based on the analysis and findings.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter presents a thorough review of relevant literature. Section 2.1 gives descriptions of key concepts underlying the study. The concepts covered are market integration, price transmission and market efficiency. Section 2.2 provides a review of the market structure for maize and rice in Tanzania. Section 2.3 offers a brief discussion of approaches used to analyze price transmission.

2.2 Description of Key Concepts

2.2.1 Market integration

According to Gabre-Madhin (2001) cited by Ashimogo and Mbiha (2007) the extent to which price changes in one market are associated with price changes in other markets is known as market integration. This can occur when prices in different markets move together; there is existence of trade between or among markets and or combination of these two conditions (Minot and Rashid, 2010). In an economy comprising of a number of regions, trade for a homogeneous commodity between regions will take place if and only if the price in the importing region equals the price in the exporting region plus the per unit transfer cost between the two regions. This will happen only if there is free flow of commodities and information, and thus prices across regions are said to be integrated (Sexton *et al.*, 1991).

Studies on market integration are increasingly becoming important, particularly in developing countries where market failures and government interventions are common leading to price distortions and poor price transmission. These studies have implications on policy aspects such as devising strategies for market intervention (Alexander and Wyeth, 1994) including trade facilitation (Barrett, 1996) and enhancing market efficiency (Familow and Benson, 1990).

2.2.2 Price transmission

Normally price transmission can take place between/among spatially separated markets (spatial price transmission), along different nodes of the commodity value chain (vertical price transmission) as well as between/among commodities (inter-commodity price transmission). Price transmission is generally measured in terms of the transmission elasticity, defined as the percentage change in the price in one market resulting from one percent change in the price in another market (Minot *et al.*, 2011). Essentially, price transmission is closely related or associated with market integration. That is, in order for market integration to occur, there must be a transfer of price shocks either between markets, in the supply chain or among related commodities. Therefore, if price changes in one market, point in the supply chain or related commodities occurs and it is transmitted into another market, point in the supply chain or related commodity then markets are said to be integrated since price transmission exist. On the other hand, the flow of commodities between markets is one of the conditions for the occurrence of market integration and, indeed, it is highly influenced by the degree of price transmission.

2.2.3 Market efficiency

Market efficiency can be defined as the extent to which markets minimize costs and match supply with demand (Minot and Rashid 2010). Furthermore, market efficiency can be measured in terms of exchange and operational efficiency. Exchange (arbitrage) efficiency is the one which exists when all opportunities for beneficial trade among actors in the markets are exploited. On the other hand, operational efficiency exists when there is no possibility to reduce transfer costs below the existing level. Operational efficiency can further be classified into short and long-run efficiency. Minot and Rashid (2010) point out that short-run operational efficiency refers to the inability to reduce transfer costs in the short run through changes in procedures or policies, while long-run operational efficiency refers to the inability to reduce transfer costs through infrastructural investment such as the improvement of roads and communications networks.

2.3 Market Structure for Maize and Rice in Tanzania

2.3.1 Maize

Literature shows that maize is the most important staple food among households in Tanzania. According to the 2002-03 National Sample Census of Agriculture (NSCA) maize is produced by 4.5 million farm households representing about 82% of all Tanzanian farmers. Furthermore, about 98% of total maize grown in Tanzania is produced by smallholder farmers (Minot and Rashid 2010). Maize marketing is dominated by large number of small traders operating both in the main producing areas and major urban areas where some of the surplus production is sold (Nyange and Wobst, 2005). Maize is mainly substituted with rice especially when households' earnings increase. This substitution steams from the fact that many of the households in Tanzania are poor; hence they consider maize which tends to be relatively cheaper as inferior to rice. Thus maize has relatively smaller income elasticity than rice.

2.3.2 Rice

Rice is also an important staple food in Tanzania. Its per capita consumption is about 16Kg and it contributes about 8% of calorific intake among Tanzanians (Minot *et al.*, 2010). The largest proportion of rice (99%) is produced by smallholder farmers including those who grow it in large scale rice irrigation schemes that were formerly state-managed farms (NBS, 2006). Rice is the most commercialised crop and is widely consumed in commercial places such as hotels and restaurants and institutions (Gabagambi, 1998). However, many of the regular consumers of rice in hotels and food vending places are not poor people who cannot afford to buy it. Furthermore, preference for rice consumption in restaurants and institutions is mainly due to its convenience in terms of catering (Gabagambi, 1998).

2.3 Approaches used to Analyze Price Transmission

There are several previous studies on price transmission which were conceived in a market integration perspective. These include but not limited to studies by Ravallion (1986), Gardner and Brooks (1994) and Rapsomanikis *et al.* (2005). To date many of the earlier approaches used to test the extent of integration between geographically separated markets have been significantly advanced. Historically, the very early studies on price transmission relied on correlation analysis to test the degree of market integration (e.g. Badiane, 1997). However, factors such as population growth, seasonality, changes in procurement policy and general price inflation can potentially alter price levels and variability thereby inducing spurious changes in correlation coefficients (Badiane, 1997; Kilima, 2006).

Apart from correlation analysis, authors such as Monke and Petzel (1984), Mundlak and Larson (1992) and Gardner and Brooks (1994) recommend the use regression in testing market integration. This analysis is essentially based only on contemporaneous prices of the commodities between spatially separated markets. Besides, the regression coefficient is taken as a determinant of the extent of market integration or co-movement between price series. Nonetheless, this approach has several limitations due to its static nature in the sense that it only considers contemporaneous arbitrage. Moreover, this approach may lead to an estimation of spurious regression which can bring incorrect insights about the extent and direction of price transmission when non-stationary data are used in the estimation. On the other hand, the approach down plays the influence of transaction costs and price variation in price transmission and the extent of market integration (Kilima, 2006; Onya and Ajutu, 2006).

Time series techniques have also been used in testing the integration of spatially separated markets (Boyd and Brorsen, 1986; Delgado, 1986; Ravallion, 1986 and Trotter, 1992). Several techniques including Granger causality, dynamic regression tests, models, and co-integration analysis are all falling under this group. Granger causality (GC) tests are commonly used to explain the nature of causation between variables and are conducted within the VAR framework proposed by Granger (1969). It tests the extent of integration among dynamically interconnected prices between geographically separated markets of a particular commodity in terms of lead and lag relationships and has been widely used (Alexander and Wyeth 1994; Koontz *et al.*, 1990; Mendoza and Rosegrant, 1995; Uri *et al.,* 1993). However, the techniques suffer from various limitations including those invalidating the use of correlation coefficient and standard regression analyses. For instance, GC tests can only indicate whether the relationship between contemporaneous and lagged prices is statistically different from zero, but it fails to reveal the nature of the relationship (Kilima, 2003). Dynamic regression techniques pioneered by Ravallion (1986) are the alternative to dynamic standard regressions and GC tests. Timmer (1987) advanced the techniques developed by Ravallion (1986) after introducing the index of market connectedness (IMC). This index shows the degree of short-run market integration depending on its value. According to this index smaller values (<1) means that markets are connected at least in the short-run while larger values (>1) implies that markets are not integrated in the short-run. However, its interpretation is still ambiguous and hence, its use should be based on prior information about markets and commodity at hands. For instance Kilima (2006) argues that a higher value of IMC suggests that markets are not connected probably due to higher transport costs. Similarly, a low value might indicate that markets are integrated in the short-run, but it does not tell the extent to which the markets are connected.

Normally, price series for interconnected markets are expected to rely on its own past values and previous values of other markets as well. This implies that any past change in prices in one market will be transmitted and induce some changes in the present or future prices in other markets. Literature shows that these co-movements might have some recurring long term relationships. Thus, researchers have introduced co-integration analysis in order to study long-run linkages between non-stationary sets of prices (Badiane, 1997). Indeed, co-integration between price series simply means that the series may diverge in the short-run, but, in the long-run they will eventually converge towards its long-run equilibrium (Arshad and Hameed, 2009). This divergence may be attributed by various factors such as policy changes or seasonal variability (Palaskas, 1995; Enders, 1995). If the divergence persists, economic forces like market mechanisms may bring them together in the long-run. However, co-integration techniques do not reveal the dynamic relationships between prices such as the speed of adjustment and the direction of causality. Therefore, an error correction model (ECM) has been used to explain more of the features of dynamic relationships between price series. Thus, the short-run and long-run parameters of ECM measure the speed and degree of price transmission from one price series to another (Prakash, 1999).

Since many of these earlier approaches did not capture transfer costs in testing the degree of market integration, researchers introduced the parity bound model (PBM) and threshold autoregressive (TAR) model which take into account the transfer costs incurred in moving commodity between the markets. The techniques recognize the fact that prices in geographically separated markets may not move together if price differential is less than marketing cost between the markets (Rashid and Minot *et al.*, 2010). Normally, inter spatial price difference between two markets can be equal to marketing costs, less than marketing costs or greater than marketing costs. These situations imply that markets are competitive; no co-movement of prices and temporary disequilibrium or market imperfections, respectively. Notably, PBM is capable of estimating the proportion of time of which a pair of markets is in all three conditions (Baulch, 1997). Nonetheless, the technique is criticised for being biased to bivariate analyses of variables (Fackler, and Tostam 2008). On the other hand, its results are highly influenced by the nature of distribution of the data and its assumptions (Barrett and Li, 2002). Furthermore, Fackler and Tostam (2008) argues that the technique assumes shocks to be serially independent and hence fails to capture the dynamic adjustments of the variables.

TAR model approximates the threshold for price margin between markets so as to judge the co-movement of prices and whether the trade is profitable. Thus, if the price margin is greater than the threshold, then co-movement between prices exists and if it is less than the threshold the trade is not profitable and hence co-movement of prices does not exist (Rashid and Minot *et al.*, 2010). The TAR model is almost similar to PBM since the "threshold" can be estimated within the model or it can be fixed based on outside information. A short summary of the characteristics for some of the techniques discussed above is presented in Appendix 2.

In summary, the extent of price transmission lacks a direct unambiguous empirical counterpart in the form of single formal testing (Rapsomanikis *et al.*, 2003; Kilima, 2006;

Onya and Ajutu, 2006). Therefore, this study employed both Granger-Causality and co-integration tests. The main reasons for the selection of these techniques, amongst others, were the limitations in capacity (software) to use sophisticated techniques and data requirements and availability. For instance, some of approaches require the inclusion of transfer costs as one of the independent variables; however, in many cases it is very difficult to get data on transfer costs, especially in developing countries including Tanzania.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This chapter presents a detailed description of the methodology employed by the present study. Section 3.1 provides the elaboration of the conceptual framework of the study. Section 3.2 identifies the selected markets/regions (area of the study). Section 3.3 explains the types and sources of the data used in the analysis. Section 3.4 presents the research design employed in the present study. Section 3.5 explains the sampling procedures followed and sample size used in this study. Section 3.6 describes the procedures followed in analyzing the data collected. In this aspect, it covers issues such as deseasonalisation of nominal maize and rice prices, econometric analysis (the framework of testing causality and price transmission, unit root test and co-integration test).

3.2 The Conceptual Framework

It has been stated that the overall objective of the present study is to examine price linkages between maize and rice to inform food policy in Tanzania. The business environment that surrounds maize and rice markets should be critically examined to understand such linkage, market integration as well as price transmission between these two crops. Market integration and price transmission are influenced by commodity markets and marketing systems that are affected by market policies and interventions. Therefore, it is essential to investigate how implicit and explicit government interventions influence price integration and transmission.

In practice, price integration and transmission are analysed using econometric models. These models normally include variables such as transportation cost and market information. Moreover, there are other factors like degree of substitutability between commodities, distance between markets and quality of the roads connecting the markets. Therefore, this study combined econometric and qualitative methods to analyze price integration and transmission and identify factors underlying these mechanisms as per conceptual frame in Figure 1.

In developing countries, the governments have been introducing various interventions in agricultural markets. Indeed, these interventions affect the markets of the particular commodities positively or negatively. In a policy context for Tanzania, interventions such as banning inter-regional, inter-district and/or inter-country trade for staple crops such as maize tend to affect the whole agricultural marketing systems. These kinds of interventions have negative implication on the nature of substitutability between crops and eventually the price integration and transmission among markets.

Although some government-led interventions in agricultural markets enhance market integration, experience shows that many of these interventions tend to block markets and hence reduce the degree of market integration (Wu, 2004). Thus, the intervention may lead to what can be referred as planned market integration rather than real market integration. Therefore, these interventions are likely to impede free movement of commodities due to increased taxes and levies for transported agricultural produce and hence increasing transportation costs (James and Corthay, 2009). On the other hand, the government decisions towards developing transportation networks especially roads networks play a crucial role in promoting the market efficiency. For instance, the government of Tanzania through the roads networks strategic interventions, the government has been improving the roads infrastructure in our country. In fact, the quality of these roads and the distance between markets have an impact on transaction costs. For instance, if markets are connected with poor road networks the transaction costs of moving commodities between the markets tend to be higher and hence affect the degree of price integration and transmission. Moreover, the induced bureaucracy due to the government interventions in agricultural markets affects the flow of information and the degree of substitutability between substitutes crops. The bureaucracy resulting from government interventions may limit the flow of market information and reduce the degree of substitutability between related crops (Rashid, 2011). As a result, key actors within the commodity value chains such as producers, processors, transporters and suppliers become less informed about market conditions and hence fail to adjust to market changes, especially price levels and fluctuations. Owing to this uncertainty, commodity prices will be distorted thereby impeding spatial arbitrage that transmits price changes from one to another market.

Also distances between regions affect the flow of commodities. It is expected that when the condition of transportation infrastructure and market conditions are good, the flow of agricultural commodities will be higher between regions that are close than those which are far from each other. However, when the quality of transportation infrastructure is different its quality will have different impact on market integration since it can either speed up or lower the rate of flow of the commodities between regions.

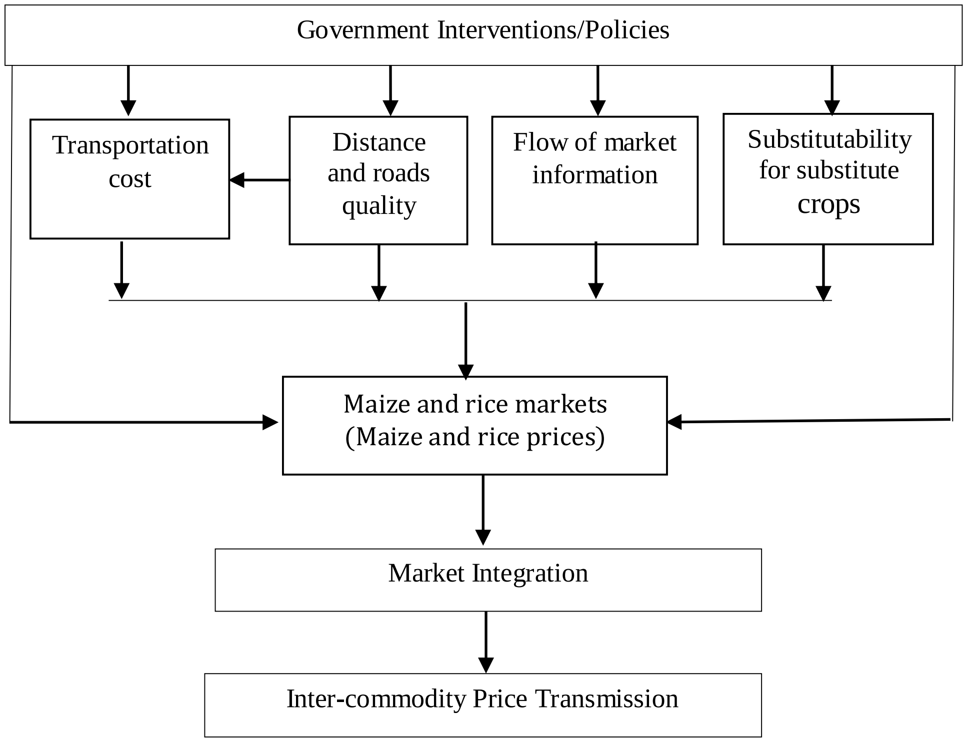


Figure 1: Conceptual Framework

Figure 1 above reveals that government interventions in commodity markets can be in form of taxes on transportation services, which lead to increased cost of transportation that reduces spatial market integration and limit the scope of commodity substitution (Mkenda and Campenhout, 2011). Another form of government intervention could be restricting spatial movement of commodities either within the country or between countries that may adversely affect the degree of market integration which will eventually affect the degree of substitutability between commodities. Note that the fact that substitutability between commodities across space and time is possible if and only if markets are integrated (Rashid, 2011). On the other hand, an intervention by the government on agricultural markets can be in the form of policies that can improve the flow of market information in specific areas.

For instance, the use of information and communication technology such as the use of mobile phones in provision of market information and establishment of institutions that provide marketing information can lead to reduce information asymmetry among actors in agricultural markets (Rashid *et al.*, 2011; Nyange, 1999). Also government intervention in form of policies leading to construction and rehabilitation of roads has a direct positive impact on the performance of agricultural commodity markets. For example, the current speed of Tanzanian government in constructing roads has been simplifying the movement of commodities among regions due to good roads network. Teravaninthon and Raballand (2009), Nyange (1999) and Minten and Kyle (1999) argue that the performance of markets and degree of market integration depend on the quality of the road infrastructures.

3.3 Area of the Study

The selection of the regions/markets was based on the farming systems which reflect different agro-ecological zones in Tanzania. In fact, this study used two criteria in selecting the markets included for the study namely, to ensure each Agro-ecological zone is represented in the analysis and also including only surplus or deficit markets of the two commodities i.e. maize and rice. Thus, at least one region/market was purposively selected to make a sample of ten (10) regions/markets in order to have a fair representation of the farming systems and agro-ecological zones available in Tanzania.

3.4 Data and Sources

The overall objective of the present study is to examine price linkages between maize and rice and inform food price policies in Tanzania. To achieve this objective, this study used historical market prices series of the commodities considered. The series represent monthly wholesale prices for maize and rice from July 1992 to December 2012 that was obtained from the Ministry of Industry and Trade in Tanzania. In order to ensure consistence and data quality, the prices series for both crops in all markets where deseasonalised first before any analysis.

The results obtained from the analysis of time series data were supplemented by the experience from the previous studies and other official publications on the same topic. Therefore, the interpretation and discussions of the findings from econometric analysis was backed-up with previous findings on the same topic. The main reason to rely on previous findings is that the techniques adopted in this study do not incorporate the information on variables such as transportation cost and quality/condition of transportation infrastructure that have been acknowledged to affect market integration and substitutability of commodity prices.

3.5 Research Design

The present study used time series data so as to achieve the stated objectives. Thus, the analyses were based on high frequency prices series data for the commodities considered. In fact, the data used are appropriate for addressing trends and dynamism of the economic phenomena over time. In addition, price series data are appropriate in econometric analyses since they are easily available and commonly used to address the long-run price linkages between commodities.

The analysis was done for ten (10) sampled regions/markets namely Arusha, Dar es Salaam, Dodoma, Iringa, Mbeya, Morogoro, Mwanza, Shinyanga, Songea and Tabora. The selection considered the potentiality of the regions/markets in the formation of prices, production and marketing of at least one of the two crops i.e. being either surplus or deficit region/market of at least one crop. For instance, Dar es Salaam and Mwanza are among the most important regions in the formation of maize prices in Tanzania (Nyange, 1999). Moreover, the selection also took into account the agro-ecological zones of Tanzania so as to incorporate the difference in climate or weather conditions of the markets which influence whether a particular market is a surplus or deficit market for these two crops.

3.6 Sampling Procedures and Sample Size

The present study employed purposive sampling in drawing the markets/regions for the analysis. A sample of ten (10) regions/markets was purposively selected from ten (10) farming systems available in Tanzania. The selection criteria were: i) each farming system must have at least one market in the analysis; ii) the market must be either a surplus or deficit market of at least one of the crops under investigation. This ensured the accommodation of different agro-ecological zones into the analysis. Indeed, the selection criteria were consistent with previous studies on market integration and price transmission (Nyange, 1999; Ashimogo and Mbiha, 2007).

3.7 Data Analysis

The present study applied both descriptive and econometric analyses. Specifically, descriptive analysis was undertaken so as to assess spatial price trends for the two commodities considered. Graphs and descriptive statistics such as coefficient of variation (CV) were used to assess price trends. The CV was used to compare the degree of volatility between the two crops, and among the markets. This is a common and the simplest measure of price variation and it provides some clues on the co-movement and price integration for the proposed pairs of markets. The descriptive analysis was done with the aid of Statistical Package for Social Science (SPSS) software and Excel.

Similarly, Granger-Causality and Co-integration techniques were used to determine the direction and the extent of price transmission between maize and rice prices. Both techniques were used due to the fact that co-integration test is capable of determining the nature of co-movement between or among variables; however, it fails to determine the nature of causality between or among variables. Procedures proposed by Rapsomanikis *et al.* (2003) were followed to determine the degree of market integration/price transmission. These analyses were performed on deseasonalised prices.

3.7.1 Deseasonalisation of nominal maize and rice prices

The original (nominal) price data for both crops were deseasonalised in order to remove seasonal fluctuations so that trend and cycle can be studied. Therefore, ratio-to- moving average method was adopted because it is the most commonly used method to compute the typical seasonal pattern (Lind *et al.,* 2008). In addition, it eliminates the trend, cycles and irregular components from the original data.

3.7.2 Econometric analysis

3.6.2.1 The framework for testing causality and price transmission

The present study first tested the stationarity of all individual prices series for both crops in each market/region. The tests were done using Augmented-Dickey Fuller (ADF) technique in order to determine whether the prices series for proposed pairs of markets/region are integrated of the same order/degree or not. Specifically, all pairs of markets which were found to have different order of integration were concluded to be not connected, instead the causality test was done based on Granger-causality technique. For the cases of market pairs with prices found to be stationary at their level i.e. (0), an autoregressive distributed lag (ADL) model was estimated in order to perform Granger-causality test.

Also for the pairs of markets which were found to be integrated of the same degree but not stationary i.e. I(d) where d≠0 were exposed to long-run movement of price (co-integration) test using co-integration approach. In this case, the ADF test was done on the residuals so as to determine if are stationary or not. In all cases where the null hypothesis of no co-integration failed to be rejected an autoregressive distributed lag (ADL) model was estimated and the test for causality was also done based on GC as well. However, in all cases where the null hypothesis of no co-integration was rejected, a Granger-causality test was done using an error correction model (ECM) in order to determine the extent of price transmission between market pairs.

The framework followed to undertake econometric analysis to determine the degree of price transmission and causality between maize and rice prices is summarised in Appendix 4.

3.6.2.2 Unit root test

In order to avoid the problem of spurious regression, the stationarity (unit root) test was conducted using Augmented-Dickey Fuller (ADF) test (Dickey and Fuller, 1981). The test was specifically done to each price series for both crops at the level and first difference for all proposed markets. In the unit root tests, the augmented Dickey- Fuller (ADF) test consists of estimating the following regression:

$$\Delta P_t = \beta + \delta P_{t-1} + \sum_{m=1}^{M} \alpha_m \Delta P_{t-m} + \varepsilon_t \quad \text{.......} (1)$$

Where:

P_t Can either be maize or rice price

Δ is the difference operator,

$\Delta P_{t-1} = (P_{t-1} - P_{t-2})$;

$\Delta P_{t-2} = (P_{t-2} – P_{t-3})$; Thus, $\Delta P_{t-m} = (P_{t-m} – P_{t-m-1})$

M represents the number of lags included in a model

β, δ, and α are parameters to be estimated

ε_t is a white noise error term

The null hypothesis is that δ = 0; that is there is a unit root (the price series is non-stationary) and the alternative hypothesis is that δ <0; that means the price series is stationary.

3.7.2.3 Co-integration test

The next important procedure was to determine the co-integration of each proposed pair for the markets that were presumed to trade. In doing this exercise, a unit root test using ADF test i.e. stationarity test was applied on the errors/residuals obtained from the co-integration regression/Equation (2) below.

$$P_{it}^{R} = \alpha + \beta P_{jt}^{M} + \mu_t \qquad (2)$$

Where:

P_{it}^{M} and P_{jt}^{R} are maize and rice prices for market i and j at time “t” respectively,

α andβ are parameters estimated and

μ_t is a usual error term.

Therefore, a unit root test on errors (μ_t) using Dickey-Fuller test was done so as to determine whether a pair of markets are co-integrated or not.

An error correction model (ECM) was used so as to determine the speed of adjustment, short run elasticity and long run elasticity of price transmission between maize and rice for co-integrated series for 12 market pairs/channels. On the other hand, an Autoregressive Distributed Lag (ADL) model was estimated in order to test the causality between maize and rice prices which were found to have different order of integration after conducting stationarity test using ADF test.

Thus, the following general ADL models were estimated:

$$P_t^M = \propto + \sum_{i=1}^{N} \beta_i P_{t-i}^R + \sum_{k=1}^{K} \theta_k P_{t-k}^M + \mu_t \quad (3)$$

$$P_t^R = \delta + \sum_{i=1}^{N} \gamma_i P_{t-i}^M + \sum_{k=1}^{K} \Psi_k P_{t-k}^R + \upsilon_t \quad (4)$$

Where:

P_t^M and P_t^R are maize and rice prices respectively

P_{t-i}^R Lagged price for rice in natural logarithm

P_{t-k}^M Lagged price of maize in natural logarithm

α, β, ρ, Ψ, δ, γ and θ are parameters estimated in specific granger causality models

μ_t and υ_t are the normal error term

Also the following general ECMs were estimated:

$$\Delta P_t^M = \emptyset + \delta ECT_{t-1} + \sum_{i=1}^{N} \Psi_i \Delta P_{t-i}^R + \sum_{k=1}^{K} \Omega_k \Delta P_{t-k}^M + \gamma_t \quad (5)$$

$$\Delta P_t^M = \emptyset + \delta(P_{t-1}^M - \beta P_{t-1}^R) + \sum_{i=1}^{N} \Psi_i \Delta P_{t-i}^R + \sum_{k=1}^{K} \Omega_k \Delta P_{t-k}^M + \gamma_t \quad (6)$$

$$\Delta P_t^R = \emptyset' + \delta' ECT'_{t-1} + \sum_{i=1}^{N} \Psi'_i \, \Delta P_{t-i}^M + \sum_{k=1}^{K} \Omega'_k \Delta P_{t-k}^R + \gamma'_t \text{.........................} (7)$$

$$\Delta P_t^R = \emptyset' + \delta'(P_{t-1}^R - \beta' P_{t-1}^M) + \sum_{i=1}^{N} \Psi'_i \, \Delta P_{t-i}^M + \sum_{k=1}^{K} \Omega'_k \Delta P_{t-k}^R + \gamma'_t \text{.................} (8)$$

Where:

P_t^M Is the natural logarithm of deseasonalised maize price in TZS

P_t^R Is the natural logarithm of deseasonalised rice prices in TZS

Δ is the difference operator, i.e. $\Delta P_t^M = P_t^M - P_{t-1}^M$; $\Delta P_t^R = P_t^R - P_{t-1}^R$

Ø and Ø' are intercepts

Ω is the autoregressive term, reflecting the effect of each change in the maize and rice prices on the change in maize and rice prices respectively in the next period

Ψ and Ψ' are the short-run elasticities of the maize and rice prices relative to the rice and maize prices respectively in different markets.

δ and δ' are the rates reflecting speed of adjustment for maize and rice in the long-run respectively

β and β' are the long-run elasticity parameters to be estimated

γ_t and γ'_t are the normal error terms

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of descriptive and econometric analyses. Descriptive analysis was used to identify the trends in the price series for each crop under the investigation. On the other hand, econometric analysis was employed to determine the direction of price causality between maize and rice markets as well as the degree of price transmission for commodities considered.

4.2 Maize and Rice Price Trends

The first objective of this study was to analyze trends in monthly wholesale prices for maize and rice in the selected markets (Arusha, Dar es Salaam, Dodoma, Iringa, Mbeya, Morogoro, Mwanza, Shinyanga, Songea and Tabora).

Results show that rice prices in six rice surplus regions follow an upward trend although there are fluctuations in specific periods (Figure 2). This upward trend might be attributed by an increase in population which triggers up the demand for cereal crops. In addition, the trend displays some co-movement. Morogoro and Shinyanga are the regions observed to have the highest and lowest prices relative to other rice surplus regions.

The trend observed in Morogoro market implies that there is a significant trade between the latter and Dar es Salaam market (one of the consumer markets) owing to the close proximity of these two markets. Therefore, more of rice from Morogoro flows into Dar es Salaam city due to relative higher demand and prices in the latter. Moreover, good road connection and short distance between the two regions are presumed to be among the main factors which speed up the rate of flow of rice from Morogoro to Dar-es-Salaam city. As a result, the prices in Morogoro tend to be higher compared to the rest of rice surplus regions. For the case of Shinyanga, it is located far from rice deficit regions such as Dar es Salaam and Iringa where the demand of rice is relative higher. Thus, the transportation of rice to other areas especially deficit areas becomes expensive to the extent that it is no longer profitable for traders to engage in the trade. In addition, Shinyanga is located very closer to other rice surplus regions namely Tabora and Mwanza leading to excessive supply of rice especially in the northern and central parts of our country. Owing to this situation, it is likely that substantial amount of rice produced in Shinyanga is not marketed in other regions because the latter are either rice surplus regions or located very far from the former (Shinyanga) even when the demand for rice is relatively higher. Therefore, this leads to lower rice prices in Shinyanga than other nearby rice surplus regions. See Table 1 below which shows the distance between the markets/regions under the present study.

Table 1: Distance between selected markets/regions in this study

	AR	DSM	DOM	IR	SONG	MBY	MOR	MWZ	TBR	SHY
AR		646	425	689	1144	1020	621	787	661	624
DSM	646		451	492	947	822	192	1152	829	989
DOM	425	451		264	720	594	259	701	378	538
IR	689	492	264		455	330	300	965	642	802
SONG	1144	947	720	455		466	755	1420	1033	1257
MBY	1020	822	594	330	466		630	924	567	761
MOR	621	192	259	300	755	630		960	637	797
MWZ	787	1152	701	965	1420	924	960		357	163
TBR	661	829	378	642	1033	567	637	357		194
SHY	624	989	538	802	1257	761	797	163	194	

Source: TANROADS distance chart March 2017

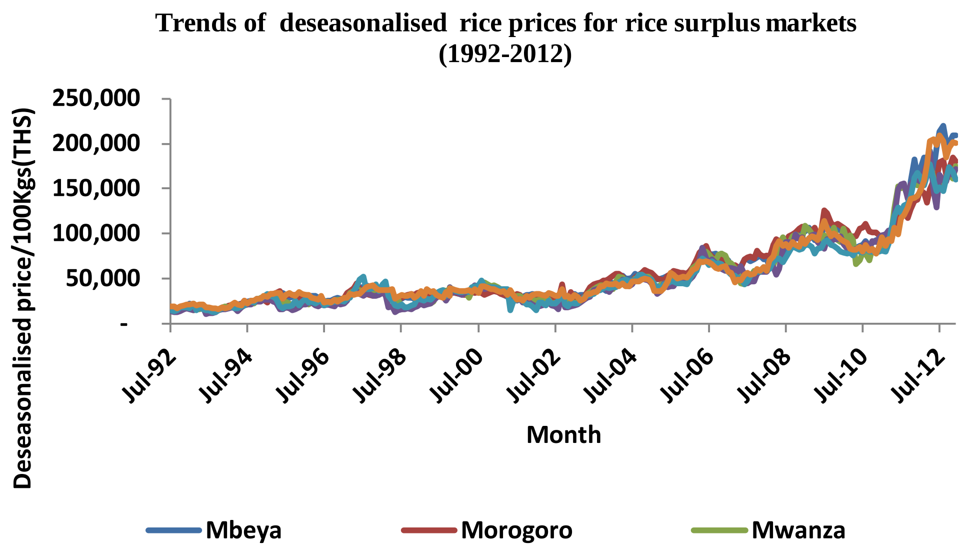


Figure 2: Price Trends in rice surplus markets

4.2.1 Trends of rice prices for rice deficit markets

Figure 3 shows the trends of deseasonalised rice prices in four rice deficit regions. As it was the case for rice surplus regions, prices in rice deficit regions follow an upward trend, however, with some fluctuations. Findings show that Dar-es-Salaam and Iringa have the highest and lowest rice prices, respectively.

Higher rice prices in Dar-es-Salaam might be attributed to high demand for rice in the city. As pointed out by Gabagambi (1998) that in urban is where there are many consumers of rice due to factors such as presence of restaurants and institutions like schools. On the other hand, lower prices observed in Iringa may be reflecting the low demand of rice in the region. Also Iringa is located between Morogoro and Mbeya which are among the major producers of rice in Tanzania. Therefore, the supply of rice from Morogoro and Mbeya to Iringa becomes easy due to short distance separating the regions. This increases the supply of rice in the region and hence leads to lower prices.

Indeed, the fluctuations and upward trends of the deseasonalised rice prices in surplus and deficit regions might be catalysed by factors such as variations in oil prices and rapid increase in demand for rice in the country, respectively; especially in urban areas. For the case of oil prices, it influences tremendously the prices of major staple foods in Tanzania since transport cost is the main component of the food prices (Mkenda and Campenhout, 2011).

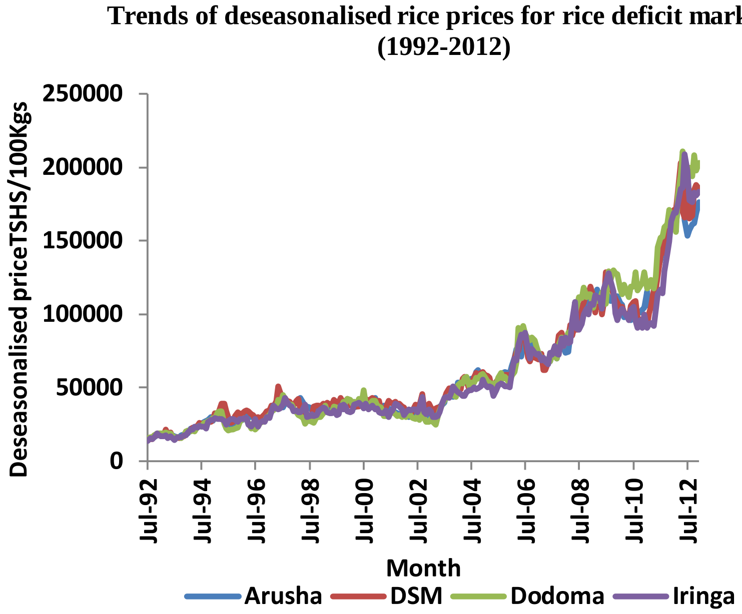


Figure 3: Trends of rice prices in rice deficit regions

4.2.2 Trends of maize prices for maize surplus regions

Maize prices follow an upward trend although there are some fluctuations in specific periods (Figure 4). In addition, prices in all five regions seem to move together throughout the specified period. Findings show that Arusha has the highest prices and Songea has the lowest prices among maize surplus regions.

The higher prices of maize in Arusha might be attributed to high demand for maize than the remaining maize surplus regions since the former is a tourist region. Besides, it has high population which might also be driving up the demand of maize in the region. Inter-country maize bans are presumed to cause lower prices in maize surplus regions that are located in country's borders. Specifically, Songea in Ruvuma region has been one of the regions that are adversely affected by this policy. Consequently, huge stock of maize is not marketed to the neighbouring countries where prices might be more attractive. Therefore, in many cases substantial amount of maize remains in warehouses for a long period of time since it is expensive to transfer to other deficit areas due to long distance. Besides, Songea is located closer to other maize surplus regions namely Iringa and Mbeya. This reduces the prospect of inter-regional maize trade within southern highlands. This situation leads to lower prices in Ruvuma region in general and Songea in particular.

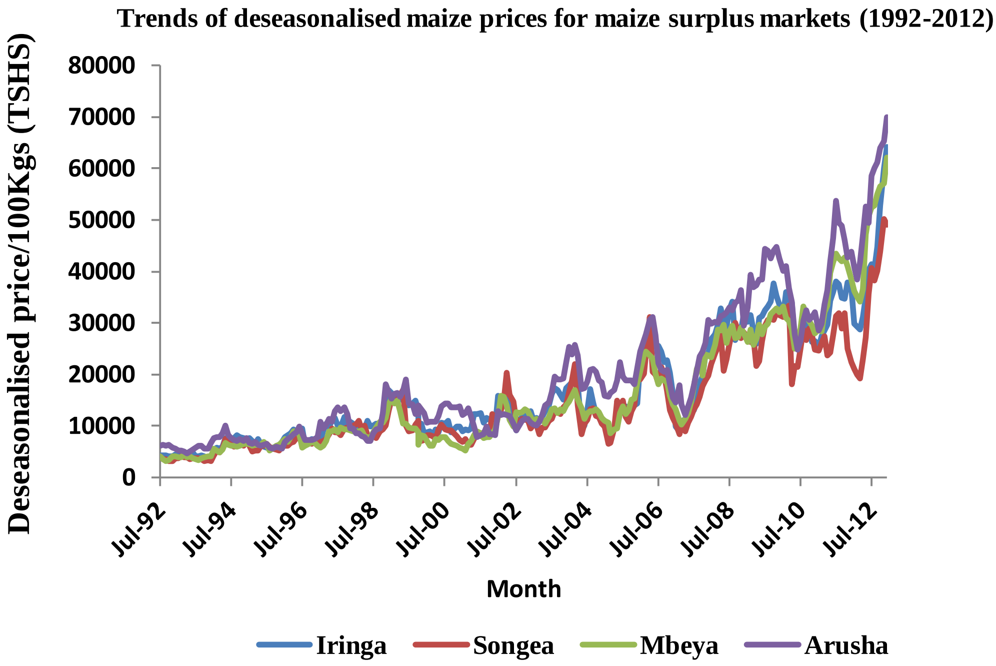


Figure 4: Trends of maize prices for maize surplus regions

4.2.3 Trends of maize prices for maize deficit markets

Figure 5 shows that price trends follow an upward trend even in maize deficit markets. Similarly, prices for all markets seem to move together as it is the case for maize surplus markets. Findings show that Tabora has the lowest prices among the maize deficit markets. Conversely, Dar-es-Salaam and Mwanza have almost the highest prices over the entire range period.

The observed trend for Dar-es-Salaam and Mwanza is expected. Both markets are among the well-developed cities in Tanzania with high population that make effective demand for maize to be high. In addition, the cities have several economic activities such as fishing, mining (for Mwanza) which enable its people to have sufficient purchasing power for food. Thus, demand for maize in these regions has been growing very fast leading to high price (Figure 5).

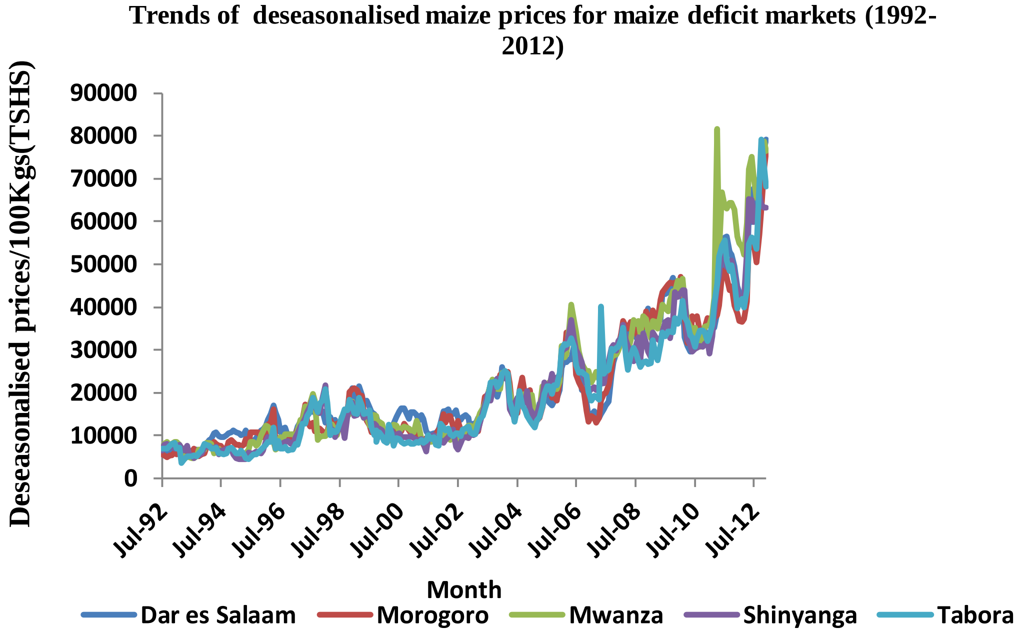


Figure 5: Trends of maize prices in maize deficit regions

4.2.4 Seasonal indices for maize and rice markets

1. Arusha market

Figure 6 shows that maize prices in Arusha are highest in May (112%) and lowest in two months namely August and September (89%). This implies that in May maize prices are 12% above the typical average monthly wholesale maize price while in August and September maize prices are 11% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in March (108%) and lowest in August (94%) (Figure 6). This implies that rice prices in March are 8% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 6%.

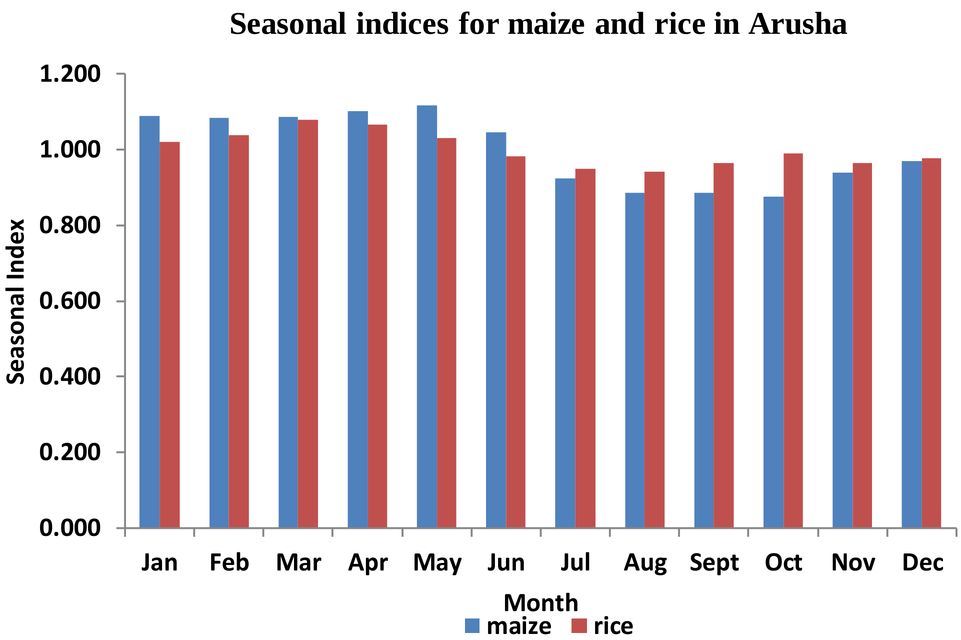


Figure 6: Seasonal indices for maize and rice in Arusha

2. Dar es Salaam market

Observation shows that maize prices in Dar es Salaam are highest in February (112%) and lowest in July (90%) (Fig.7). Therefore, in February prices are 12% above the typical monthly wholesale average price, and for July they are 10% below the typical average monthly wholesale price. Similarly, findings show that rice prices are highest in March (111%) and lowest in August (87%) (Figure 7). This implies that rice prices in March are 11% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 13%.

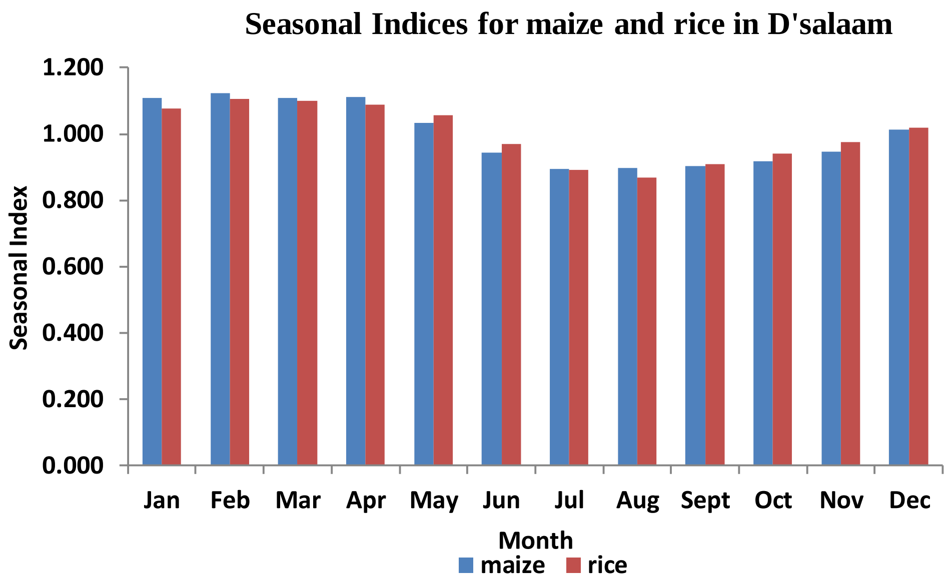


Figure 7: Seasonal Indices for maize and rice in Dar es Salaam

3. Dodoma market

Trends show that maize prices in Dodoma are highest in March (114%) and lowest in August (86%) (Figure 8). This implies that in March maize prices are 14% above the typical average monthly wholesale maize price while in August maize prices are 14% below the typical average monthly wholesale maize price for the region.

On the other hand, findings show that rice prices are highest in April (113%) and lowest in August (88%) (Fig.8). Thus rice prices in March are 13% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 12%.

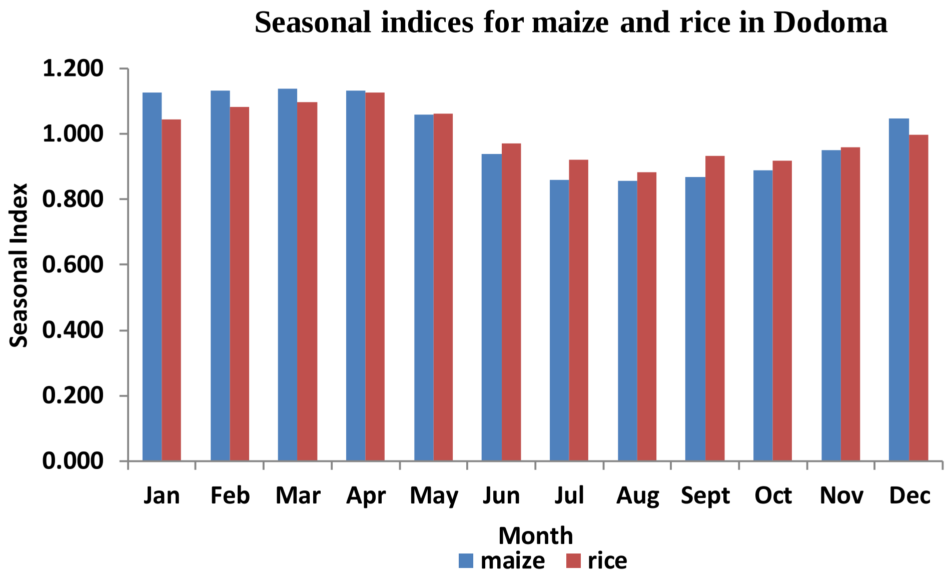


Figure 8: Seasonal indices for maize and rice in Dodoma

4. Morogoro market

Figure 9 shows that maize prices in Morogoro are highest in March (118%) and lowest in July (85%). This implies that in March maize prices are 18% above the typical average monthly wholesale maize price while in July maize prices are 15% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in April (114%) and lowest in August (86%) (Figure 9). This implies that rice prices in April are 14% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 14%.

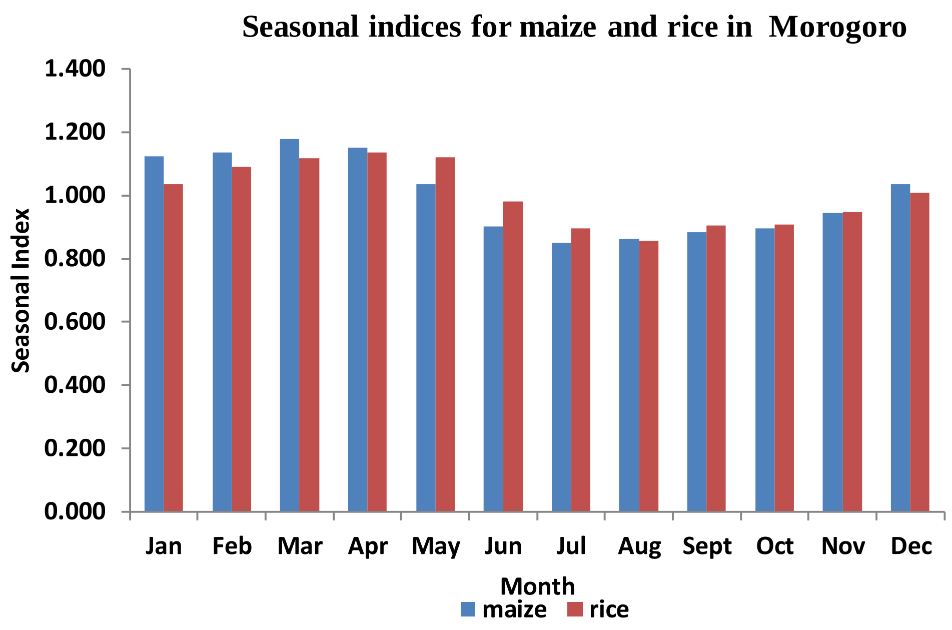


Figure 9: Seasonal indices for maize and rice in Morogoro

5. Iringa market

Findings show that maize prices in Iringa are highest in March (116%) and lowest in September (86%) (Figure 10). This implies that in March maize prices are 16% above the typical average monthly wholesale maize price while in July maize prices are 14% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in April (114%) and lowest in August (87%) (Figure 10). This implies that rice prices in April are 14% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 13%.

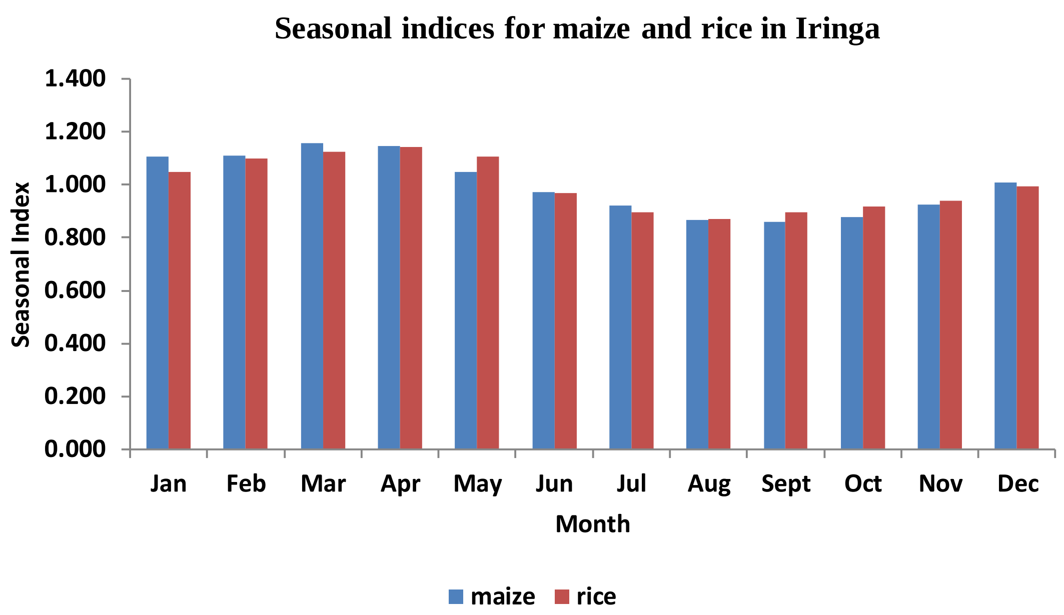


Figure 10: Seasonal indices for maize and rice in Iringa

6. Mwanza market

Figure 11 shows that maize prices in Mwanza are highest in January (113%) and lowest in September (90%). This implies that in January maize prices are 13% above the typical average monthly wholesale maize price while in September maize prices are 10% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in April (113%) and lowest in August (88%) (Figure 11). This implies that rice prices in April are 13% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 12%.

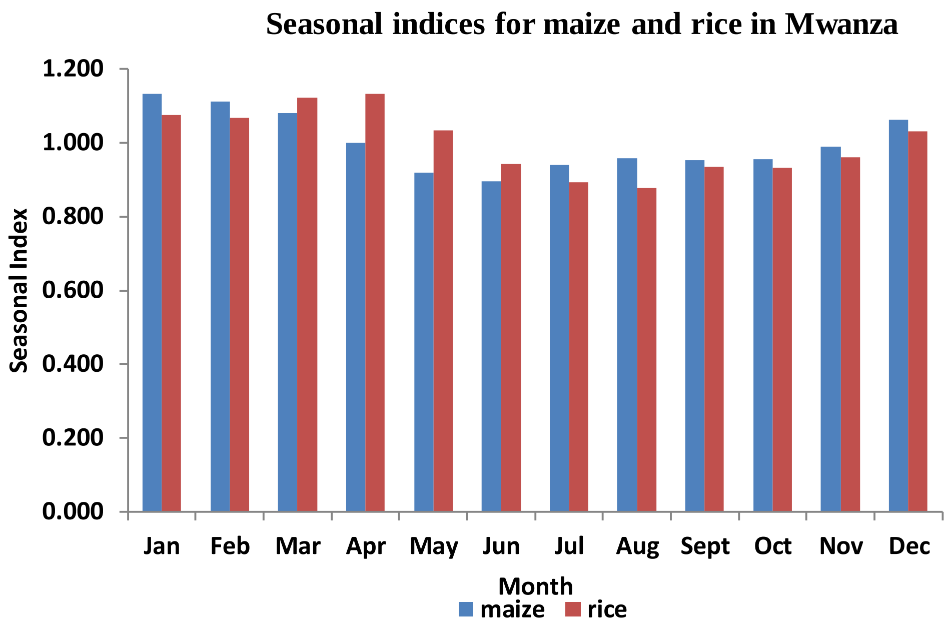


Figure 11: Seasonal indices for maize and rice in Mwanza

7. Songea market

Figure 12 shows that maize prices in Songea are highest in March (120%) and lowest in July (80%). This implies that in March maize prices are 20% above the typical average monthly wholesale maize price while in July maize prices are 20% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in March (111%) and lowest in July (85%) (Figure 12). This implies that rice prices in March are 11% above the typical average monthly wholesale price while in July it is below the typical average monthly wholesale price by 15%.

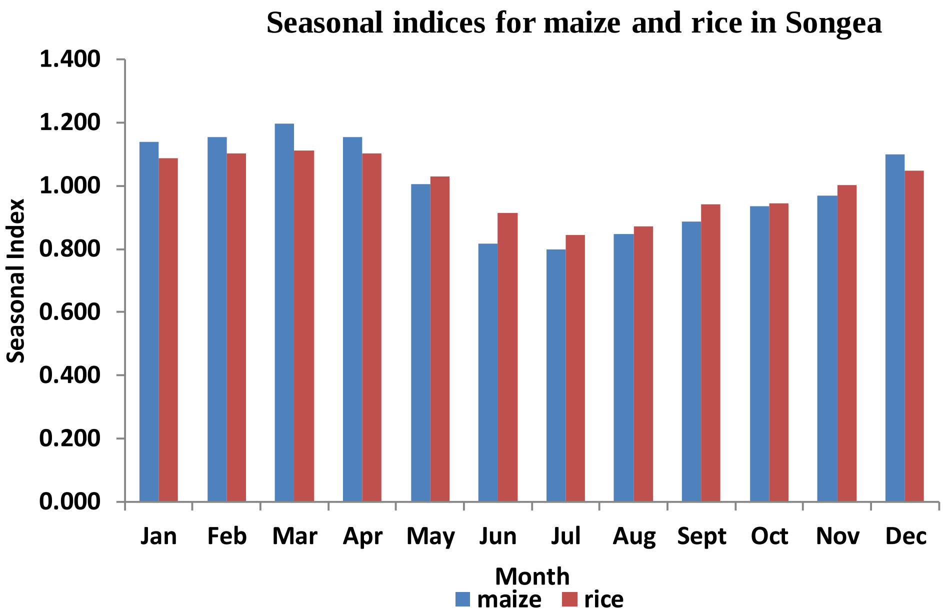


Figure 12: Seasonal indices for maize and rice in Songea

8. Mbeya market

Findings show that maize prices in Mbeya are highest in March (118%) and lowest in June and July (86%) (Figure 13). This implies that in March maize prices are 18% above the typical average monthly wholesale maize price while in June and July maize prices are 14% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in March (113%) and lowest in August (86%) (Figure 13). This implies that rice prices in March are 13% above the typical average monthly wholesale price while in July it is below the typical average monthly wholesale price by 14%.

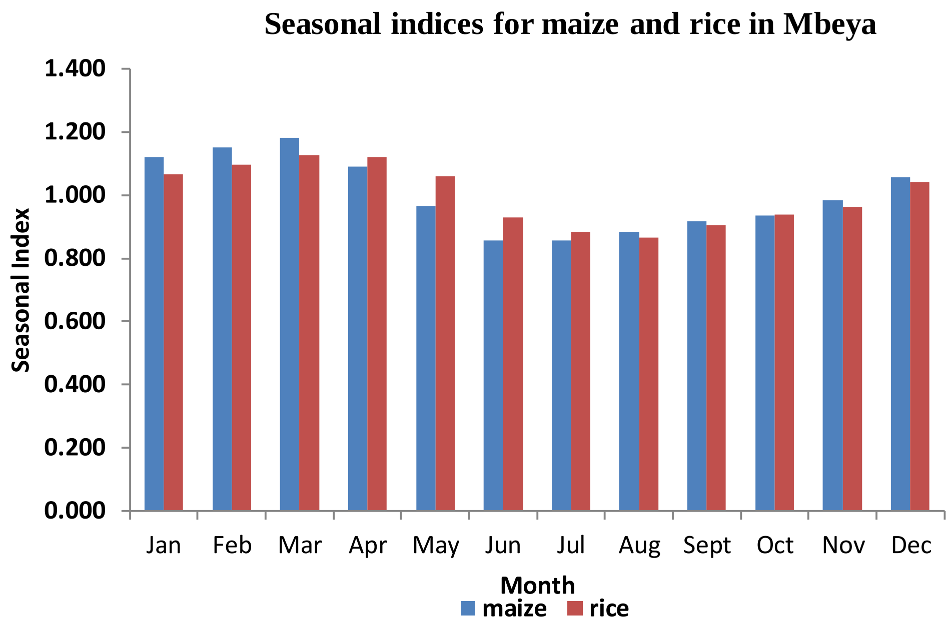


Figure 13: Seasonal indices for maize and rice in Mbeya

9. Shinyanga market

Fig. 14 show that maize prices in Shinyanga are highest in January (114%) and lowest in July (91%). This implies that in March maize prices are 14% above the typical average monthly wholesale maize price while in July maize prices are 9% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in March (112%) and lowest in August (85%) (Fig. 14). This implies that rice prices in March are 12% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 15%.

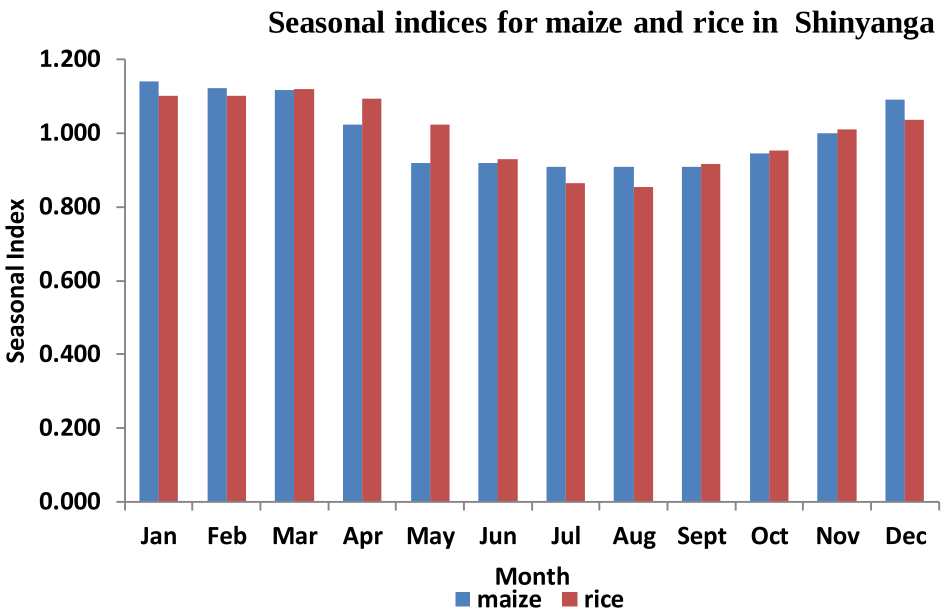


Figure 14: Seasonal indices for maize and rice in Shinyanga

10. Tabora market

Fig. 15 show that maize prices in Tabora are highest in March (117%) and lowest in June (82%). This implies that in March maize prices are 17% above the typical average monthly wholesale maize price while in June maize prices are 18% below the typical average monthly wholesale maize price for the region. For the case of rice, findings show that prices are highest in April (114%) and lowest in August (88%) (Fig. 15). This implies that rice prices in April are 14% above the typical average monthly wholesale price while in August it is below the typical average monthly wholesale price by 12%.

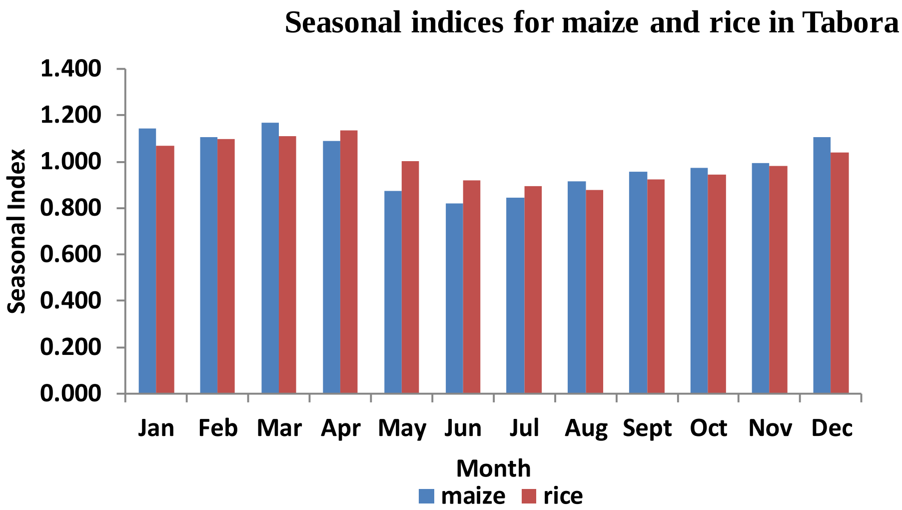


Figure 15: Seasonal indices for maize and rice in Tabora

4.2.5 Descriptive statistics for deseasonalised maize and rice prices

4.2.5.1 Rice

Findings show that coefficients of variation for rice prices are consistently high in all markets (Table 2). This implies that the variation of rice prices is high. Generally, this high variation might be a result of frequently changes in oil prices and changes in demand.

Also findings show that Shinyanga and Arusha are the regions with the highest and lowest rate of variation (about 80% and 67%, respectively) (Table 2). A closer look at these findings shows that rice surplus markets have relatively higher coefficients of variation than rice deficit regions. Higher rates of variation in rice surplus regions are presumed to be the result of rice outflow to deficit regions, thus stimulating supply fluctuation. Similarly, rice deficit regions have lower rate of variation because they receive rice from multiple production zones, thus reducing the effect of supply fluctuation.

Table 2: Descriptive statistics for deseasonalised rice prices 1992-2012 (TZS/100KG)

Market	N	Minimum	Maximum	Mean	Std. deviation	C.V (%)
Arusha	246	15 514.0	182 229.7	60 023.5	40 213.1	67.0
DSM	246	14 622.4	203 025.8	61 787.7	41 506.3	67.2
Dodoma	246	15 398.5	210 886.4	62 550.9	47 038.0	75.2
Iringa	246	13 781.0	209 133.5	58 669.2	41 854.8	71.3
Songea	246	15 871.3	209 376.5	55 254.7	40 720.2	73.7
Mbeya	246	14 871.7	220 147.6	57 876.9	43 582.9	75.3
Morogoro	246	12 634.0	184 903.5	57 148.6	39 097.3	68.4
Mwanza	246	13 135.1	178 859.4	53 481.8	39 623.5	74.1
Tabora	246	12 298.4	176 733.6	50 976.0	37 169.5	72.9
SHY	246	11 077.7	190 263.7	50 800.6	40 502.4	79.7

4.2.5.2 Maize

Table 3 shows that maize markets under the study experience high coefficients of variation as it was the case for rice. Findings show that Mwanza has the highest coefficient of variation (77%) while Songea has the lowest coefficient of variation (66%). This implies that maize prices are also volatile and less consistent. The observed high price variations for rice might be attributed by fluctuation in demand for maize and changes in oil prices in the world in general and in Tanzania in particular.

Table 3: Descriptive statistics for maize prices 1992-2012

Market	N	Minimum	Maximum	Mean	Std. deviation	C.V(%)
Arusha	246	4596.0	69 904.3	19 507.5	13 848.47	71.0
DSM	246	5778.8	79 111.8	21 568.2	14 401.33	66.8
Dodoma	246	4725.5	81 986.0	20 083.5	15 289.75	76.1
Iringa	246	3796.3	64 106.8	16 683.0	11 072.16	66.4
Songea	246	3138.4	50 255.2	14 417.1	9478.57	65.7
Mbeya	246	3259.2	62 114.0	16 065.1	12 182.87	75.8
Morogoro	246	4789.2	76 226.8	20 559.1	14 036.38	68.3
Mwanza	246	4508.7	81 681.0	22 241.8	17 131.45	77.0
Tabora	246	3637.4	79 131.0	19 864.3	14 316.00	72.1
Shinyanga	246	4458.7	66 110.4	20 199.4	14 443.58	71.5

4.3 Analysis of Price Transmission between Maize and Rice Prices

In the present study twelve (12) market channels/pairs were established to represent the markets which trade one or both of the crops. Results for price transmission in these pairs of markets are presented in sub-sequent section.

4.3.1 Augmented Dickey-Fuller (ADF) unit root tests for maize and rice prices

All deseasonalised prices for the commodities considered were tested for stationarity using ADF test for the presence of unit root. Price series for each market for both crops were tested at their level and first difference as well.

Table 4 and table 5 summarize the results of ADF unit root tests for maize and rice price series, respectively. The null hypothesis of the existence of unit root (non-stationarity) could not be rejected for each of the price series for the markets under the present study in the level, except for Songea maize price series. Specifically, maize prices in Songea were found to be stationary (I(0)) at their levels. On the other hand, all other remaining price series were non-stationary with the presence of unit root at their levels in all cases (zero mean, single mean and with time trend term). However, the null hypothesis for all price series in their first differences was rejected at the 1% level of significance (zero mean, single mean and with time trend term), which suggests that stationarity was achieved after taking the first difference.

Table 4: ADF test results for deseasonalised maize price series

	Levels			First Differences		
Market (Natural log)/Market	Zero Mean	Non-zero Mean	Trend	Zero Mean	Non-zero Mean	Trend
Arusha	1.249	-0.812 (0.8155)	-3.914 (0.0116)	-8.221	-8.322 (0.0000)	-8.326 (0.0000)
DSM	1.300	-1.139 (0.6991)	-3.682 (0.0236)	-7.866	-7.987 (0.0000)	-7.980 (0.0000)
Dodoma	1.299	-0.776 (0.8261)	-3.867 (0.0135)	-8.615	-8.736 (0.0000)	-8.741 (0.0000)
Iringa	2.383	-0.658 (0.8575)	-2.848 (0.1799)	-6.120	-6.658 (0.000)	6.638 (0.000)
Songea	0.973	-1.717 (0.4223)	-4.720 (0.0006)	-11.107	-11.171 (0.0000)	-11.149 (0.0000)
Mbeya	2.685	-0.181 (0.9407)	-2.101 (0.5457)	-4.592	-5.335 (0.0000)	-5.336 (0.0000)
Morogoro	1.294	-1.204 (0.6717)	-3.895 (0.0123)	-8.891	-9.013 (0.0000)	-9.002 (0.0000)
Mwanza	1.089	-0.801 (0.8189)	-3.909 (0.0118)	-11.661	-11.729 (0.0000)	-11.739 (0.0000)
Tabora	1.147	-0.700 (0.8468)	3.546 (0.0347)	-8.284	-8.373 (0.0000)	-8.397 (0.0000)
Shinyanga	1.250	-0.653 (0.8586)	-3.144 (0.0962)	-7.778	-7.875 (0.0000)	-7.889 (0.0000)

Note: Figures in parenthesis represent P values

Table 5: ADF results for deseasonalised rice price series

	Levels			First Differences		
Series (Natural log)/Market	Zero Mean	Non-zero Mean	Trend	Zero Mean	Non-zero Mean	Trend
Arusha	2.913	-0.368 (0.9154)	-2.043 (0.5778)	-8.538	-9.057 (0.0000)	-9.043 (0.0000)
DSM	2.122	-0.547 (0.8824)	-2.761 (0.2115)	-7.763	-8.207 (0.0000)	-8.198 (0.0000)
Dodoma	1.914	-0.472 (0.8974)	-2.776 (0.2058)	8.593	-8.859 (0.0000)	-8.860 (0.0000)
Iringa	2.875	0.408 (0.9818)	-1.379 (0.8670)	-3.626	-4.784 (0.000)	-4.843 (0.000)
Songea	1.983	0.026 (0.9606)	-1.941 (0.6332)	-7.226	-7.486 (0.0000)	-7.538 (0.0000)
Mbeya	2.445	-0.080 (0.9514)	-1.850 (0.6800)	-7.176	-7.548 (0.0000)	-7.574 (0.0000)
Morogoro	2.280	-0.164 (0.9427)	-2.288 0.4407)	-7.200	-7.681 (0.0000)	-7.694 (0.0000)
Mwanza	1.496	-0.754 (0.8323)	-3.011 (0.1291)	-11.455	-11.604 (0.0000)	-11.588 (0.0000)
Tabora	1.300	-1.043 (0.7372)	-3.075 (0.1122)	-5.077	-5.334 (0.0000)	-5.332 (0.0000)
SHY	1.421	-0.818 (0.8138)	-3.021 (0.1262)	-10.164	-10.313 (0.0000)	-10.307 (0.0000)

Note: Figures in parenthesis represent P values

4.3.2 Co-integration tests for pairs of markets presumed to trade

Following the proposed analytical framework for testing price transmission, hence all price series for the two crops i.e. I (1) were then tested for the existence of co-integration using the ADF unit root test in the residuals for each of the proposed market pair/channel. Therefore, the bivariate long run relationship was tested as depicted in Equation 2 to determine the existence of long-run relationship between the commodities considered. Table 7 shows the results of co-integration tests which were done for 90 possibilities of long-run price relationships between the two commodities for both cases i.e. between different markets and within the same market. Findings show that eleven (11) pairs of maize and rice prices tested were not co-integrated (between different markets). Specifically, rice prices for Dodoma, Songea and Shinyanga were found to be not co-integrated with some maize prices in other markets such as Iringa, Arusha and Mbeya, respectively. This implies that the long-run relationship does not exist for non-co-integrated price series.

Factors such as long distance between markets, asymmetry market information among key actors and some of the interventions by the authorities in cereals marketing systems are highly responsible for the absence of co-integration for some market channels. Usually, long distance to markets tends to increase transportation cost and may reduce the margin from the trade and discourage it. For instance, Minot, (2009) argues that moving products from southern highlands regions to markets like Dar es Salaam, Shinyanga and Dodoma involves a very high transportation cost. He further argues that poor road systems and infrastructure reduce market access for farmers and increase prices of net food buyers in deficient areas. In table 6 below, most of the markets/regions with “X” in brackets i.e. means not connected, are very long apart from each other. This justifies the influence of distance in the price linkages among commodities.

Table 6: Distance between markets/regions

	AR	DSM	DOM	IR	SONG	MBY	MOR	MWZ	TBR	Shinyanga
AR		646	425	689	1144	1020	621	787	661	624
DSM	646		451	492	947	822	192	1152	829	989
DOM	425	451		264 (**X**)	720	594	259	701	378	538
IR	689	492	264		455	330	300	965	642	802
SONG	1144 (**X**)	947	720 (**X**)	455 (**X**)		466 (**X**)	755	1420 (**X**)	1033	1257 (**X**)
MBY	1020	822	594	330	466		630	924	567	761 (**X**)
MOR	621	192	259	300	755	630		960	637	797
MWZ	787	1152	701	965	1420	924	960		357	163
TBR	661	829	378	642	1033	567	637	357		194
SHY	624	989	538	802 (**X**)	1257	761 (**X**)	797	163	194	

"X" means the channel is not connected.

Source: TANROADS DISTANCE CHART MARCH 2017

Table 7: Results of Co-integration test for I(1) price series

		MAIZE								
		AR	DSM	DOM	MOR	MBY	SHY	IR	MWZ	TBR
RICE	AR	C	C	C	C	C	C	C	C	C
	DSM	C	C	C	C	C	C	C	C	C
	DOM	C	C	C	C	C	C	x	C	C
	MOR	C	C	C	C	C	C	C	C	C
	MBY	C	C	C	C	C	x	C	C	C
	SONG	x	C	x	C	x	x	x	x	C
	SHY	C	C	C	C	x	x	x	C	C
	IR	C	C	C	C	C	C	C	C	C
	MWZ	C	C	C	C	C	C	C	C	C
	TBR	C	C	C	C	C	C	C	C	C

Note: **C** implies co-integrated series; **X** implies series which are not co-integrated.

4.3.3 Results for granger causality (GC) tests

GC tests highlight the existence of at least unidirectional causality linkages as an indication of some degree of integration for the series of interest. Unidirectional causality informs about leader-follower relationships in terms of price adjustments for two co-integrated markets.

The number of optimal lags used to run each ADL model was selected based on minimum Akaike Information Criterion (AIC) with a maximum of 24 lags. For ECM, three (3) months lags were selected so as to capture the status of short-run price transmission in all tests.

4.3.3.1 Granger causality (GC) based on ADL model results

Table 8 shows the results of GC tests based on ADL model for price series found to have different degree of integration i.e. I(1) and I(0).. A unidirectional causality was observed in four channels namely Mwanza-Shinyanga, Songea-Morogoro, Iringa-Mbeya, and Tabora-Shinyanga. Specifically, rice prices in Morogoro were found to granger cause maize prices in Songea (α=1%; F=0.0003) while rice prices in Mbeya were found to granger cause maize prices in Iringa (α=1%; F=0.0037). On the other hand, results show that maize prices in Mwanza granger caused rice prices in Shinyanga (α=1%; F=0.0000) while maize prices in Tabora were also found to granger cause rice prices in Shinyanga (α=1%; F=0.0033). Similarly, bidirectional causality was observed between maize prices in Songea and Rice prices in six markets namely Mwanza, Shinyanga, Dodoma, Mbeya, Iringa and Arusha. Other channels which were found exhibit bidirectional causality are Iringa-Dodoma, Shinyanga-Mbeya, and Iringa-Shinyanga.

The observed unidirectional causality between maize and rice prices implies that over time, changes or shocks in the price of the either crop in a certain market that was observed to granger cause the price series in another market do pass into the latter and not vice versa. For the case of bidirectional causality observed, it means that over time, changes or shocks to either maize prices in Songea or rice prices in Mwanza, Shinyanga, Dodoma, Mbeya, Iringa and Arusha do pass from one another (i.e. Songea versus each region mentioned).

Table 8: Granger causality results based on ADL model

Maize prices	Rice prices	Causal reference	Optimum number of lags based on AIC
Songea	Morogoro*	$P_t^{Songea(M)} \longleftarrow P_t^{Morogoro(R)}$	2
Songea*	Mwanza**	$P_t^{Songea(M)} \longleftrightarrow P_t^{Mwanza(R)}$	1
Songea*	Shinyanga**	$P_t^{Songea\ M)} \longleftrightarrow P_t^{Shinyanga(R)}$	1
Songea**	Dodoma*	$P_t^{Songea(M)} \longleftrightarrow P_t^{Dodoma(R)}$	1
Songea**	Arusha*	$P_t^{Songea(M)} \longleftrightarrow P_t^{Arusha(R)}$	1
Iringa*	Dodoma*	$P_t^{Iringa(M)} \longleftrightarrow P_t^{Dodoma(R)}$	2
Shinyanga*	Mbeya**	$P_t^{Shinyanga(M)} \longleftrightarrow P_t^{Mbeya(R)}$	2
Iringa	Mbeya*	$P_t^{Iringa(M)} \longleftarrow P_t^{Mbeya(R)}$	3
Songea*	Mbeya*	$P_t^{Songea(M)} \longleftrightarrow P_t^{Mbeya(R)}$	2
Songea**	Iringa*	$P_t^{Songea(M)} \longleftrightarrow P_t^{Iringa(R)}$	1
Mwanza*	Shinyanga	$P_t^{Mwanza(M)} \longrightarrow P_t^{Shinyanga(R)}$	1
Tabora*	Shinyanga	$P_t^{Tabora(M)} \longrightarrow P_t^{Shinyanga(R)}$	1
Iringa*	Shinyanga**	$P_t^{Iringa(M)} \longleftrightarrow P_t^{Shinyanga(R)}$	2

Note: The symbols with single and double arrow(s) denote unidirectional and bidirectional causality respectively. The superscript *, and ** implies significant at 1% and 5% respectively.

4.3.3.2 Degree of price transmission and causality based on ECM results

The granger causality (GC) and price transmission results based on error correction model (ECM) for all market channels are summarised in appendix 1 of this work. It provides information on the direction of causality, speed of adjustment based on the values and sign of error correction term (ECT), short-run and long-run price transmission status between the two commodities in spatially separated markets.

4.3.3.2.1 Price transmission

The results for ECM tests show that nineteen (19) out of sixty-four (64) tests between the commodities considered in sixteen (16) hypothesised market channels were found to bear short-run transmission of price shocks. That is, forty-five (45) tests denied the presence of short-run price transmission between the two commodities with the inclusion of three lag months. For the case of long-run elasticity of price transmission, fifty-five (55) tests out of 64 indicated the presence of long-run price transmission between the two commodities. For the case of movement of price shocks or changes from rice to maize in the long-run, the values range between 73% and 100% inclusively which are the rates for Shinyanga-Dar es Salaam and Dodoma-Dar es Salaam routes, respectively. In this case, it implies that over time, 73% of the shocks or changes in rice prices in Shinyanga are transmitted in maize prices in Dar es Salaam. Similarly, 100% of the shocks or changes in rice prices in Dar es Salaam are transmitted into maize prices in Dodoma. On the other hand, the long-run elasticity of price transmission from maize to rice ranges between 84% and 100% inclusively for Shinyanga-Dar es Salaam route. This implies that over time, 84% of the shocks or changes in maize prices in Shinyanga are transmitted into rice prices in Dar es Salaam. Similarly, 100% of the shocks or changes in maize prices in Dar es Salaam are transmitted into rice prices in Shinyanga.

Generally, it can be concluded that on average three months are not enough for the transmission of price shocks or changes between maize and rice in the short-run (Appendix 1). Conversely, findings show that price shocks or changes do pass between the considered commodities in the long-run. Therefore, prices for maize and rice may drift apart in the short-run but tend to return into their equilibria in the long-run.

The observed integration of the markets for the considered commodities is presumably the result of the construction and rehabilitation of important roads which connect regions in Tanzania. This promoted the flow of commodities among regions in Tanzania. In addition, availability of marketing information such as prices for major cereal crops through mobile phones also attributed to this integration. For instance, farmers in rural areas can access price of the crop using their mobile phones.

4.3.3.2.2 Granger causality (GC) results

Findings show that eight (8) causality tests out of sixty-four (64) suggest a unidirectional causality (leader-follower relationship). In addition, five (5) out of these eight (8) tests indicated that maize prices granger cause rice prices while three (3) tests showed that rice prices granger cause maize prices (Appendix 1). On the other hand, the remaining fifty-six (56) tests suggested bidirectional causality.

Moreover, results indicate that the average long-run elasticity of price transmission from maize to rice and rice to maize are 94.1%and 92.5% respectively. Therefore, price shocks or changes in either of the considered commodities do pass from one another. However, it is important to note that shocks or changes to maize prices have a little bit more impact on maize prices based on average rates for long-run price transmission i.e. maize is 94.1% > 92.5% of Rice.

Indeed, results indicate that eight (8) out of sixty-four (64) tests for the speed of adjustment for disequilibria were insignificant (Appendix 1). For all significant cases, the coefficients of ECT carried negative values. This suggests that ECT acted as a significant force which caused the integrated prices for the considered commodities to return to their long-run stable conditions whenever they deviated from it. Specifically, the values of

ECT for maize prices as a result of changes in rice prices range between 5% and 17%. Similarly, the values of ECT for rice as a result of changes in maize prices range between 5% and 20%. Thus, the average speed of adjustment of maize prices as a result of changes in rice prices is 11% while for rice prices as a result of changes in maize prices is 8%. This implies that on average 11% and 8% of the deviation in maize and rice prices respectively are corrected each month.

4.4 The Implications of the Findings for Policy Interventions

4.4.1 Cost of implementing policy interventions

In general, findings reveal that many of the markets/regions are integrated. Owing to this fact, the effect of food policy interventions by the government in one market of either of the considered commodities would be transmitted to other markets. This will reduce the cost of managing the interventions comparing to the situation when markets are not integrated. Indeed, if markets are not integrated each one will need its own policy or program which is costly.

4.4.2 Price stabilization policy

The observed long-run price linkages between maize and rice provide an important massage for food price stabilization policies in Tanzania. Thus, based on the results of the present study, setting credible price bands focusing on maize and rice in Tanzania can stabilize food prices in a more cost-effective way.

4.4.3 Food imports programs

Occasionally, the government of Tanzania has been planning for the importation of food in order to ensure food security. This has been happening when food prices are high and/or there is a shortage of food due to bad seasons. The findings on seasonal indices can be very useful in targeting time of food importation based on the seasonal high index and seasonal low index for the commodities under investigation i.e. based on the time when prices are higher and when prices are lower. Indeed, the government should ensure that food import programs of either commodity do not displace trade, cause production disincentives, and trigger price instability. Thus, it should ensure a consistency between food import programs and production in terms of timing and quantity as well.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This section summarizes the results of the study and some implications. Section 5.1.1 summarizes maize and rice price trends in Tanzania over the period July 1992 to December 2012. Section 5.1.2 describes the econometric analysis of price transmission between considered commodities in spatially separated markets in Tanzania. The implications of the results for policy are discussed in Section 5.1. Finally, the recommendations of the study are presented in section 5.2.

Maize and rice price trends: Results show that prices in regions follow an upward trend although there are fluctuations in specific periods. Surplus regions for both crops were found to have lower prices comparing to deficit markets. Specifically, maize prices are higher around February and March; and lower in June or July depending on the specific area. For the case of rice, prices are higher in April and lower in August. The observed trends reflect the cropping cycle for considered commodities in Tanzania based on rainfall distribution. This reveals the truth that majority of the farmers are smallholder farmers who depend on rainfall for cultivation.

Also findings indicate that the coefficient of variation (CV) for the considered commodities is consistently high. Generally, this high variation might be a result of frequently changes in oil prices and changes in demand. In addition, prices of surplus markets for both commodities were found to have higher CV than deficit markets. Higher rates of variation in surplus regions are presumed to be the result of commodities outflow to deficit regions, thus stimulating supply fluctuation. Similarly, deficit regions presumably have lower rates of variation because they receive commodities from multiple production zones, thus reducing the effect of supply fluctuation.

Degree of price transmission between maize and rice prices: In general, results show that majority of the markets are integrated. However, prices in Songea (maize) and Shinyanga (rice) were found to be not integrated with some other markets/regions. This situation might be attributed by long distances and some of the interventions such as inter-regional or inter-district ban. On The other hand, co-integration tests reveal that prices of the two commodities considered are co-integrated in majority of the market pairs. This suggests the existence of long-run price linkages between the considered commodities among regions/markets.

Findings also reveal that few market pairs experience short-run price transmission. Conversely, price shocks between the two commodities in various markets are transmitted in the long-run. The average long-run price transmission rate is 92.5% from rice to maize and 94.1% from maize to rice. Therefore, the considered commodities adhere to the fact that related goods must show some significance in degree of price transmission if markets are working effectively.

Causality between maize and rice prices: In general, bidirectional causality was mainly observed in many cases than unidirectional (only eight (8) cases). The values for long-run elasticity of price transmission and ECT in many cases were significant suggesting the existence of causality between the considered commodities. Specifically, ECT carried negative values in all cases. This implies that it acted as a force which corrected disequilibria in all cases whenever prices were deviating from their long-run equilibria.

The implications of the results of the study for policy

(i) Price stabilization policy

Results confirm the existence of long-run price linkages between the considered commodities. This provides an important message for food price stabilization policies in Tanzania. Therefore, proper price bands will be more effective if they will focus on maize and rice.

(ii) Food imports program

The findings of the present study also convey a useful message for proper designing of effective food imports programs. The message will enable important key actors such as donors, NGOs and traders to proper coordinating their activities and in deciding timing for imports and the quantity to be imported.

(iii) Cost of implementing policy interventions

Generally, the findings of the present study suggest that majority of the markets in Tanzania are connected. The observed integration among markets provides an important message on the cost of implementing and administering policy interventions. This follows the fact that an intervention in a single market is enough because its effect will be transmitted to other markets which are integrated.

5.2 Recommendations

Based on the analyses and findings of the present study, the following aspects are recommended:

(i) The government should make efforts to reduce food price instability

Indeed, the government of Tanzania should make efforts to stabilize food prices. This can be done using buffer stock, trade or combination of the two. For instance, proper price bands for food commodities especially maize and rice can be imposed. The focus on the two commodities (maize and rice) is highly emphasised since they were observed to have a long-run relationship. Therefore, price stabilization schemes targeting on these crops can stabilize cereal prices in a very cost-effective way based on the observed long run relationship and its significance in shock transmission. Indeed, the present study appreciates the efforts already done by the government of Tanzania such as the establishment of National food reserve Agency (NFRA). However, the capacity of the NFRA is too small to affect food prices in Tanzania. Thus, this calls for more efforts to be put on reducing the food price variation in Tanzania.

(ii) The government should improve the transportation infrastructure

In recent years, the government has been working hard to improve transportation infrastructures especially road networks among regions. However, the government should concentrate in interior areas as well where crops are produced. Improving roads in towns or connecting regions alone is not enough instead the exact areas where crops are produced must be connected with towns areas.

(iii) Need for Further research

The present study has drawn inferences on existence of price transmission between maize and rice prices for the hypothesised market channels. However, it does not explain empirically the factors/reasons for or against the observed market integration and price transmission between considered commodities. Therefore, further empirical researches should be done to determine empirically the factors underlying price transmission for maize and rice in Tanzania. The focus area should be on factors like information on marketing costs and transfer costs.

REFERENCES

Abdulai, A. (2007). Spatial and vertical price transmission in food staples market chains in Eastern and Southern Africa: What is the evidence?. *Paper Presented at the Trade and Markets Division Workshop on Staple Food Trade and Market Policy Options for Promoting Development in Eastern and Southern Africa*. Rome, 1 – 2 March, 2007. pp. 1 – 33.

Alderman, H. (1993). Intercommodity price transmittal: Analysis of food markets in Ghana. *Oxford Bulletin of Economics and Statistics* 55(1): 43 – 64.

Alexander, C. and Wyeth, J. (1994). Co-integration and market integration: An application to the Indonesian rice market. *Journal of Development Studies* 2(30): 303 – 328.

Arshad, F. M. and Hameed, A. A. A. (2009). The long run relationship between petroleum and cereals prices. *Global Economy and Finance Journal* 2(2): 91 – 100.

Ashimogo, G. and Mbiha, E. (2007). Impact of market liberalization on integration of grain markets in Tanzania. *Eastern and Southern Africa Journal of Agricultural Economics and Development* 4(2): 114 – 125.

Ashimogo, G. C. (1995). Pea*sant Grain Storage and Marketing in Tanzania: A Case Study of Maize in Sumbawanga District*. Verlag, Berlin. 369pp.

Badiane, O. (1997). *Market Integration and the Long-Run Adjustment of Local Markets to Changes in Trade and Exchange Rate Regimes: Options for Market Reform and Promotion Policies*. Discussion Paper No. 11. International Food Policy Research Institute, Washington DC. 55pp.

Barrett, C. B. (1996).market analysis methods: Are our enriched toolkits well suited to enlivened markets?", *American Journal of Agricultural Economics* 78: 825 – 829.

Barrett, C. B. and Li, J. R. (2002). Distinguishing between equilibrium and integration in spatial price analysis. *American Journal of Agricultural Economics* 84: 292 – 307.

Basu, K. and Bell, C. (1991). Fragmented duopoly: Theory and applications to backward agriculture. *Journal of Development Economics* 36: 145 – 165.

Baulch, B. (1997). Testing for food market integration revisited. *Journal of Development Studies* 33: 477 – 487.

Boyd, M. and Brorsen, B. W. (1986). Dynamic price relationships for US and EC corn gluten feed related markets. *European Review of Agricultural Economics* 13: 199 – 215.

Dawe, D. and Opazo, C. M. (2009). *How Much Did Developing Country Domestic Staple*. Food and Agriculture Organization, Rome, Italy 12 pp.

de-Janvry, A., Fafchamps, A. and Sadoulet, E. (1991). Peasant household behaviour with missing markets: Some paradoxes explained. *Economic Journal* 101(409): 1400 – 1417.

Delgado, C.L. (1986). A variance components approach to food grain market integration in Northern Nigeria. *American Journal of Agricultural Economics* 68: 970 – 979.

Dercon, S. (1996). Risk, crop choice, and savings: Evidence from Tanzania. *Economic Development and Cultural Change* 44(3): 485 – 513.

Dickey, D. A. and Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* 49: 1057 – 1072.

Enders, W. (1995). *Applied Econometric Time Series*. John Wiley and Sons Inc., New York. 433pp

Fackler, P. and Tastan, H. (2008). Estimating the degree of market integration. North Carolina State University. *Journal of Agricultural Economics* 90(1): 69 – 85.

Fafchamps, M. (1992). Cash crop production, food price volatility, and rural market integration in the third world. *American Journal of Agricultural Economics* 74 (1): 90 – 99.

Faminow, M. D. and Benson, B. L. (1990).Integration of spatial markets. *American Journal of Agricultural Economics* 72(1): 49 – 62.

FAO (2009a). Food balance sheet.[http://faostat.fao.org/site/368/default.aspx#ancor] site visited on 20/6/2017.

Gabagambi, D. M. (1998). Evaluation of agricultural marketing efficiency in Tanzania: A case study of paddy and Cotton in Ulanga District. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 136pp.

Gardner, B. and Brooks, K. M. (1994). Food prices and market integration in Russia. *American Journal of Agricultural Economics* 76: 641 – 646.

Gjolberg, O., Guttorrmsen, A. G. and Temu, A. (2004). *Malfunctioning Commodity Markets: Empirical Evidence from Tanzania. Department of Economics Resource Management.* Discussion Paper No. 27. Agricultural University of Norway. 120pp.

Granger, C. W. J. (1969).Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37: 424 – 438.

Kilima, F. T. M. (2006). *Are Prices in The World Market Transmitted to Markets in Less Developed Countries? A Case Study of Sugar, Cotton, Wheat, and Rice in Tanzania*. Discussion Paper No. 160. Institute for International Integration, Dublin. 34pp.

Koontz, S. R., Garcia, P. and Hudson, M. A. (1990). Dominant-satellite relationships between live cattle cash and futures markets. *Journal of Futures Markets* 10: 123 – 136.

Lind, D. A., Marchal, W. G. and Wathen, S. A. (2008). *Statistical Techniques in Business and Economics*. (13th Ed.), McGraw Hill Publishers, Boston. 859pp.

Mendoza, M. S. and Rosegrant, M. W. (1995). *Pricing Behaviour in Phillipine Corn Markets: Implications for Market Efficiency*. Research Report No. 101. International Food Policy Report Research Institute, Washington DC. 84pp.

Minot, N. (2010). Staple food prices in Tanzania. *A Paper Presented at the COMESA Policy Seminar on Variation in Staple Food Prices: Causes, Consequences, and Policy Options*. Maputo, Mozambique, 25 – 26 January, 2010. pp. 1 – 15.

Minot, N. (2011). *Transmission of World Food Price Changes to Markets in Sub-Saharan Africa*. Discussion Paper No. 1059. International Food Policy Research Institute, Washington DC. 44pp.

Behute, B., Lemma, S., Minot, N. and Rashid, S. (2010). Are staple food markets in Africa efficient? *Spatial Price Analyses and Beyond. Paper Presented at the COMESA Policy Seminar on Variation in Staple Food Prices: Causes, Consequences, and Policy Options*. Maputo, Mozambique, 25 – 26 January, 2010. pp. 1 – 35.

Minten, B. and Kyle, S. (1999). The effect of distance on road quality and food collection, marketing margins and traders' wages: evidence from the former Zaire. *Journal of Development Economics* 60: 467 – 495.

Mkenda, B. K. and Campenhout, B. V. (2011). Estimating Transaction costs in Tanzania supply chain. Working Paper No. 898. International Growth Centre, London. 48pp.

Monke, E. and Petzel, T. (1984). Market Integration: An Application to International Trade in Cotton. *American Journal of Agricultural Economics* 66: 481 – 487.

Mundlak, Y. and Larson, D. F. (1992). On the transmission of world agricultural prices. *World Bank Economic Review* 6: 399 – 422.

Murdoch, J. (1995). Income smoothing and consumption smoothing. *Journal of Economic Perspectives* 9(3): 103 – 114.

NBS (2006). *Results of the 2002-03 National Agricultural Sample Census: National Bureau of Statistics.* Ministry of Agriculture and Food Security, Ministry of Cooperatives and Marketing, and Ministry of Livestock, Zanzibar. 371pp.

Nyange, D. A. (1999). Estimation of Inter-regional Maize Market Integration in Tanzania and its Determinants. *Journal of Rural Problems* 135: 59 – 71.

Nyange, D. and Wobst, P. (2005). Effects of strategic grain reserve, trade and regional production on maize price volatility in Tanzania. [http://www.pasad.uni-bonn.de] site visited on 10/7/2017.

Onya, R. and Ajutu, E. (2006). Modelling International commodity price transmission to domestic prices of commodities exported by Uganda. [http://www.ubos .org/publications/agriculture] site visited on 20/10/2016.

Onyuma, S., Icart, E. and Owuor, G. (2006).Testing market integration for fresh Pineapples in Kenya. *Poster Paper Prepared for Presentation at the International Association of Agricultural Economist Conference*, Gold Coast, Australia, 12 – 18August, 2006. pp. 1 – 16.

Palaskas, T. B. (1995). Statistical analysis of price transmission in the European Union. *Journal of Agricultural Economics*46: 60 – 69.

Prakash, A. B. (1999). The transmission of signals in a decentralised commodity marketing system: The Case of the UK Pork Market. Thesis for Award of PhD Degree at Wye College, University of London, 189pp.

Rapsomanikis, G., Hallam, D. and Conforti, P. (2003). *Market Integration and Price Transmission in Selected Food and Cash Crop Markets in Developing Countries: Review and Applications.* Commodity Market Review No. 04. Food and Agriculture Organization, Rome. 120pp.

Rashid, S. (2011). *Intercommodity Price Transmission and Food Price Policies: An Analysis of Ethiopian Cereal Markets.* Discussion Paper No. 1079. International Food Policy Research Institute, Washington DC.17pp.

Rashid, S. and Lemma, S. (2011). *Strategic Grain Reserve in Ethiopia: Institutional Design and Operational Performance.* Discussion Paper No. 1054. International Food Policy Research, Washington DC. 36pp.

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

Sadoulet, E. and de Janvry, A. (1995). *Quantitative Development Policy Analysis.* The Johns Hopkins University Press, Baltimore, London. 438pp.

Sexton, R. J., Kling, C.L. and Carman, H. F. (1991). Market integration, efficiency of arbitrage, and imperfect competition: Methodology and Application to US. Celery. *American Journal of Agricultural Economics* 73(3): 568 – 580.

Teravaninthon, S. and Raballand, G. (2009). *Transport Prices and Costs in Africa: A Review of the International Corridors.* The World Bank, Washington DC. 145pp.

Timmer, C. P. (1989). *Agricultural Prices and Stabilization Policy*. Discussion Paper No. 290. Harvard Institute for International Development, Cambridge, USA. 38pp.

Trotter, B. (1992). *Applying Price Analysis to Marketing Systems: Methods and Examples from the Indonesian Rice Market.* Marketing Series No. 3. Natural Resources Institute, Chatham. 60pp.

Uri, N. D., Chomo, G. V., Hoskin, R. and Hyberg, B. (1993). The integration of the market for soybeans and soybean products. *Food Policy* 18: 200 – 213.

APPENDICES

Appendix 1: Results of price transmission and granger causality (GC) tests based on error correction model (ECM)

Market channel	Dependent variable	Independent variable	Speed of adjustment (%)	Short-run adjustment	Long-run adjustment (%)	Causal reference (Long-run)
MOR-DSM	$\Delta P_t^{Moro(M)}$	$\Delta P_t^{DSM(R)}$	14.7*	N/E	100*	$P_t^{Moro(M)} \longleftrightarrow P_t^{DSM(R)}$
	$\Delta P_t^{DSM(R)}$	$\Delta P_t^{Moro(M)}$	7.8*	E*	93.8*	
	$\Delta P_t^{DSM(M)}$	$\Delta P_t^{Moro(R)}$	14.1*	E*	87.3*	$P_t^{Moro(R)} \longrightarrow P_t^{DSM(M)}$
	$\Delta P_t^{Moro(R)}$	$\Delta P_t^{DSM(M)}$	5 (NS)	E***	100(NS)	
Iringa-DSM	$\Delta P_t^{Iringa(M)}$	$\Delta P_t^{DSM(R)}$	14.1*	N/E	97.3*	$P_t^{Iringa(M)} \longleftrightarrow P_t^{DSM(R)}$
	$\Delta P_t^{DSM(R)}$	$\Delta P_t^{Iringa(M)}$	4.7***	N/E	92.2	
	$\Delta P_t^{Iringa(R)}$	$\Delta P_t^{DSM(M)}$	3.3 (NS)	N/E	100 (NS)	$P_t^{Iringa(R)} \longrightarrow P_t^{DSM(M)}$
	$\Delta P_t^{DSM(M)}$	$\Delta P_t^{Iringa(R)}$	17.3*	N/E	88.1*	
Mbeya-DSM	$\Delta P_t^{Mbeya(M)}$	$\Delta P_t^{DSM(R)}$	8.8*	N/E	100*	$P_t^{Mbeya(M)} \longleftrightarrow P_t^{DSM(R)}$
	$\Delta P_t^{DSM(R)}$	$\Delta P_t^{Mbeya(M)}$	8*	E**	87*	
	$\Delta P_t^{Mbeya(R)}$	$\Delta P_t^{DSM(M)}$	4.6***	E**	100***	$P_t^{Mbeya(R)} \longleftrightarrow P_t^{DSM(M)}$
	$\Delta P_t^{DSM(M)}$	$\Delta P_t^{Mbeya(R)}$	13.5*	N/E	86.4*	
Arusha-DSM	$\Delta P_t^{Arusha(M)}$	$\Delta P_t^{DSM(R)}$	12.1*	N/E	100*	$P_t^{Arusha(M)} \longleftrightarrow P_t^{DSM(R)}$
	$\Delta P_t^{DSM(R)}$	$\Delta P_t^{Arusha(M)}$	7.8*	N/E	89.9*	
	$\Delta P_t^{Arusha(R)}$	$\Delta P_t^{DSM(M)}$	4.1***	N/E	100***	
	$\Delta P_t^{DSM(M)}$	$\Delta P_t^{Arusha(R)}$	16*	N/E	89.1*	$P_t^{Arusha(R)} \longleftrightarrow P_t^{DSM(M)}$

Appendix 1 continues

Market channel	Dependent variable	Independent variable	Speed of adjustment (%)	Short-run adjustment	Long-run adjustment (%)	Causal reference (Long-run)
Iringa-MOR	$\Delta P_t^{Iringa(M)}$	$\Delta P_t^{Moro(R)}$	11.9*	N/E	92.8*	$P_t^{Iringa(M)} \longleftarrow P_t^{Moro(R)}$
	$\Delta P_t^{Moro(R)}$	$\Delta P_t^{Iringa(M)}$	3.3 (NS)	E**	94.5*	
	$\Delta P_t^{Iringa(R)}$	$\Delta P_t^{Moro(M)}$	4.6***	N/E	98.7*	$P_t^{Iringa(R)} \longleftrightarrow P_t^{Moro(M)}$
	$\Delta P_t^{Moro(R)}$	$\Delta P_t^{Iringa(R)}$	15.2*	N/E	96.6*	
Mbeya-MOR	$\Delta P_t^{Mbeya(M)}$	$\Delta P_t^{Moro(R)}$	7.8*	E*	100*	$P_t^{Mbeya(M)} \longleftrightarrow P_t^{Moro(R)}$
	$\Delta P_t^{Moro(R)}$	$\Delta P_t^{Mbeya(M)}$	7.1*	E*	91.5*	
	$\Delta P_t^{Mbeya(R)}$	$\Delta P_t^{Moro(M)}$	5**	E***	100**	$P_t^{Mbeya(R)} \longleftrightarrow P_t^{Moro(M)}$
	$\Delta P_t^{Moro(M)}$	$\Delta P_t^{Mbeya(R)}$	10.9*	N/E	95.7*	
Tabora-MWZ	$\Delta P_t^{Tabora(M)}$	$\Delta P_t^{Mwanza(R)}$	5.7***	N/E	96.4*	$P_t^{Tabora(M)} \longleftrightarrow P_t^{Mwanza(R)}$
	$\Delta P_t^{Mwanza(R)}$	$\Delta P_t^{Tabora(M)}$	8.4*	N/E	96.5*	
	$\Delta P_t^{Tabora(R)}$	$\Delta P_t^{Mwanza(M)}$	19.7*	E***	89.9*	$P_t^{Tabora(R)} \longleftarrow P_t^{Mwanza(M)}$
	$\Delta P_t^{Mwanza(R)}$	$P_t^{Tabora(R)}$	2.7(NS)	N/E	79.5*	
Arusha-MWZ	$\Delta P_t^{Arusha(M)}$	$\Delta P_t^{Mwanza(R)}$	4.4(NS)	N/E	86.3*	$P_t^{Arusha(M)} \longrightarrow P_t^{Mwanza(R)}$
	$\Delta P_t^{Mwanza(R)}$	$\Delta P_t^{Arusha(M)}$	14.4*	N/E	100*	
	$\Delta P_t^{Arusha(R)}$	$\Delta P_t^{Mwanza(M)}$	8.9*	E**	87.8*	$P_t^{Arusha(R)} \longleftrightarrow P_t^{Mwanza(M)}$
	$\Delta P_t^{Mwanza(M)}$	$\Delta P_t^{Arusha(R)}$	14.8*	N/E	100*	

Appendix 1 continues

Market channel	Dependent variable	Independent variable	Speed of adjustment (%)	Short-run adjustment	Long-run adjustment (%)	Causal reference (Long-run)
Mbeya-MWZ	$\Delta P_t^{Mbeya(M)}$	$\Delta P_t^{Mwanza(R)}$	2.7(NS)	N/E	86.8*	$P_t^{Mbeya(M)} \rightarrow P_t^{Mwanza(R)}$
	$\Delta P_t^{Mwanza(R)}$	$\Delta P_t^{Mbeya(M)}$	9.4*	E**	97.4*	
	$\Delta P_t^{Mbeya(R)}$	$\Delta P_t^{Mwanza(M)}$	9.1*	N/E	93*	$P_t^{Mbeya(R)} \leftrightarrow P_t^{Mwanza(M)}$
	$\Delta P_t^{Mwanza(M)}$	$\Delta P_t^{Mbeya(R)}$	9.7*	N/E	100*	
Mbeya-Tabora	$\Delta P_t^{Mbeya(M)}$	$\Delta P_t^{Tabora(R)}$	2.2 (NS)	N/E	78.5*	$P_t^{Mbeya(M)} \rightarrow P_t^{Tabora(R)}$
	$\Delta P_t^{Tabora(R)}$	$\Delta P_t^{Mbeya(M)}$	11.4*	N/E	92.1*	
	$\Delta P_t^{Mbeya(R)}$	$\Delta P_t^{Tabora(M)}$	5.2**	N/E	96.6*	$P_t^{Mbeya(R)} \leftrightarrow P_t^{Tabora(M)}$
	$\Delta P_t^{Tabora(M)}$	$\Delta P_t^{Mbeya(R)}$	9.1**	N/E	100*	
Tabora-DSM	$\Delta P_t^{Tabora(M)}$	$\Delta P_t^{DSM(R)}$	9.4**	N/E	100*	$P_t^{Tabora(M)} \leftrightarrow P_t^{DSM(R)}$
	$\Delta P_t^{DSM(R)}$	$\Delta P_t^{Tabora(M)}$	5.4**	E***	84.5*	
	$\Delta P_t^{Tabora(R)}$	$\Delta P_t^{DSM(M)}$	11.8*	N/E	100*	$P_t^{Tabora(R)} \leftrightarrow P_t^{DSM(M)}$
	$\Delta P_t^{DSM(M)}$	$\Delta P_t^{Tabora(R)}$	7.9*	E**	80.1*	
Tabora-MOR	$\Delta P_t^{Tabora(M)}$	$\Delta P_t^{Moro(R)}$	11.3*	N/E	100*	$P_t^{Tabora(M)} \leftrightarrow P_t^{Moro(R)}$
	$\Delta P_t^{Moro(R)}$	$\Delta P_t^{Tabora(M)}$	5.7**	E**	88.7*	
	$\Delta P_t^{Tabora(R)}$	$\Delta P_t^{Moro(M)}$	12.4*	N/E	100*	$P_t^{Tabora(R)} \leftrightarrow P_t^{Moro(M)}$
	$\Delta P_t^{Moro(M)}$	$\Delta P_t^{Tabora(R)}$	5.7***	N/E	86.3*	

Appendix 1 continues

Market channel	Dependent variable	Independent variable	Speed of adjustment (%)	Short-run adjustment	Long-run adjustment (%)	Causal reference (Long-run)
Dodoma-DSM	$\Delta P_t^{Dodoma(M)}$	$\Delta P_t^{DSM(R)}$	12.5*	N/E	100*	$P_t^{Dodoma(M)} \leftrightarrow P_t^{DSM(R)}$
	$\Delta P_t^{DSM(R)}$	$\Delta P_t^{Dodoma(M)}$	7.7*	E**	84.5*	
	$\Delta P_t^{Dodoma(R)}$	$\Delta P_t^{DSM(M)}$	4.5***	N/E	100*	$P_t^{Dodoma(R)} \leftrightarrow P_t^{DSM(M)}$
	$\Delta P_t^{DSM(M)}$	$\Delta P_t^{Dodoma(R)}$	12.7*	E*	79.5*	
Dodoma-MOR	$\Delta P_t^{Dodoma(M)}$	$\Delta P_t^{Moro(R)}$	12.6*	N/E	100*	$P_t^{Dodoma(M)} \leftrightarrow P_t^{Moro(R)}$
	$\Delta P_t^{Moro(R)}$	$\Delta P_t^{Dodoma(M)}$	8.3**	N/E	88.3*	
	$\Delta P_t^{Dodoma(R)}$	$\Delta P_t^{Moro(M)}$	7.1*	N/E	100*	$P_t^{Dodoma(R)} \leftrightarrow P_t^{Moro(M)}$
	$\Delta P_t^{Moro(M)}$	$\Delta P_t^{Dodoma(R)}$	9.9**	N/E	86.4*	
Dodoma-Mwz	$\Delta P_t^{Dodoma(M)}$	$\Delta P_t^{Mwanza(R)}$	4.4(NS)	N/E	95.9*	$P_t^{Dodoma(M)} \rightarrow P_t^{Mwanza(R)}$
	$\Delta P_t^{Mwanza(R)}$	$\Delta P_t^{Dodoma(M)}$	10.8*	N/E	94.2*	
	$\Delta P_t^{Dodoma(R)}$	$\Delta P_t^{Mwanza(M)}$	10.6*	N/E	98.6*	$P_t^{Dodoma(R)} \leftrightarrow P_t^{Mwanza(M)}$
	$\Delta P_t^{Mwanza(M)}$	$\Delta P_t^{Dodoma(R)}$	9.2**	E***	98.8*	
SHY-DSM	$\Delta P_t^{SHY(M)}$	$\Delta P_t^{DSM(R)}$	8.7*	E***	100*	$P_t^{SHY(M)} \leftrightarrow P_t^{DSM(R)}$
	$\Delta P_t^{DSM(R)}$	$\Delta P_t^{SHY(M)}$	5.7**	N/E	84.4*	
	$\Delta P_t^{SHY(R)}$	$\Delta P_t^{DSM(M)}$	8*	N/E	100*	$P_t^{SHY(R)} \leftrightarrow P_t^{DSM(M)}$
	$\Delta P_t^{DSM(M)}$	$\Delta P_t^{SHY(R)}$	7.8*	N/E	72.7*	

Note: *, ** and *** implies significant at 1%, 5% and 10% respectively. N/E and NS imply does not exist and not significant respectively

Appendix 2: Characteristics of methods of analyzing market integration

	Analytical methods					
Characteristics	**Correlation analysis**	**Regression analysis without lags**	**Regression analysis with lags**	**Co-integration analysis**	**Parity bounds method (PBM)**	**Threshold autoregression (TAR)**
Measures co-movement of prices	Yes, but biased for non-stationary variables	Yes, but biased for non-stationary variables	Yes, but biased for non-stationary variables	Yes	Yes	Yes
Can include more than two markets	No	Yes	Yes	Yes	No	No
Can measure speed of adjustment	No	No	Yes	Yes	Only indirectly	Yes
Takes into account transfer costs	No	No	No	No	Yes	Yes
Can make use of information on marketing costs	No	No	No	No	Yes	Yes
Can identify market inefficiency and causes	No	No	No	No	No, unless transfer costs available	No, unless transfer costs available

Source: Rashid *et al.* (2010)

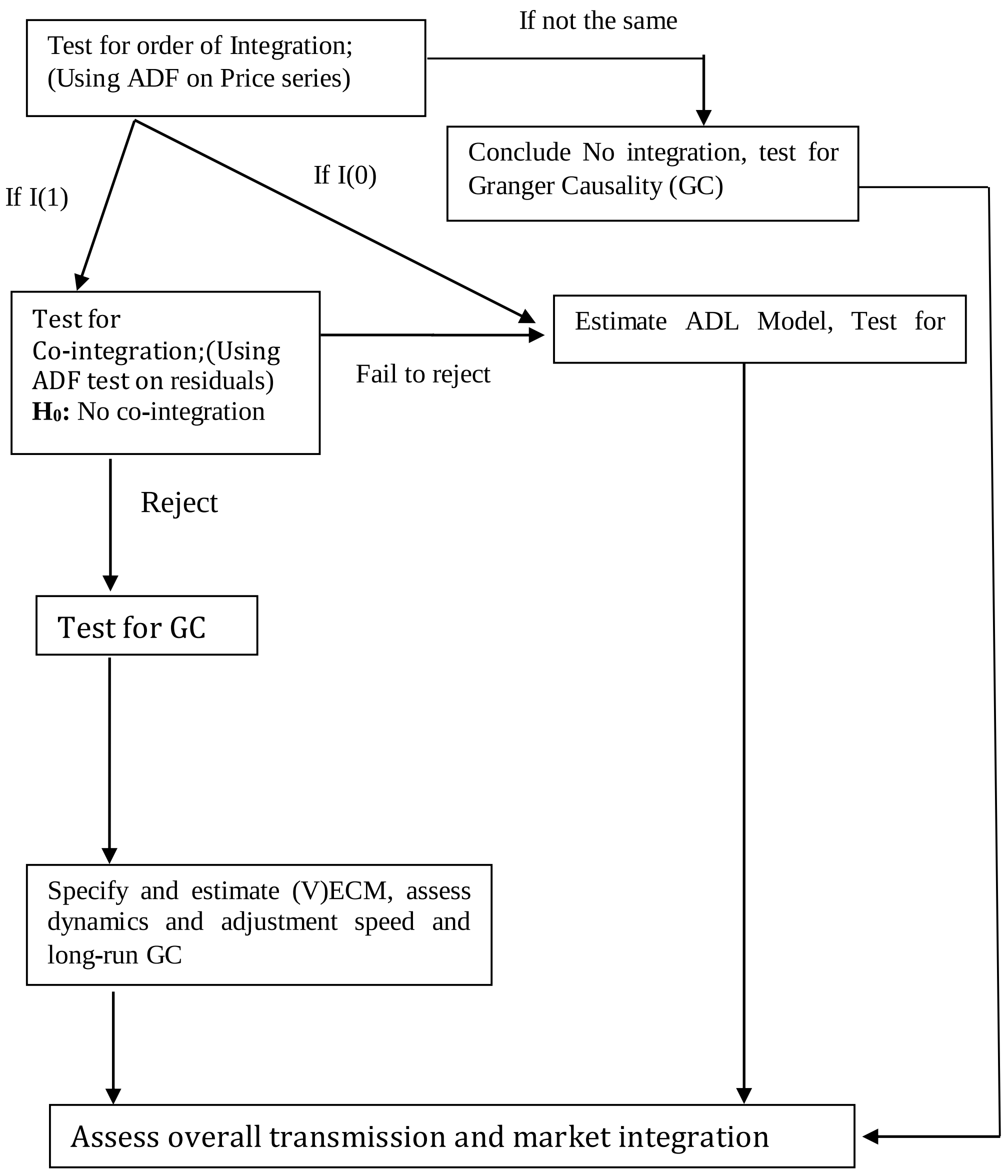
Appendix 3: Summary of Empirical Analysis on Spatial and Vertical price transmission in food staples market chains in Eastern and Southern Africa

Transmission	Author	Year	Country	Commodity	Period of time	Approach
SPATIAL	Loveridge	1991	Rwanda	Dry beans	1985	Correlation coefficient
	Goletti and Babu	1994	Malawi	Maize	01/1984 to 12/1991	Cointegration/ causality
	Dercon	1995	Ethiopia	Teff	07/1987 to 09/1993	Cointegration/ causality
	Chirwa	1999	Malawi	Maize and rice	1989 to 1998	Cointegration/VAR
	Chirwa	2001	Malawi	Maize/rice/beans/ groundnuts	1989 to 1998	Cointegration/ causality
	Loy and Wichern	2000	Zambia and Malawi	Maize	01/1994 to 06/1998	Cointegration/ causality
	Rashid	2004	Uganda	Maize	1993 to 1994 and 1999 to 2001	Cointegration/ causality
	Tostao and Brorsen	2005	Mozambique	Maize	1994 to 2001	PBM/causality
	Negassa and Myers	2007	Ethiopia	Maize and wheat	08/1996 to 08/2002	PBM
	Moser et al.	2006	Madagascar	Rice	2000 to 2001	PBM
	Van Campenhout	2007	Tanzania	Maize	1989 to 2000	TAR
	Conforti	2004	Egypt/Ethiopia	Food and cash crops	**Egypt:** 01/1969- 05/2001 **Ethiopia:** 09/1993-05/2001	Cointegration/ causality
VERTICAL	Guvheya et al.	1998	Zimbabwe	Tomatoes	1996	Causality/Houck
	Negassa	1998	Ethiopia	Grain	08/1996 to 08/1997	Correlation coefficient/causality
	Traub and Jayne	2004	South Africa	Maize	05/1976 to 09/2003	OLS/Generalised Least Squares
	Minten and Kyle	2000	Zaire	Food	1987-1989	SURE/Houck
	Getnet et al.	2005	Ethiopia	White teff	01/1996 to 12/2000	Cointegration/ARDL
ACROSS COUNTRIES	Rapsomanikis et al.	2006	Ethiopia/Rwanda/Uganda	Coffee	01/1990 to 12/2001	Cointegration/causality
	Baffes and Gardner	2003	Madagascar	Coffee/rice/sugar	1970-1991	Cointegration/error correction
	Kilima	2006	Tanzania	Sugar/cotton/wheat/rice	06/1994 to 06/2005	Cointegration/causality

Note: ARDL refers to autoregressive distributed lag modeling. PBM refers to parity bounds model. SURE is used to denote seemingly unrelated regression estimation.

Source: Abdulai (2007)

Appendix 4: Procedures for undertaking market integration/Price transmission analysis



Source: Modified from Rapsomanikis *et al.* (2003)