ST. MARY'S UNIVERSTY

INSTITUTE OF AGRICULTURE AND DEVELOPMENT STUDIES

THE CONTRIBUTION OF MODERN INFORMATION AND COMMUNICATION TECHNOLOGY TO SPATIAL MAIZE MARKET INTEGRATION IN ETHIOPIA

By

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A THESIS SUBMITTED TO, ST. MARY'S UNIVERSTY,INSTITUTE OF AGRICULTURE AND DEVELOPMENT STUDIES,FOR PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTERS OF SCIENCE DEGREE IN AGRICULTURAL ECONOMICS

BY

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JUNE, 2015

ADDIS ABABA, ETHIOPIA

APPROVAL OF BOARD EXAMINERS

As members of the Board of Examining of the final MSc thesis open defense, we certify that we

have read and evaluated the thesis prepared by Medhin Haftom under the title "THE CONTRIBUTION OF MODERN INFORMATION AND COMMUNICATION TECHNOLOGY TO SPATIAL MAIZE MARKET INTEGRATION IN ETHIOPIA" We recommend that the thesis be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Agricultural Economics

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ACKNOWLEDGMENTS

Acronyms

ATA...Agricultural transformation agency

FTC...Farmers Training center

IRIR..Integrated regional information network

ICT...Information and communication technology

CSA...Central statistical authority

UNDP...United nations development programme

ECX...Ethiopian commodity exchange

SMS...Short message service

IVR...Interactive voice response

WFP...World food programme

TAR...Threshold auto regressive

OLS... Ordinary list square

IT...Information technology

TKDL..Traditional knowledge digital library

ITK...Indigenous technical knowledge

FAO...Food and agricultural organization

WSIS..World summit the information society

FRI..Farm radio international

IPMS..Improving productivity and market success

DVD...Digital video disk

WB...World bank

EGTE..Ethiopia grain trade enterprise

SF...State farm

CF...Commercial farm

MIS..Market information system

ETV...Ethiopian television

FOB...Free onboard

MICT...Ministry of information and communication technology

ECM..Error correction model

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Abstract

This paper tries to analyze whether the expansion of modern information and communication technology has a significant impact in increasing the level of integration between spatially separated sample maize markets in Ethiopia. A total of 14 markets are taken for this analysis including the central market (Addis Ababa) and the other thirteen regional markets from various parts of the country and monthly retail price data starting from January 2003 to December 20014 is taken and partitioned into before and after ICT periods.

A threshold autoregressive (TAR) model in the form of error correction method is used to analyze the data and the result shows, the overall integration between Addis Ababa and the respective regional markets is increased in the after ICT period.

Regarding the deficit and surplus areas, in the before ICT period, the level of integration between markets is higher in surplus areas than in deficit areas, but in the after ICT period, the level of integration is not determined by the amount production. This is indicated by speed of adjustment of the error correcting terms which shows, in the before period the deviation from the equilibrium was not adjusted immediately in deficit markets than the surplus markets both in the above and below the threshold level but in the after period, the speed of adjustment is improved in both types of markets.

The study proposes that coordinated infrastructure development is required through government intervention as communication alone does not bring the required result and expansion of modern commodity exchanges is highly recommended to increase grain market integration.

Key words: market integration, threshold autoregressive error correction model, ICT expansion , maize and Ethiopia

Declaration

I declare that this Msc. thesis is my original work, has never been presented for a degree in this or any other university and all source of materials used for the thesis have been duly acknowledged.

Student Name: Medhin Haftom Hailu

Signature:_____

Date of Submission:June 29, 2015

ENDORSEMENT

This thesis has been submitted to St. Mary's University, school of Graduate Studies for examination with my approval as a University advisor.

Adviser **: <u>Tesfaye Welde(PhD)</u>**   _____

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CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Agriculture has been the dominant sector of the country's economy, representing nearly 42% of GDP, 77% of employment and 84% of export. In addition, the majority agriculture sector consists of smallholder farmers who make their living from less than two hectares of land. Despite significant increase in overall agricultural outputs in recent past, the sector is still dominated by subsistence modes of production. The significant increase in cereal production (63%) in the past six years has not translated in to a proportional increase in marketable surplus which in 2013/14 was only 16% with two thirds of the production being consumed by the producing farmers and similar picture is seen for livestock sector(ATA, 2015).

The majority of Ethiopian population lives in the countryside and makes a living by producing agricultural products. Farmers in the rural areas sell their agricultural products to merchants from the cities at very low prices.

This is because farmers do not have access to major market places in Ethiopia. In addition, farmers do not have the option of getting market information of agricultural products in the major market places other than their localities. In spite of this fact, it is ironic that the Ethiopia's economy depends on agricultural products that come mainly from the primitive rural areas of the country.

If markets are not well integrated, then local scarcities of grain products will emerge. This is because, distant markets that might supply grain products to local markets facing a shortage will not have information and do not communicate through price signals, concerning the increased demand in the markets facing grain shortages. Moreover, if it is found that markets are not spatially or inter-temporally integrated, this could be indicative of and exacerbate market concentration and collusion with insufficient competition in local grain markets, which results in distortions in the national grain market.

Such marketing challenges may be tackled via commodity exchanges platforms that bring together buyers and suppliers. According to Gabre-Madhin and Goggin (2005), commodity exchanges stimulate market transparency and price discovery, and attenuate collusion, (speculative) bubbles and price volatility. They may also lower transaction costs by increasing the range of trading partners, by providing monitoring and enforcement of standards and contracts, and by tackling conflicts via arbitration services (Sitko and Jayne 2012).

The extent to which markets make food available and keep prices stable depends on whether markets are integrated with each other. Integrated markets can be defined as markets in which prices for comparable goods do not behave independently. If markets are well integrated, it can be assumed that market forces are working properly, meaning that price changes in one location are consistently related to price changes in other locations and market agents are able to interact between different markets. (WFP, 2007).

Market integration play great role in the optimization of resource use, output management, increase in farm incomes, widening of markets, growth of agro-based industries, addition to national income through value addition, and employment creation, it ensures that accurate price signals are communicated to both consumers and producers for efficient product movement in addition to competitiveness, effective arbitrage and the efficiency of pricing. market integration of agricultural products has retained importance in developing countries for its potential application to policy-making. That is information on the extent of market integration can be used by government to formulate policies that will prevent exploitation of the markets (Acquah and R. Owusu, 2012).

Ethiopian farmers bring only 30 percent of what they produce to the market. Subsistence farming is way of life in rural Ethiopia. Studies show that Ethiopia produces more maize than the total maize production of Kenya, Uganda, and Tanzania combined. Equipping Ethiopian farmers with information on the types of agricultural products they can grow and the price they can sell their products can help improve livelihood of farmers. Furthermore, it will bring profits back to the agricultural sector helping it to grow. In spite of the fact that Ethiopia is the second largest maize producer, Ethiopian farmers are getting poorer and poorer. (Baldauf,(2007)).

Market integration is widely recognized as conducive to economic growth and poverty alleviation. A higher degree of market integration entails less restrictions to trade, smooth trade flows from surplus areas to deficit areas, better transmission of price signals, less price volatility, production decisions according to comparative advantage, realization of gains from trade and, in summary, higher welfare. Higher degrees of market integration are also likely to stimulate a quicker response to policies and to induce more adequate reactions to shocks (Zant, Wouter,(2010)).

Ethiopian government has given higher attention to improve market information by establishing a new entity known as Ethiopian commodity exchange which started trading operations in April 2008, with a new initiative for Ethiopia to revolutionize Ethiopians tradition bound agriculture through creating a new marketplace that serves all market actors, from farmers to traders to processors to exporters to consumers by harnessing innovation and technology (ECX, 2009).

1.2. Statement of the problem

The development of the agricultural market in Ethiopia is the same as the agriculture; it is based on old traditional methods (ECX, 2009). It is characterized by insufficient market information, poor quality, unstable price, lack of trust among trading partners, and uncoordinated markets (Gabre-Madhin and Goggin, 2005). The lack of market information creates fluctuating prices and huge price overhead on the consumers. Farmers are getting only a small portion of the profit due to weak access to storage, telecommunication and transportation infrastructures and existence of multiple middle men at every stage of the market chain (Gabre-Madhin and Goggin, 2005).This indicates grain price hikes and volatility is not only due to demand and supply shocks in the locality but also due to lack proper integration among spatially dispersed grain markets throughout the country.

There has been a lot of emphasis and support given for increased grain production through the package of agricultural technologies and inputs. It is only recently that market integration has immerged as an important issue in Ethiopia (Negassa, (1997); Negassa et.al., (2004); Sinkie,(1995); Tschirley et.al., (2003); Gabre-Madhin, (2003) and Dessalegn, (1998)).

Ethiopia has launched a new initiative in agricultural marketing called Ethiopia Commodity Exchange (ECX). This organization's mission is to connect all buyers and sellers in an efficient, reliable, and transparent market by harnessing innovation and technology and based on continuous learning, fairness, and commitment to excellence. Establishment of ECX was considered as the starting point of application modern information and communication technology for market information and trade among markets.

In fact there are few articles which have focused on spatial market integration in Ethiopia (e.g. Negassa,(1997),Tamru, (2006)). According to Seneshaw Tamru in his study stated that, deficit areas are isolated from Addis while the surplus areas were found to be well integrated and differences and distance are important factors affecting spatial markets integration between Addis and the regional markets .And Asfaw Negassa(1997) stated that grain markets in Ethiopia exhibit a high degree of vertical and spatial integration. What makes this study different from the above studies is; it particularly focuses on maize markets integration along with expansion of modern information and communication technology in Ethiopia.

This paper mainly targets to assess the contribution of modern information and communication technology for spatial integration of maize markets in Ethiopia.

1.3. Objectives:

The general objective of this study is to assess the contribution of modern information and communication technology expansion to increase the level of integration among spatially separated maize markets in Ethiopia.

Specific objectives:

- ➢ To analyze the contribution of modern information and communication technology expansion in integrating spatially dispersed maize markets.
- ➢ To investigate the extent of market integration between markets that are assumed as food deficit areas and surplus areas with Addis Ababa.

1.4. Research Hypothesis

1. Expansion of modern information and communication technology is expected to increase the level of spatial market integration by providing timely information and enabling fast transmission of demand and supply shocks from one market to the other through fast information transmission.

2. The level of integration of regional markets with Addis Ababa is expected to be higher for deficit areas than surplus areas.

1.5. Significance of the study

As market information is the most determinant factor to make decisions about the market for producers, inefficient and poorly integrated markets may result in inefficient product movement due to inaccurate price information (Goodwin and Schroeder, 1991).

As the degree of transmission of price signals mainly depend on how well markets are integrated, well integrated markets have been found to contribute a lot in improving lives of poor rural households in developing countries. (seneshaw , 2006).

Thus, knowledge of market integration is important in designing successful agricultural price stabilization policies and well integrated markets may reduce high policy cost of segmented markets.

1.6. Scope and limitation of the study

The study relies on price data of agricultural products, particularly maize as representative of staple food products collected from various spatially dispersed markets to assess the level of spatial market integration between Addis Ababa and the regional markets. Based on data availability the study covers a total of fourteen markets. ie Addis Ababa, Adama, Assela, Nekempt, DireDawa, Mekelle, Gondar, Dessie, Bahirdar, Ambo, Welkite, Hawassa, Welytasodo and Harrar. And the price data collection period covers 2003-2014 on monthly bases. The price data is portioned in before ICT period (2003-2009) and after ICT period (2010-2014) to compare the level of integration between these two periods.

This paper depends on price data of only fourteen markets and one grain product (maize) due to lack availability of organized data, and the result of this analysis may not fully represent the

actual situation of the whole country. And since this paper follows Engle Granger two step methodology in analyzing co integration and error correction; comparison is made between Addis Ababa and regional markets (no comparison of regional markets with each other).

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1.7. Organization of the paper

This paper contains a total of five chapters. Chapter one deals with the introductory parts of the paper. Chapter two reviews literatures related to the study. Chapter three focuses on methods of data collection and model specification, chapter four deals with data analysis and Chapter five provides conclusion and recommendation.

CHAPTER TWO

2. REVIEW OF RELATED LITRATURE

2.1. Market integration

Many literatures have tried to define spatial market integration in various
ways. On the one hand, markets are said to be integrated if there are enough agents who
intervene in the markets and act in such a way that prices reflect all the available information and
no abnormal profit exists in any of those markets. On the other hand, markets are said to be
integrated if the price difference between two markets is small (D' Angelo, 2001).

Alternatively, spatial market integration could be defined as a co-movement of prices, and,
more generally, as a smooth transmission of price signals and information across spatially
separated markets. It could also be the opening and development of trade between markets
and their integration in to a single operative entity (flow) and trade is the central part of
market integration. But market integration alone does not guarantee or imply the markets
arecompetitive (Baulch, 1997).

Markets are important determinants of food availability and food access. The extent to
which markets make food available and keep prices stable depends on whether markets are
integrated with each other. Integrated markets can be defined as markets in which prices for
comparable goods do not behave independently. If markets are well integrated, it can be assumed
that market forces are working properly, meaning that price changes in one location are
consistently related to price changes in other locations and market agents are able to interact
between different markets. If markets are integrated, food will flow from surplus to deficit areas
- and imports will flow from port and border areas into the hinterland. High prices in deficit areas
provide the incentive to traders to bring food from surplus to deficit areas, making food
available.

As a result of these flows, prices should decline in deficit areas, making food more
accessible to households. Prices usually give important indications on whether markets are
integrated. Markets are integrated if prices among different locations move in similar patterns,

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given that the differences between prices is explained by the transfer and transaction costs as food flows between the locations. Otherwise markets are segmented. This could, for example, be a result of prohibitive transaction costs related to poor infrastructure in remote areas or damaged roads or bridges because of a disaster. (WFP, 2007).

2.2.The role of ICT to improve agriculture

Today a new paradigm of agricultural development is fast emerging: in both developing and developed countries the overall development of rural areas is expanding in new directions; old ways of delivering important services to citizens are being challenged; and traditional societies are being transformed in to knowledge societies all over the world. Information and Communication Technology (ICT) is seen as an important means of achieving such a transformation. When used as a broad tool for providing local farming communities with scientific knowledge, ICT heralds the formation of knowledge societies in the rural areas of the developing world. However, this can only be realised when knowledge and information are effectively harvested for overall agricultural and rural development. The development of precision farming in countries of the North emphasizes knowledge-intensity; hence the agricultural paradigm in the developing world will have to be recast to take advantage of knowledge availability to achieve multiple goals: of income, food, jobs, etc. ICT has a significant role to perform in evolving such a paradigm, as was evident from the Interdisciplinary Dialogue on IT:Reaching the Unreached (ODI, 2004).

2.3. ICT and agriculture in Ethiopia

ICT can play a crucial role in benefiting the resource-strapped farmers with up to date knowledge and information on agricultural technologies, best practices, markets, price trends, and weather conditions. The experiences of most countries indicate that rapid development of ICT, which facilitates the flow of data and information, has tremendously enhanced the knowledge management practice in agriculture.

However, in Ethiopia the use of ICT for the accumulation and dissemination of knowledge and information is still low. Currently, among the various ICT related initiatives, radio is widely used to share and inform users on agricultural issues, including new and upgraded farming techniques, production management, market information, and other issues. Due to its strategic importance in reaching the majority of the smallholders, attempts are being made to strengthen the delivery of knowledge and information through radio programs(UNDP Ethiopia NO3/2012).

Information and communication technologies (ICTs) have long been recognized as playing a major role in the delivery of information and services throughout many sectors. ICT can play a huge role in agricultural development and the lives of smallholder farmers. And data, research, quantifiable information, performance history and statistical analysis are all essential to inform and fuel transformational change.

For Ethiopia agriculture, reliable data and analysis, in all of their synthesized forms, are pivotal to inform the identification and prioritization of interventions and deliverables, as well as enabling necessary course corrections and validation that quantifiable progress is underway. At the smallholder farmers level, locally and context-specific information is vital to ensure that the investments made on each plot of land are those that will yield the greatest return (ATA, 2016)

Information and communication technology (ICT) can play a critical role in facilitating rapid, efficient, and cost effective knowledge management. However, ICT application in Ethiopia remains low in comparison with several African countries. For instance, in a number of Sub-Saharan African countries, smallholder farmers get technology-related advice as well as location-specific market information on inputs and outputs through ICT kiosks. Furthermore, mobile telephone service is being successfully used to deliver agricultural information to users.

In Ethiopia, public agricultural extension services have been in action for about half a century. Studies show that Ethiopia has the largest agricultural extension system in Sub-Saharan Africa, and third largest in the world after China and India (Swanson and Rajalahti, 2010). According to the Bill and Melinda Gates Foundation (BMGF 2010), a total of 8,500 farmer training centers (FTCs) have been established and 63,000 field extension workers (known as development agents-DAs) have been trained. The current extension approach, therefore, follows FTC-based extension system.

To speed up technology adoption, the government of Ethiopia should harnessing its public extension service delivery system and particularly the agricultural extension system and provide an enabling framework for utilizing advances in information and communication technology to deliver agricultural extension services. Using available ICTs will not only improve information and knowledge management for extension workers and farmers but optimize and rationalize public resources devoted to agricultural extension services (Koricho,2014).

ICTs have great potential – through easier access, wider coverage and simplicity – in easing the common challenges of development interventions: meeting urgent demands for results, going to scale and sustainability. However, ICTs on their own are nothing without an enabling environment and policy that supports the various services. Digital literacy, transparency and good governance are also essential.

E-extension, through the use of ICTs, is an area receiving greater interest by government and non-government organizations in developing countries. The situation is similar in Ethiopia, though it's lagging behind, but is definitely on the right track. Government programs like **ATA**, **ECX**, and donor funded projects like LIVES, are piloting the use of ICTs for better extension service delivery and market information which consequently will contribute to increased productivity, better market value, lesser risk and increased nutrition. The recent initiative, **M Birr**, a mobile money service provision by five of the largest micro finance institution in Ethiopia is another worthy intervention (Mekonnen,2013).

The Ethiopian Commodity Exchange (ECX) is yet another notable organization that has embarked on some modern types of ICT-based information management system. It carries out trading of the agricultural commodities on its trading floor located in Addis Ababa and disseminates price information in real time to producers, consumers, and traders using electronic price tickers as well as its website. The price tickers are also used to transmit any change of price information directly in real time to the users. In addition, ECX has developed a prototype for data dissemination using short message services (SMS) and interactive voice response (IVR). There are currently about 200 thousand users of the SMS service, and about 50 thousand IVR users per day of which, the majority (65 percent), are from outside Addis Ababa (ECX, 2012).

2.4. ICT and agricultural marketing

2.4.1.Farmers' Changing Information Needs and Sources

Studies of farmers' information needs paint a mixed picture. Information needs differ significantly between countries and within countries for farmers producing different products. Farmers differ in their perceptions of the information they require (as revealed by market research) and in their priorities when they come to access information. The primary message underlying these disparities appears to be that farmers require a package of information and that their needs and priorities change throughout the production cycle.

A number of initiatives by governments aim to provide market price services, driven by the view that greater price transparency is a public good. Price has been disseminated in many ways: chalked on notice boards, broadcast by local radio stations, published in newspapers, and (more recently) posted on websites. The information on these websites is confined mainly to product standards and specifications as well as market studies particularly of external markets but increasingly of local value chains including databases of contacts such as buyers, traders, agricultural processors, and input suppliers. To the extent that these sites become more accessible, their usefulness could increase, but at present they are out of reach for most rural people (WB.2012).

Ethiopia has one of the most extensive agriculture extension systems in the world. Nearly 85 percent of the population work the land for a living, and a multilingual mobile phone-based resource centre has turned into a popular source of information for farmers.

The hotline, operated by the Ministry of Agriculture, the Ethiopian Institute of Agricultural Research, and Ethio Telecom, and created by the Ethiopian Agricultural Transformation Agency (ATA), has proved a huge hit. Since its July 2014 launch and still in its pilot phase, more than three million farmers in the regions of Amhara, Oromia, Tigray and the Southern Nations, Nationalities, and Peoples' Region (SNNPR) have punched 8028 on their mobile phones to access the system, which uses both interactive voice response (IVR) and SMS technology.

traders to upload price and supply information directly. They facilitate marketing by linking buyers and sellers (IRIN, 2014).

2.5.The Ethiopian commodity exchange

The Ethiopia Commodity Exchange (ECX) is a new initiative for Ethiopia and the first of its kind in Africa. The vision of ECX is to revolutionize Ethiopia's tradition bound agriculture through creating a new marketplace that serves all market actors, from farmers to traders to processors to exporters to consumers. The ECX is a unique partnership of market actors, the Members of the Exchange, and its main promoter, the Government of Ethiopia. ECX represents the future of Ethiopia, bringing integrity, security, and efficiency to the market. ECX creates opportunities for unparalleled growth in the commodity sector and linked industries, such as transport and logistics, banking and financial services, and others .

ECX assures all commodity market players the security they need in the market through providing a secure and reliable End-to-End system for handling, grading, and storing commodities, matching offers and bids for commodity transactions, and a risk-free payment and goods delivery system to settle transactions, while serving all fairly and efficiently.

The Ethiopia Commodity Exchange (ECX) commenced trading operations in April 2008. ECX has invited membership of the agricultural and trade industry.

The Ethiopian Commodity Exchange was started to benefit and modernize the way Ethiopia was trading it's most valuable assets, it's commodities. Ethiopia needed a change from the traditional means of trading to better support the needs of all those involved in the trading and production

Before ECX was established agricultural markets in Ethiopia had been characterized by high costs and high risks of transacting, forcing much of Ethiopia into global isolation. With only one third of output reaching the market, commodity buyers and sellers tended to trade only with those they knew, to avoid the risk of being cheated or default. Trade is done on the basis of visual inspection because there was no assurance of product quality or quantity, this drove up market costs, leading to high consumer prices. For their part, small-scale farmers, who produce 95 percent of Ethiopia's output, came to market with little information and are at the mercy of merchants in the nearest and only market they know, unable to negotiate better prices or reduce their market risk.(Agri-Hub Ethiopia, 2010).

Figer 2.1: The Ethiopian grain market structure before ECX
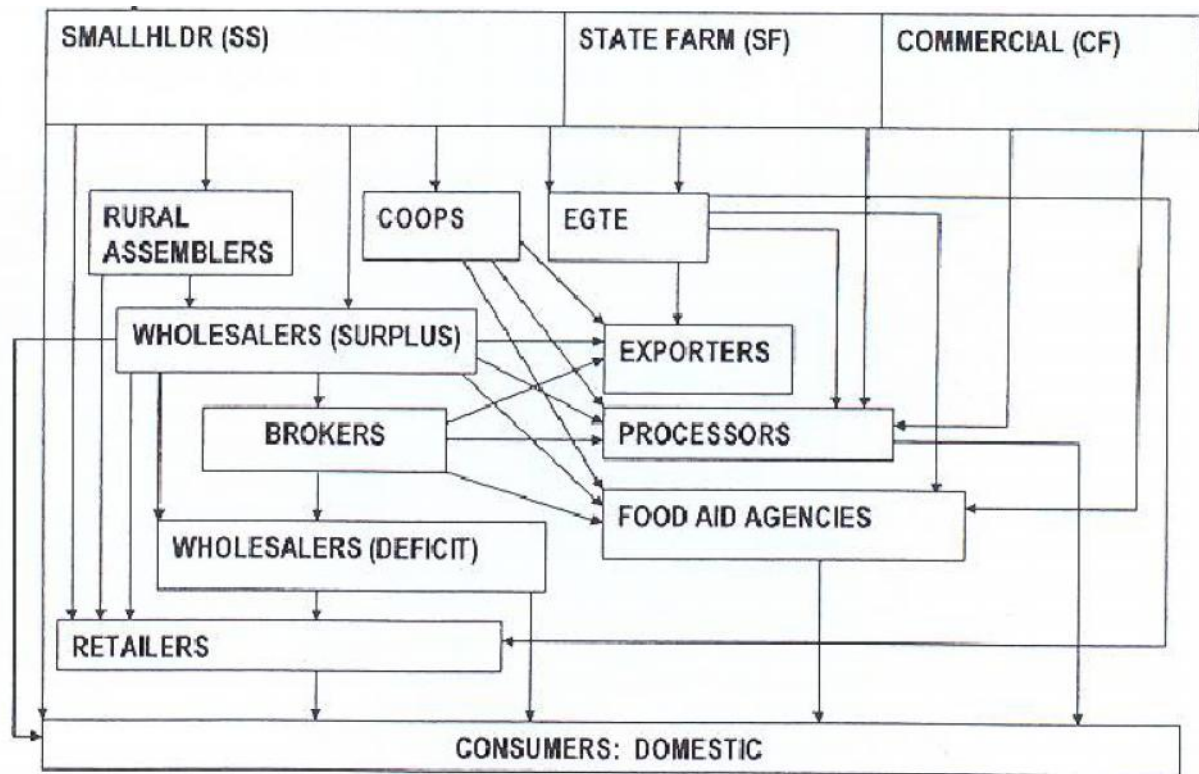
Source: ECX (2009)

2.6. ICT tools used by ECX for market information dissemination

The ECX Market Data strategy involves harnessing the power of modern information and communication technologies (ICTs) to empower all market actors, including smallholder farmers to access markets more efficiently and profitably. The key market dissemination channels at ECX are rural based Market Information Tickers, mobile phone Short Messaging Service (SMS), Interactive Voice Response (IVR) service, Mass media (TV, Radio, Newspaper) and Website . ECX collects, processes, updates and disseminates market information in real-time to all market actors and other market intermediaries through the MIS. Market information includes prices of commodities in different markets, and commodity offers to sell and bids to buy, as well as short extension messages.

The application of ICTs is taking the market to the door-step or farm-gate of the farmer, commodity dealers, processors , exporters and importers. The components of the ECX MIS are:

- Electronic Tickers
- Mobile Phone Short Messaging Service (SMS)
- Interactive Voice Response (IVR) service
- Bulletins – Market Commentary
- Mass media (radio, TV, print)
- Information Center

These components are briefly described below.

Tickers

ECX envisages disseminating its market information during on and off trading hours to 200 strategically selected regional market sites across Ethiopia. The ECX Electronic Displays are transmitting real time (under 4 seconds) prices of all commodities traded on its platform. Currently, the electronic displays are operational in 21 locations Such as 6 Coffee sites: Addis Ababa,Nazareth,Shashemene,Awassa,Nekempte,Jimma,DireDawa,Harar,Gonder,Bahdar,Dessie and Mekelle

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The Mobile Phone SMS

SMS is text messages sent and received with mobile phones. ECX is harnessing this technology to disseminate market information and intelligence. ECX is the process of developing an SMS market information via Ethiopia's mobile phone service provider. The SMS system will allow anyone from anywhere in the country where the mobile phone network exists can in easy steps access market prices, commodity related news headlines, weather forecasts, and other relevant market information.

The IVR System

The ECX Interactive Voice Response (IVR) system is a fully automated telephone based system that will allow stakeholders to access price information 24 hours a day, 7 days a week. Once it goes live, the IVR system may be accessed using mobile / wireless/ fixed line telephone

networks which makes critical market price information within the reach of stakeholders located in all parts of the country. The IVR system features a voice menu that disseminates real –time and historical (up to 7 days) price information in Amharic, Oromiffa, Tigrigna, and English languages.

The Website

The ECX website (www.ecx.com.et) provides real time market data on all commodities traded. It also provides historical data, research, news, graphs, contract specifications and other key information.

Media (TV, Radio, and Newspaper):

ECX is disseminating market information on daily basis via radio, television and newspaper. Prices are disseminated in Amharic, Oromifa, Somali and English languages.

- TV- ETV is transmitting ECX market updates three times a day (noon, afternoon and evening).
- Radio –National Radio stations, FM Addis and regional FM radio stations are transmitting ECX market updates four times a day (morning, noon, afternoon, and evening)
- Newspaper – daily, bi-weekly and weekly newspapers are publishing ECX market updates.

Market Intelligence

- Market Bulletin - ECX provides a summary of price comparisons with local and international prices; analysis and market developments via its weekly market bulletin. The analysis includes graphs, commentary and research on international markets and commodities traded on its platform.
- Market Hotline - ECX provides real time market information and updated international market prices for ECX members via a dedicated telephone line.
- Info Center - ECX info center provides a variety of market information such as, daily domestic and international prices, market trends, production and weather forecast, market related news and events, etc.

Fig 2.2: The ECX Model

- Anend-to-endmarketsystem…
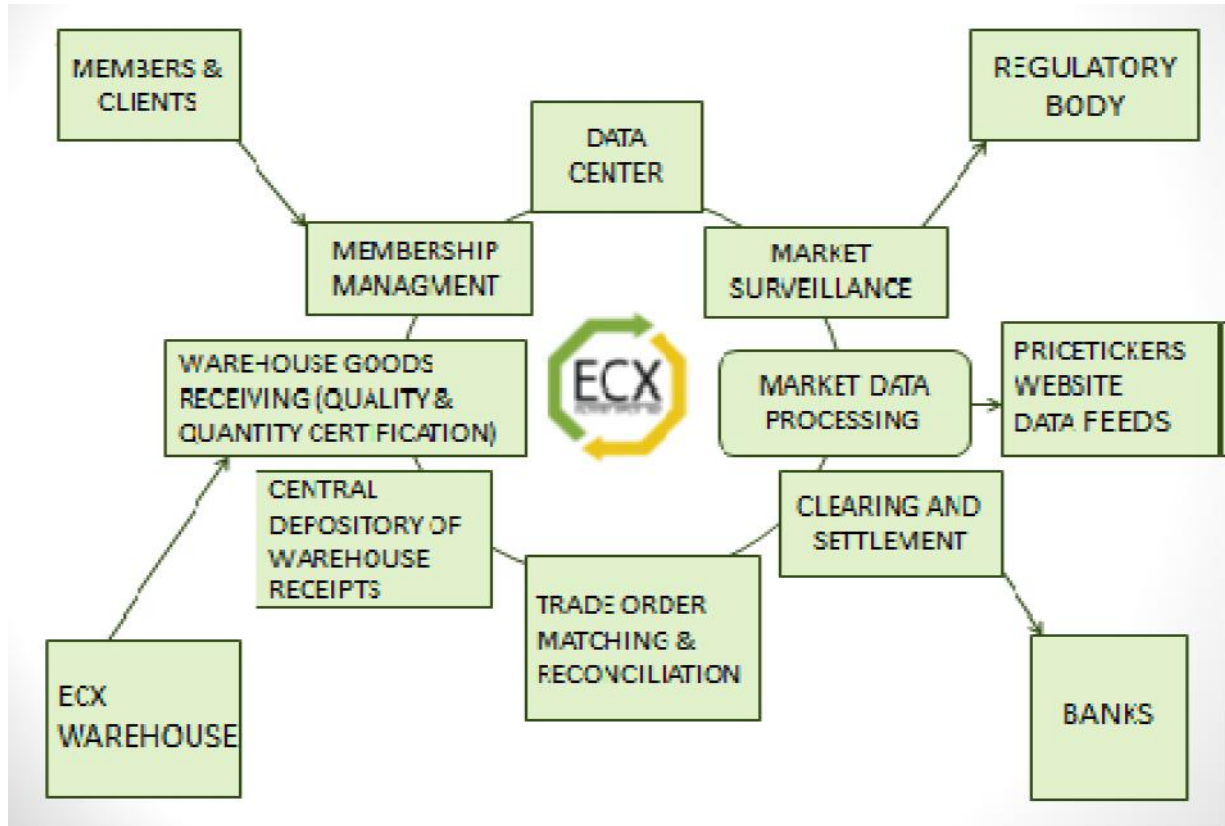
Source: ECX(2012)

2.7. Empirical literatures of co integration

Negassa (1997), in his paper "Vertical and Spatial integration of Grain Markets in Ethiopia: Implications for grain markets and food security policies", using weekly price data collected from August 1996 to July 1997 deflated by CPI (1995=100), for Addis Ababa market, he tried to analyze the vertical and spatial integration of grain markets in Ethiopia. He used Granger Causality tests and found that the grain markets in Ethiopia exhibit a high degree of vertical and spatial market integration.

Tamru, (2006), in his study stated that, deficit areas are isolated from Addis while the surplus areas were found to be well integrated and differences and distance are important factors affecting spatial white wheat markets integration between Addis and the regional markets.

Marcel Fatchamps and Gavian (1995), assessed the Niger's degree of livestock market spatial integration. They have used data from 35 districts and 3 urban centers, from January 1968 to December 1988 by applying four different method of analysis. They adopted four different techniques, in the intention of partially compensating for the weakness of their data. The methods used were: co-integration; Granger causality; Ravallion's (1986) model of market integration and Baulch's (1994) parity bounds model. In their analysis, they found Niger's geographical market integration of livestock is low, that is prices in different districts frequently exceed their parity bounds and often fail to co-move.

Mohammad Ismet et.al., (1998), evaluated the long-run spatial price relationships and factors affecting the degree of integration of Indonesian rice markets using multivariate co integration tests. They relied on weekly price data of the periods from 1982 to 1993. In their analysis, they used a before-after approach of self sufficiency periods as well as for the entire period. The co-integration test they have used for entire Indonesian rice market, represented by nine most relevant price series, produced a result that the pre-self sufficiency period has shown a relatively higher degree of market integration. The decline in the degree of market integration overtime indicates that rationalizing of the Indonesian rice price policy post 1984 rice self-sufficiency has resulted in low market integration.

Serra et.al (2004), on the other hand, argued that nonparametric modeling is better suited than the TAR model and they tried to reveal their argument by analyzing degree of market integration of U.S. egg markets at the turn of the nineteenth century. They compared the results found from TAR and nonparametric model using monthly price data from October 1881 to October 1911. In their analysis, they found that in the majority of the cases studied, non parametric regression supports the TAR results. But, their results indicate that non-parametric methods indicate a higher level of market integration than the one found by TAR model (method).

Gbegbelegbe and de Groote (2012) tested the hypothesis that the market liberalization of the 1990s increased efficiency and decreased volatility in Kenya and they found that The analysis of temporal variation shows that real maize prices have decreased over time in Kenya. Major factors in price variation are the differences between years, although a distinct one-season effect is demonstrated. Prices are clearly higher in the surplus zone during the high season, but lower otherwise. The coast has higher prices in the lower season. Price volatility has been decreasing over the years, and most likely market liberalization has played a positive effect on this trend.

Moser, et al (2005) tried to assess the extent to which rice markets in Madagascar are integrated across space, time and form at three different spatial scales—sub-regional, regional, and national and determine whether non integration is due to high transfer costs or lack of competition. The results indicate that markets are fairly well integrated at the sub-regional level and that factors such as high crime, remoteness, and lack of information are among the factors limiting competition. A lack of competition persists at the regional level and high transfer costs impede spatial market integration at the national level. Only six percent of rural communes appear to be intertemporally integrated and there appear to be significant untapped opportunities for interseasonal arbitrage.

Tione (2014) showed the effectiveness of modern ICT-based market interventions in improving maize market efficiency in Malawi. A Threshold Autoregressive Error Correction model was used to assess price transmission speed. Comparisons were made of the speed of price transmission in the periods before and after the introduction of ICT technologies by the Malawi Agriculture Commodity Exchange. The spatial integration results show that maize markets in

Malawi were better integrated fol-lowing the introduction of ICT-based market interventions. Furthermore, the study results for pre- and post-ICT interven-tions shows that ICT-based market interventions positively influenced market integration and price transmission, contrib. uting to a reduction of market search transaction costs which lead to improved maize marketing efficiency.

CHAPTER THREE

3. METHODOLOGY

In this study both descriptive and econometric analysis are used to assess ICT contribution for maize market integration in Ethiopia. The descriptive analysis used maize production data in the study period to identify surplus and deficit areas and price data to asses integration level between markets as well as telecom infrastructure expansion and coverage comparison between the before and after periods. In the econometric analysis , co integration test to see level of co integration between markets, Granger causality test and error correction analysis is undertaken to see the speed of adjustment of the error correcting terms between co integrating markets.

3.1. The data

This research entirely depend on secondary price data collected from central statistical authority starting from 2003 to 20014,which is divided in to two periods. That is, before information and communication technology infrastructure expansion, which covered a period of 2003 to 2009 and after ICT infrastructure is expanded which covered a period from 2010 to 2014. Thus the study tries to compare the level of spatial maize markets integration before and after the ICT development.

The study aims to analyze maize market integration level by measuring price transmission levels among various markets using the TAR model for fourteen selected markets in Ethiopia. These markets are: Addis Ababa as central market, Adama and Assela from central Ethiopia, Nekempt and Ambo from western Ethiopia ,DireDawa and Harrar from eastern Ethiopia, Mekelle, Gondar, Dessie and Bahirdar, from northern Ethiopia , Welkite, Hawassa and Welytasodo from southern Ethiopia ,which were selected purposively for their high production capacity, continuous transaction of maize and thus data availability and some markets are also considered as representative of deficit areas to compare the degree of integration between Addis ababa and the surplus and deficit areas.

3.2. Time series components and Decomposition

Time series represents a variable observed across time. The time increment can be years, quarters, months or even days and the values of time series can be presented in a table or illustrated using a scatter diagram (keeling,2003).

The components of a time series are: Trend (T), seasonal variation(S), cyclical variation(C) and Irregular activity(I). The first three components are deterministic which are called 'signals', while the last component is random variable which is called 'noise' (seneshaw, 2006). For example, a time series variable y_t is composed of;

$Y_t = S_t . T_t . C_t . I_t$

Where the subscript t refers to a particular time period.

And the purpose of these time series decomposition and adjustment is to make appropriate decisions upon production, storage and marketing, both for producers and traders.

Trend(T): the trend is a steady increase or decrease in the time series. If a particular time series is neither increasing nor decreasing over its range of time, it contains no trend. The trend reflects any long term growth or decline in the observations.

If the rate of change in y from one time period to the next is relatively constant, the trend is a linear trend.

$TR = b_0 + b_1 t$

For some b_0 and b_1, where the predictor variable is time ' t'

When the time series appears to be slowing down or accelerating as time increases, then a non linear trend may be present. It may be quadratic trend:

$TR = b_0 + b_1 t + b_2 t^2$

Or a decaying trend, $TR = b_0 + b_{1t} e^{-1}$

The linear trend equation is an application of simple linear regression, where as the quadratic trend uses multiple regression equation using two predictors, t and t^2 (keeling, 2003).

Seasonality(S): seasonal variation or seasonality refers to the periodic increase or decrease that occur within a calendar year in a time series. They are very predictable because they occur every year. When time series data are quarterly or monthly seasonal variation may exist but data reported in annual increment cannot be used to examine seasonality. Movements in time series that follow the same pattern each year and so probably are due to seasonality. An analysis of seasonal variation is often a crucial step in planning sales and production.

Cyclical variation(C): cyclical variation describes a gradual cyclical movement about the trend. It is generally attributable to business and economic conditions.

In business applications, cycles typically are long term movements, with periods ranging from 2 to 10 years. The primary difference between cyclical and seasonal factors is the period length. Seasonal effects take place within one year, whereas the period of cyclical activity is usually more than one year.

Cyclical activity need not follow a definite, recurrent pattern.the cycles generally represent conditions withn the economy , where a peak occurs at the highest of the expansion(prosperity) period and is generally followed by a period of contraction in economic activity. The low point(trough) of each cycle usually occurs at the point of economic recession or depression(Imdadullah, 2014).

Irregular activity(I): irregular activity consists of what is left over after accounting for the effect of any trend, seasonality or cyclical activity. these value should consists of noise, much like the error term in the linear regression models.

The above time series components can be combined in various ways to describe the behavior of a particular time series. One method is summation or the additive structure. But as in many studies explained, better success has been achieved by describing a time series using multiplicative structure as the component parts unlikely to be perfectly independent.

The first step in isolating the components is smoothing the object series with a centered

moving average (CMA) and at this stage if the smoothing is to be done by moving average, it is conventional to specify the number of observations (n) from 12 to 15 elements in the moving average set. For example, in a monthly data, if n is chosen to be 12, any seasonal price movements observed in the series over the twelve months would completely be eliminated. In the process, the number of elements in the set can be diminished to the number of remaining rows in order to encounter the loss of data occur at the end of a CMA series, as the end of the series is approached. This would leave us with a combination of T.C series, as the seasonal and irregular influences are smoothed from the time series. The technique of using centered moving average for a specified time period helps in representing the actual value by the average of that value and a given number of observations taken immediately before and after it (Goetz and Weber.1986).

The technique of CMA has significant advantages in that it can take the trend of the original time series, it can show any cyclical variations around the time series and it can eliminate very short term instability (seasonal and random) appearing in the original series.

The second step entails that computing the ratios of the original time series (T.C.S.I) to the results of the first step (T.C), which by cancellation (or division) leaves a combination of S.I series and this basis for the name of the technique, "ratio-to-moving average".

The third step involves smoothing of the S.I series of the previous step to eliminate the irregular influences, leaving an isolated seasonal series, S.

The fourth step, involves, computing the ratios of (S.I) to the corresponding result of S, which by cancellation (or division) yields an isolated irregular, I, series.

The next step engages, trend regression on the unidirectional range of the time series variable, so as to produce an isolated T series.

The final step, involves computing the ratios of the results of the first step (T.C) by the results of the fifth step (T), which by cancellation yields an isolated, C, series.

3.3.Augmented Dicky Fuller test

The Dicky Fuller test of stationarity was further refined and improved to augmented Dicky Fuller test to overcome the potential shortcomings of the previous one. Thus, if y_t follows an autoregressive order p or AR(P) process, but it is used as AR(1) DF model, then the error term will be autocorrelated to compensate the misspecification of the dynamic structure of y_t because the DF test assumes that the error terms are 'White noise' and independent and identically distributed or $iid(0, {}^2)$ (sineshaw,2006). Autocorrelated errors would make the use of the DF distributions inappropriate, because the distributions are based on the assumption that Ut is 'white noise'. The ADF test is comparable to the simple DF test but involves adding an unknown number of lagged first differences of the dependent variable to capture autocorrelated omitted variables that would otherwise, by default, enter the error term, μ_t (an alternative approach to adding lagged first differences of the dependent variable is to apply a non-parametric correction to take account of any possible autocorrelation; this is the Phillips and Perron approach).

As a result assuming that y_t follows a pth order autoregressive process

$$Y_t = {}_1*Y_{t-1} + {}_1* \ Y_{t-1} + {}_2* \ Y_{t-2} + \ldots + {}_{p-1}* \ Y_{t-p+1} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where ${}^*= ({}_1 + {}_2 + \ldots\ldots + {}_p)-1$. If ${}^* = 0$, against the alternative ${}^* < 0$ then Y_t contains a unit root.

The ADF model tests for the null of a stochastic trend(non stationary) against the alternative of deterministic trend(stationary) and it is as follows.

$$Y_t = {}_1*Y_{t-1} + \sum_{i=1}^{p-1} + \psi 1 * \Delta Yt - 1 + \mu + {}_{t} + \mu_t \qquad \mu_t = IID(0, {}^2)\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The ADF can further be extended to permit for moving average (MA) parts in the μt. It is generally believed that MA terms are present in many macroeconomic time series after first differencing (e.g., time average data, an index of stock price with infrequent trading for a

subset of the index, the presence of errors in the data, etc.). Central to the ADF model is the selection of the appropriate lag-length; this is because, too few lags may results in over- rejecting the null when it is true (i.e. adversely affecting the size of the test), while too many lags may reduce the power of the test (since unnecessary nuisance parameters reduce the effective number of observations available), and hence appropriate lag selection criterion should be used (Harris 1995).

3.4. The model

Testing of market integration using the standard co integration test has been criticized on the premise that the results obtained are inconclusively drawn due to the omission of transaction costs (McNew and Fackler 1997; Barrett 1996). And applying standard linear autoregressive error correction model is also restricted in reflecting only spatial price transmission. To overcome these problems, this study will apply TAR error correction model which enables us to include transaction cost and analyze asymmetrical price adjustment

The study will employ threshold autoregressive (TAR) model of co integration in the form error correction model of Engle Granger two step methodology. Formulation of error correction model(ECM), comes from the fact that, variables may tend to have long run relationship while they are non stationary and aiming to identify the long run relationship along the short term dynamics.

The long-run is a state of equilibrium where economic forces would tend to be stable, while the short run depicts the disequilibrium state where adjustment to the equilibrium is occurring. Upon dealing with non-stationary data, equilibrium could be very much related to the concept of co integration and hence, if there is no sign of co integration between the variables to be analyzed, trying to relate them would often lead to spurious regressions which do not reflect long-run economic relationships but, rather, reflect the common trends contained in most non-stationary time series. Co integration is also related very closely to the use of short-run error correction models which helps in showing the link between the long and short run approach to econometric modeling (Harris, 1995).

As a preliminary part to threshold autoregressive(TAR) model and succeeding step of co integration analysis, Engle Granger two step approach is followed which explains, if we have two non- stationary variables containing a unit root (i.e. $I(1)$ variables), then they can be described as being co integrated if the error term is stationary (i.e. $I(O)$. that is it is belived that we can identify whether variables are co integrated or not by testing the stationarity of residuals which can be done easily using Augumented Dicky Fuller test (Enders and Sikilos, 1999).

The first stage of the two-step methodology of the Granger representation model entails using OLS to estimate the long-run equilibrium relationship of two or more variables as:

$$X_{1t} = {}_0 + {}_2 X_{2t} + {}_3 X_{3t} + \ldots\ldots + {}_n X_{nt} + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where: X_{it} are the individual $I(1)$ components of X_t, i's are the estimated parameters, and U_t is the disturbance term which may be serially correlated.

The second-step focuses on the OLS estimate of µ in the regression equation:

$$U_t = {}_1 u_{t-1} + {}_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots\ldots (4)$$

where: $_t$ is a white noise disturbance, and the residuals from (3) are used to estimate (4). Accepting the alternative hypothesis (i.e., rejecting the null hypothesis of no co integration implies that the residuals in (1) are stationary with mean zero. The granger representation theorem guarantees that if 0,equation (3) and (4) jointly imply the existence of error correction representation of the variables as below.

$$X_{it} = \Gamma(X_{it-1} - {}_0 - {}_2 X_{2t-1} - {}_3 X_{3t-1} - \ldots\ldots - {}_{nt} X_{nt-1}) + \ldots\ldots + v_t \ldots\ldots\ldots(5)$$

The above equation is based on the assumption of symmetric adjustment. But the cointegration equations and their extension may misspecified if adjustment towards long run equilibrium is asymmetric. To incorporate the above problem of EG model of cointegration, the basic threshold autoregressive (TAR) model developed by Tong (1993) allows the degree of autoregressive decay to depend on the state of variable of interest. This model is in contrary with Engle Granger

(1987) and Johansen (1996) co integration tests which implicitly assume linearity and symmetric adjustment.

Following the approach used by Enders and Sikilos (1999), an alternative specification of the error correction is developed in such a way that (4) can be rewritten as:

$$U_t = {}_1 Iu_{t-1} + {}_2 (1-I)u_{t-1} + {}_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where I is the Heaviside indicator function such that:

$$I = \begin{cases} 1 \ if \ u_{t-1} \geq \ddagger \\ 0 \ if \ u_{t-1} < \ddagger \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7) \end{cases}$$

Where τ = the threshold value.

The value of τ is unknown and needs to be estimated along with ${}_1$ and ${}_2$.

If the system is convergent, then the long run equilibrium value of the sequence is given by $U_t = \tau$, where τ is the estimated threshold. A method of searching for a consistent estimate of the threshold was undertaken by using a method proposed by Chan (1993). According to this method, the threshold value is searched from the potential threshold values so as to minimize the sum of the squared errors from the fitted model.

The sufficient conditions for the stationary of U_t are ${}_1 < 0$, ${}_2 < 0$ and $(1+{}_1)(1+{}_2) < 1$ [Petrucelli and Woolford: 1984]. In this case if u_{t-1} is above its long run equilibrium value, then adjustment is at the rate ${}_1$ and if u_{t-1} is below long run equilibrium then adjustment is at the rate ${}_2$. The adjustment would be symmetric if ${}_1 = {}_2$ (M. Reza,2011).

In searching the potential threshold value to obtain the threshold value, Monte Carlo simulation is under taken.

3.5.Cointegration Test

In Egle Granger method or the ADF based method of testing cointegration, all the variables in the OLS equation are always assumed to be non stationary or I(1) and targets to test whether the residuals are stationary(I(0)) or not.

It is only really applicable to use the single equation approach when there is a single unique

cointegration vector and when all the right hand–side variables are weakly exogenous (Harris1995).

If there are n>2 variables in the model, there can be more than one cointegration vectors. It is possible for up to n-1 linearly independent cointegration vectors to exist, and this has implications for testing and estimating cointegration relationship. Only when n=2 it is possible to show that cointegration vector is unique. Though Johansen's method of cointegration test is superior to ADF in many ways, for a bi-variate analysis ADF can also be very much reliable (Harris, 1995).

While the Johansen's method of cointegration use maximum likelihood based test and is mostly applicable and better for large samples, the Engle Granger or the ADF test is OLS based test and is better for moderate size of observations.

Based on Engle Granger two step methodology, the long run relationship of the variables are estimated using OLS method as first step and the residuals are tested using ADF test as second step to check stationarity.

Granger(1995) stated that, if there is an evidence of cointegration between two or more variables, there should exist error correction model between these variables. And this error correction model can be considered as representation of short term dynamic relationship between these variables.

As error correction model is applicable only in stationary or $I(0)$ variables, non stationary variables are always first differenced to make them all stationary.

$$X_{1t}= {}_0+ {}_2 X_{2t} + {}_3 X_{3t} +\ldots\ldots+ {}_n X_{nt}+ U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(8)$$

Wehre X_{1t} represents price Addis ababa maize and X_{2t} price of maize of the respective regional markets at time t. ${}_n$ are estimated paramteters and U_t are the disturbance terms. The other explanatory variables ${}_3 X_{3t} +\ldots\ldots+ {}_n X_{nt}$ are nonexistent in the long run as our model is bivariate analysis.

Based on this, equation (8) can rewritten as for any two markets in our model as for example addis ababa and adama as:

$$AAM_t = {}_0 + {}_2 ADAM_t + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8')$$

Where, AAM_t and $ADAM_t$ are deseasonalized retail price of maize in addis ababa and

Adama respectively and ${}_i$ are the estimated parameters and U_t is the disturbance term.

Accordingly, if the residuals in equation (8') are stationary using ADF test, the two markets can be considered as cointegrated.

As a result, the ADF test result for the residuals from the OLS result of Addis abab as dependent variable and the regional markets as independent variable is presented in table 4.8.

3.6. Monte Carlo simulation

What makes TAR model special from that of the normal autoregression is its provision of threshold value which represents a 'neutral band'. Neutral band is a band at which our long run equilibrium between markets is set.Trade between markets start if the local price shock goes beyond this band or threshold. In our case this threshold value can be considered as transaction cost of moving product from one market to the other.

To conduct an error correction model or an adjustment of the deviation from the equilibrium, estimating the threshold value is mandatory which is previously unknown along with ${}_1$ and ${}_2$.

To estimate this threshold value, Chan (1993) methodology is followed which according to that provides a supper consistent value. According to this methodology the threshold value is obtained through Monte carlo method of grid search from the potential threshold values from equation (9) and (10) in order to find the value that minimizes the residual sum of squares. In order to conduct montecarlo simulation 10000 random- walk process of the following form was generated.

$$X_{1t} = X_{1t-1} + V_{1t}, \quad t=1,\ldots\ldots,T\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

$X_{2t} = X_{2t-1} + V_{2t}, \quad t=1,\ldots\ldots T\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$

Where T is the number of usable observations.

For sample size of T, the two sets of T normally distributed and uncorrelated pseudo random numbers with standard deviation equal to unity were drawn to represent (V_{1t}) and V_{2t} sequences. Randomizing the initial value of X_{1t} and X_{2t}, the next T values of each were generated using (9) and (10). For each of the 10,000 series, the TAR model given by (3) (6) and (7) is estimated following estimation of the threshold.

To estimate the threshold value(τ), for each of the 10,000 X_{1t} and X_{2t}, the long term equation in the form of (8') is estimated. As in the presence of asymmetric adjustments $_1$ and $_2$ differ, the mean will be a biased estimator of the threshold and hence Chan's (1993) approach should be followed in that, the residuals predicted from the regression will be saved, and then, the saved residuals would be ordered in ascending order then the upper and lower 15% of the residual series values would be discarded and the middle 70% would be considered as a potential candidates to be the threshold value (seneshaw,2006).

Now we can estimate the threshold value in such a way that, each of the threshold candidates are estimated in the form of (6) and (7) and the threshold value that produce the minimum residual sum of squares will be considered as the threshold(τ) value. In addition, the two error correcting coefficients or coefficients that represent the speed adjustment towards the equilibrium ($_1$ and $_2$) are estimated simultaneously in the simulation process.

Using the Monte carlo simulation method, we also need to estimate the critical values t and F statistics for the null hypothesis of $_1=0$ and $_2=0$ and the joint hypothesis of $_1= _2=0$ respectively and recorded as the standard tests are inappropriate due to the threshold value is un identified under the null hypothesis.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. Descriptive Analysis

4.1.1. Maize production trend

Over half of all Ethiopian farmers grow maize, mostly for subsistence with 75% of all maize output consumed by farming households. This makes maize Ethiopia's leading cereal crop, in terms of production, with 6.2 million tons produced in 2013 by 9.3 million farmers across 2 million hectares of land (EATA annual report, 2013/14). According to central statistical authority data, maize production in 2013/14 shows 5.4% increment compared to production of the same season in 2012/13, although the total land cultivated was declined by 0.9%. And yield in quintal per hectare increases from 30.59 in 2012/13 to 32.54 or shows a percentage change of 6.37 in 2013/14.
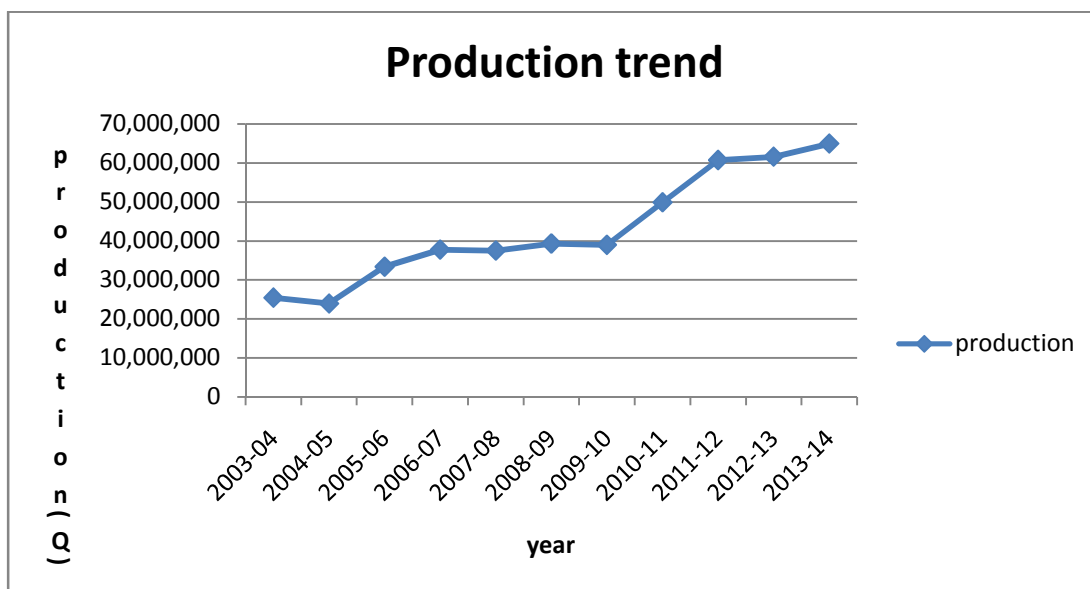
Figure 4 . 1. Country level maize production trend in quintals from 2003 to 2014.

The production trend with in the study period (2003/2004-2013/14) shows a significant increment (25,429,653 quintals in 2003/04 to 64,915,402.92 quintals in 2013/14) which is an increment of more than double.

Although the production in quintals per hectare shows a decline in 2004/05(16.8Q/h) compared to 2003/04(17.19 Q/h), it continues to increase post 2004/05 and reaches 32.54 quintals per hectare in 2013/14 as depicted in figure 4.2.
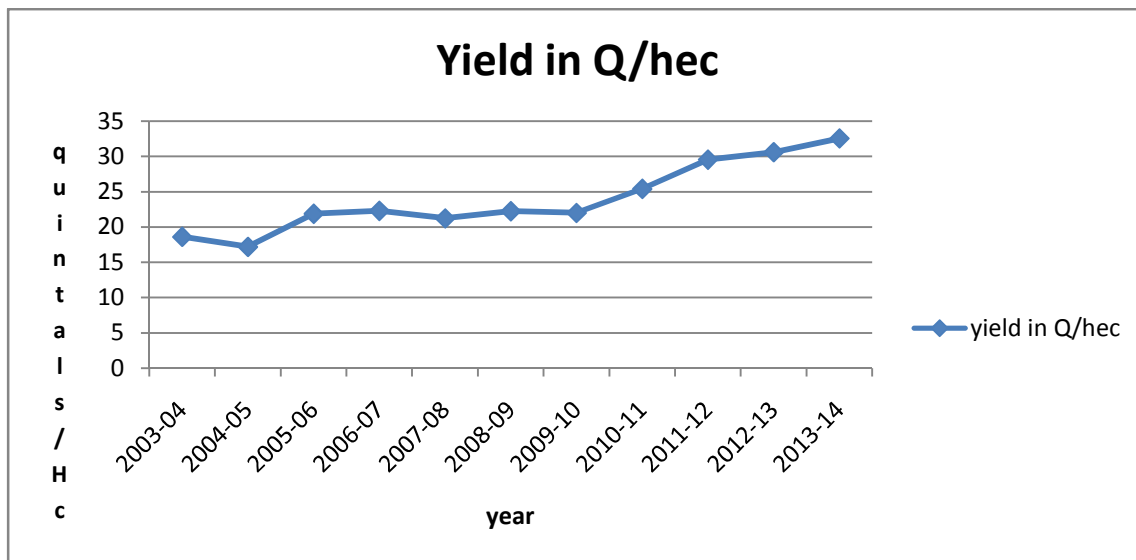
Figure 4.2: Country level maize yield in quintals per hectare from 2003 - 2014

4.1.2. Trends of maize production at zone level

Major food crops in Ethiopia are produced in almost all regions of the country in spite of the variation in volume of production across the regions. The variation may be attributed to the extent of area devoted to each crop type, weather change and a shift in preference for the crops grown. Agricultural productivity is mainly indicated by the amount of crop harvested per amount

of land planted or crop yield (CSA , 2011/2012). And crop yield is mainly affected by weather, input price, changes in farming practices, amounts of fertilizer used, quality of seed varieties, and use of irrigation.

Table 4.1: Average area cultivated, production and yield per hectare of all zones from 2003 to 2014.

Zone	Average area cultivated in hectare	Average total production in quintal	Average yield per hectare(Q/H)	Production share in % from the total
Bahirdar	158,590	4,490,639	27	25.73
Nekemt	100359.29	3002890.52	28.99	17.20
Adama	97181.20	2623233.28	27.45	15.03
Ambo	77844.10	2238946.94	26.16	12.83
Assela	70219.87	1602754.02	22.69	9.18
Gondar	54698.48	1264215.31	22.14	7.24
Hawasa	35,131	868,265	25.24	4.97
Welkite	22079.48	609653.11	27.38	3.49
W.sodo	17007.03	347949.60	20.38	1.99
Dessie	13174.12	253207.97	18.44	1.45
Mekelle	8063.13	119976.56	14.45	0.68
Harari	1295.30	24159.27	17.78	0.13
D.Dawa	257.40	3798.20	14.55	0.02

Source: Author's calculation from CSA data (2003-2014)

Table 4.1 shows average total area cultivated for maize, average total production , yield per hectare and percentage share of total production from the total of all zones since 2003/04 up to 2013/14 and the zones are ordered based on their amount of average total production and percentage share from the largest to smallest.

As we can see from the table, West Gojam(Bahirdar) has the largest total production with average total production of 4,490,639 quintals and largest average total cultivated land(158,590 hectare);although it is dominated by Nekemt(East Wellega) and Adama (East Shewa) in terms of average yield per hectare which contains 28.998 and 27.454 quintals per hectare respectively while Bahirdar is 27 quintals per hectare.

Although they dominate one from the other in terms of total production and yield per hectare; Bahirdar , Nekemt , Adama and Ambo are the top four most surplus areas in all parameters from the total sample zones taken. In contrary to this, Dire Dawa,Harari and Mekelle are the most least producers(Deficit areas) respectively in terms of average total production and Mekelle, DireDawa and Harari respectively in terms of yield per hectare. In similar fashion to the surplus, although they dominate one from the other in terms of average total production and yield per hectare; Mekelle, Dire dawa and Harari are the most least producers (deficit areas) in terms of all parameters from the total sample production zones taken.
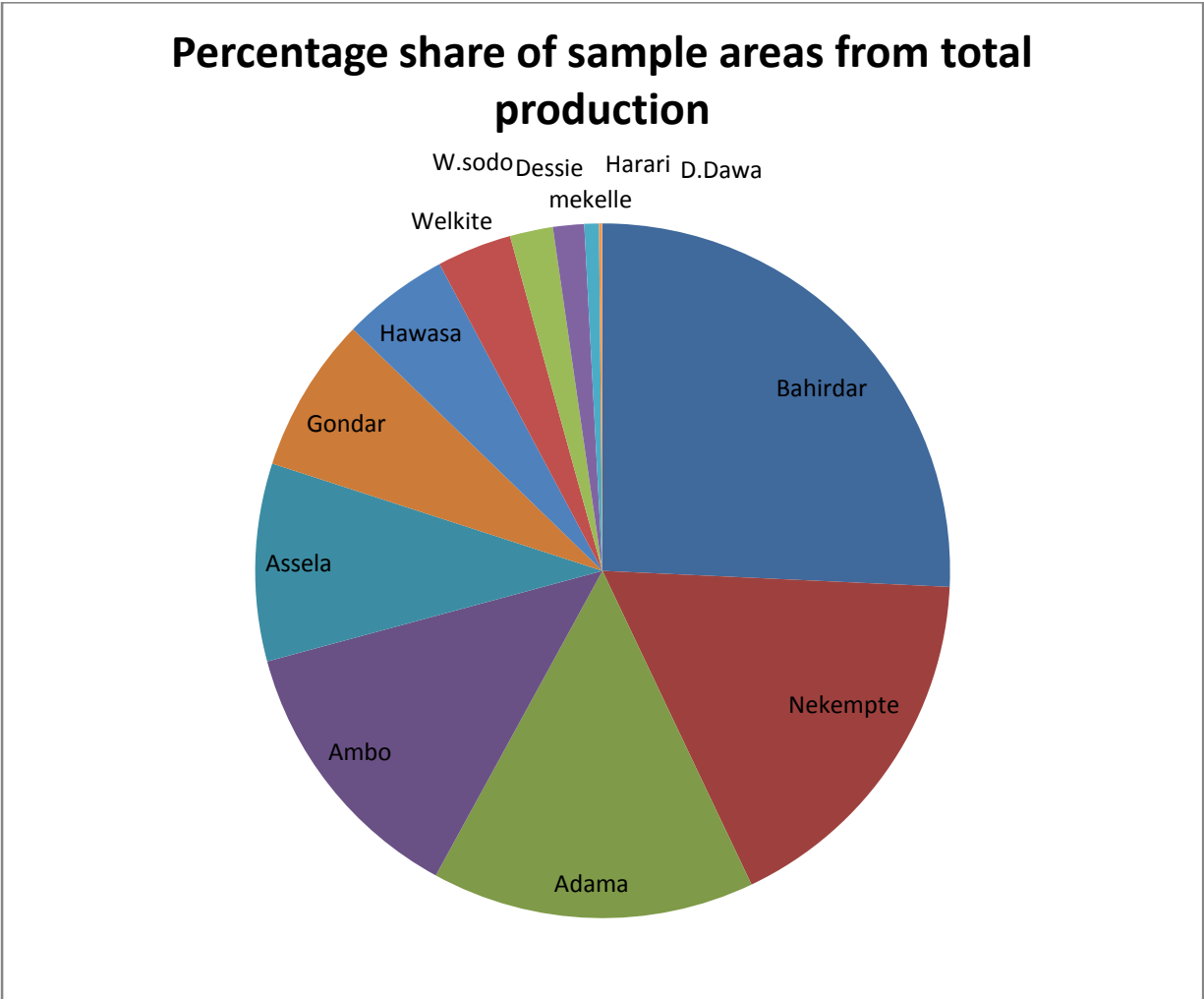
Figure 4.3: Average production share in percent of each zone from the total sample zones (2003-2014)

Source: Author's computation from CSA data (2003-2014)

As we can observe from the pie chart, the largest area in the chart which shows percentage share of average production of all sample zones is occupied by Bahirdar, Nekemt, Adama and Ambo respectively and the smallest area is occupied by Diredawa and followed by Harari and Mekelle respectively.

4.1.3. Telecom expansion in Ethiopia

Ethiopian telecommunications has made various transformations along with the country's growth and transformation plan as it is government owned sole telecom provider in Ethiopia. As company growth and transformation plan, Ethiopian telecommunications corporation started to expand its network accessibility by signing 1.5 billion USD vender financing agreement with chine's telecom company(ZTE) in 2009.

The expansion was divided in to 9 projects which cover 14 major cities in all over the country including Addis Ababa started simultaneously in all cities as first phase and continue to zonal cities and Weredas as second and third phases which were called as Next Generation Network projects (NGN projects). These projects were designed to meet the company's mission of ' to be international standard telecom service provider' and the country's ICT demand and these projects were: fixed line next generation project(FL NGN), mobile(GSM), Coded data multiplex access(CDMA), Next generation Internet protocol(IPNGN), optical fiber(backbone network), Network operation center(NNOC), customer care and billing(CCB), next generation call center (NGCC) and pay phone(public telephone).

In addition to the network expansion, Ethiopian telecommunications corporation also tried to made some structural adjustments in its internal management by signing a contract management agreement for two years term with French international telecom company (ORANGE) which enables the company to get modern international standard telecom management experience and success full knowledge and technology transfer. Along with this structural adjustment, the company changed its name from Ethiopian telecommunications corporation to' Ethio telecom' in 2010 .

As one sector of the economy, ethio telecom had set numbers of goals to be achieved with in five year growth and transformation plan (GTP) at the beginning of the GTP plan in 2010. Some of the goals were:

➢ To enable the existing network infrastructure carry modern and quality information and communication technology in broad manner.

➢ Telecom service expansion and improve quality

➢ To efficiently utilize the already built network infrastructure, provide competitive price and services quality and through structural adjustment improving the overall company's strength.

➢ Increasing accessibility of telecom service including the rural population, to improve the economic contribution of the company, etc.

Table 4.2: Comparison of Ethio telecom services at the beginning of GTP and plan to be achieved at the end of GTP.

Indicator	Achieved in 2010/11	Target 2014/15
Fixed telephon(PSTN) customers(in millions)	1	3.05
Fixed telephon(PSTN) distribution(%)	1.36	3.4
Mobile telephone(GSM) customers(in millions)	6.52	40
Mobile telephone(GSM) distribution(%)	8.7	45
Number of internet data service customers(in millions)	0.187	3.69
Global link capacity(GB/S)	3.255	20
Rural telecommunication coverage in 5 km radius (%)	62.14	100
Wireless national area coverage (%)	<50	90

Source: Ethio telecom (2014)

Ethio telecom set various strategies to achieve the above GTP plans in order to provide a diversified, competitive in terms of quality and price of telecom services to the society and to play its own role in achieving the growth and transformation plan of the country as a whole. Some of the mechanisms followed to attain the given goals were:

➢ In partnership with international telecom companies, enabling the company to provide competitive price and quality services.

- ➤ Preventing the industry from frauds and crimes by establishing strong fraud management and coordinating with legal authorities, stakeholders and the society as a whole.
- ➤ Designing human resources development strategies and get in to action.
- ➤ Improving international link lines their net work carrying capacity, improved fault prevention and delivering on time maintenance.
- ➤ etc

4.1.3.1. Major achievements from 2010 to 2015

The previously started network expansion and other related application service projects through vender financing by chine's telecom company (ZTE) are completed and begun to provide various services to the society. Due to this, the mobile core net work capacity increased to above 23 million and the fixed line net work capacity reaches 3.6 million including the next generation fixed wireless (CDMA) net works. In addition to this, NOC, call center and billing automation are completed and started work. From the previously started vender financing 9 projects, the company able to get large net work capacities in which some of them are fully utilized and others partially utilized as indicated in table below.

Table 4.3: Capacity obtained from the projects and its utilization

Projects	Capacity obtained	Capacity utilized
Fixed line		
Core network	2.4 million lines	269 thousand lines
Access network	1.2 million lines	269 thousand lines

Mobile		
Mobile core network	23 million	Fully utilized
3G Mobile core network	3000	Fully utilized
CDMA wireless core network	2.4 million lines	280,000
Transmission transport network	6000 km back bone, 1500 km metro plus the before 2010/11 4000 km existing fiber a total of 11500 kms	
Customer care and billing	That enable to handle 18 million customers	
Network operation center(NNOC)	Includes fault management, fraud management, performance management, configuration management,accounting and security management.	
Call center	36 million customers by 750 agents(advisors)	
IP network	Covering 75 cities and bearing traffic of GSM, CDMA, NGN and access network	
Public telephone(pay phone)	50,000	4000

Source: Ethio telecom (2014)

The next generation network (NGN) built, by providing various new services like data, voice and various value added services enables the society to get an access of modern and improved to telecom services and additional network coverage and the company able to significantly contribute to the economy.

From table 4.4 below, the global link capacity of the company increased from 3.255 GB/s in 2010/11 to 11 GB/s in 2014/15 and this capacity is currently fully utilized. The increment of Global link in such a way, enables not only to satisfy the increasing number of internet users but also avoids the internet service interruption due to a damage on submarine cables by making internet capacity multi directional.

The rural telecommunication service provision (universal access) expansion shows a significant increment. That is, the number of rural Kebeles which have rural telecommunication access increased from 8900 in 2010/11 to 15,097 in 2014/15. And the rural telecommunication service coverage with in 5 km radius distance, increased from 62.14% in 2010/11 to 87% in 2014/15.

The GDP contribution of the company is increased from 1.76% in 2010/11 to 1.95% in 2014/15. But the GDP contribution of Ethiotelecom is less compared to other eastern Africa countries which is in average estimated from 3.3 - 3.7% and could be for example up to 5% or more in Central or Eastern Europe. It can be explained by lack of offer (limitation of coverage and capacity, some prices are high, etc..,(Ethiotelecom, 2014).

Number of mobile subscribers 40 million, fixed line telephone subscribers 3.05 million, number of data and internet subscribers 3.69 million wireless service national area coverage 90%, Global link capacity 20GB/s were the main goals set to be achieved at the end of 2014/15. And at the end of December 2013/14; number of mobile subscribers reach 25.65 million, fixed line telephone subscribers 761.5 thousand, data and internet 4.74 million, wireless (CDMA) national area coverage 73% and Global link capacity 11GB/ is achieved and compared to the GTP goal set; mobile 64%, fixed telephone 25%, internet and data subscribers 128%, wireless (CDMA) service national area coverage 79% and Global link capacity 55% from the target is achieved.

Table 4 . 4: Yearly achievement of telecom expansion and the target at the end of 2014/15.

Service type	2009/10	2010/11	2011/12	2012/13	2013/14	Comparison to 2014/15 target	2014/15 target
Mobile subscribers(million)	6.52	10.5	17.26	23.76	25.65	64%	40
Mobile service coverage(%)	8.7	12.85	20.4	27.6	29	65%	45
Fixed line telephone subscribers(million)	1	0.85	0.805	0.79	0.76	25%	3.05
Fixed line density(%)	1.36	1.03	0.95	0.9	0.9	26%	3.4
Data and internet subscribers(million)	0.187	0.129	0.221	4.43	4.74	128%	3.69
Wireless(CDMA) service coverage(%)	50		64	73	73	79%	90
Within 5 km radius telecom service beneficiary rural Kebeles(%)	62.14		74	84	87	87%	100
Global link capacity(GB/s)	3.255	5.425	6.5	8.686	11	55%	20

Source: ethio telecom (2014)

4.1.4. Maize retail price trend

Figure 4.4 Shows the deseasonalized retail price trend of maize for 14 selected markets in Ethiopia for the study period(September 2003/04 to August 2013/14). As already explained above the study period is devided in two periods or the before ICT infrastructure expansion period from 2003 to 2009 and the after ICT infrastructure expansion a period from 2010 to 2014 in which Ethio telecom highly invested in various telecom expansion projects in coordinating with various international telecom companies in all over the country.

As we can observe from the graph, there is a continuous increment in price of maize in the post ICT period and there is a large variation or ups and downs from year to year with in a given market. Except Welayta Sodo which has a stagnant up and down movement and completely separated from the others especially in the after ICT period, all markets have similar movement.

Welayta Sodo market was moving in similar direction but with smaller up and down movement in pre ICT period and continued its horizontal movement (smaller change in price) in the after ICT period while others show higher up and down movement and follow similar direction. This might show us that, degree of transmission of price signals from Welayta Sodo to other markets and vice versa is weak compared to the others. An informal interview with Ethio telecom staffs who were assigned in southern region network expansion was conducted to see why this happened and according to them, the network expansion of Welata Sodo was completed in late 2013 and start functioning in 2014. This might be the main reason why that market is weakly integrated with other markets especially in the after ICT period.
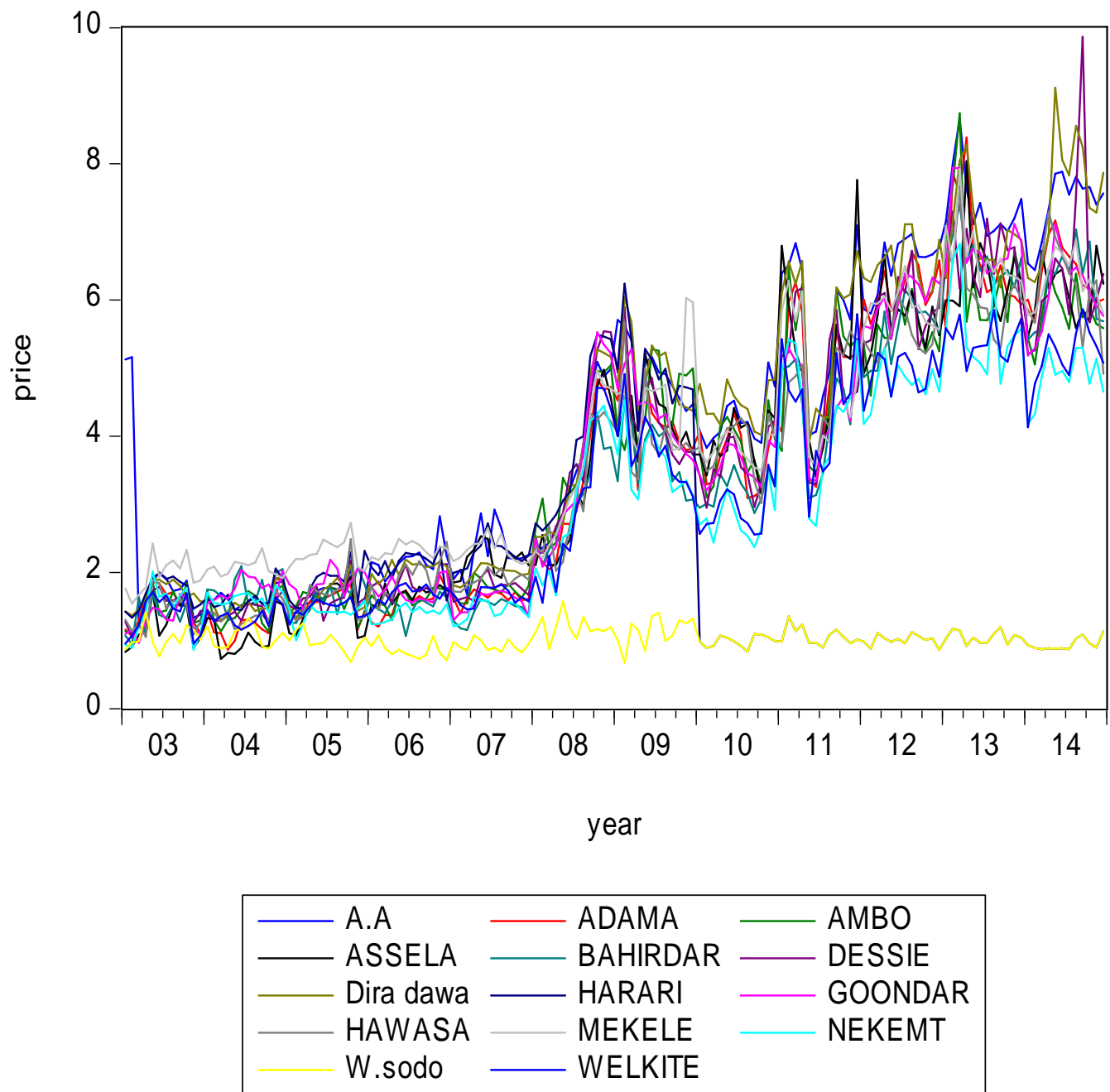
Figure 4.4: Retail maize price trend of the sample market from 2003 to 2014.

Source: Own computation from CSA data (2003-2014)

4.1.5.Variation in maize price level

The average price level of maize in the selected markets ranges from the minimum of 0.67 birr per KG in Welayta Sodo, to maximum of 9.86 birr per KG in Dessie.

The average price level of maize in all selected markets shows a significant decline in 2011 due to bumper harvest during that season and continues to raise post 2011 through the end of the study period.

As we can observe from Table 4.5, in the pre expansion of ICT infrastructure, the price variation between the selected markets ranges from minimum of 0.67 birr/KG in W.Sodo to maximum of 6.78 birr/KG in Harari or there was a range of 6.11 birr/KG between the most cheapest and expensive areas. On the other hand the minimum price level recorded in the post ICT expansion period is 0.83 birr/kg in Welayta Sodo and the maximum is 8.26 birr/kg in Dessie and the rage in price level between the most cheapest and expensive areas is 7.43 birr/kg which shows a significant increment compared to the range in the pre expansion period. But excluding W.Sodo market as an outlier as it is weakly co integrated with other markets due to lag in telecom coverage in the after ICT, the price level ranges from minimum of 3.06 birr/kg in Nekemt to maximum of 8.26 birr/kg in Dessie and the rang declined to 5.20 birr/kg.

Concerning the mean price variation, in the pre expansion period ranges from the maximum of about 2.87 birr/kg of Harar market to 1.02 birr/kg in Nekmt market. And in the after expansion period the mean price variation ranges from maximum of 6.25 birr/kg in Addis Ababa to the minimum of about 4.48 birr/kg in Nekemt market and the range in mean price variation declined from 1.85 birr/kg in before to 1.77 birr/kg in the after ICT period excluding W.Sodo market in similar fashion in the after ICT period.

In general the maize price trend in all the selected markets show a similar movement of increasing trend from the starting of the study period up to 2010/11 and shows a slack in 2011 due to excess supply or production boom and begun to increase post 2011 up to the end of the study period.

When we come to price volatility which is indicated by coefficient of variation, in the before ICT period recorded higher CV in all the selected markets which signifies higher price volatility in

pre ICT period. In the post ICT period the maize price volatility is significantly declined in almost all markets with the highest CV value in Bahirdar and the lowest in Welayta Sodo.

Table 4.5: summary statistics of retail maize price (birr/KG) for the selected markets in before and after ICT expansion periods

Markets	Before ICT expansion				After ICT expansion			
	Mean	Max	Min	CV	Mean	Max	Min	CV
A.A	2.63	6.70	1.22	0.49	6.25	8.16	3.82	0.21
Welkite	2.05	4.91	0.95	0.49	4.56	5.86	3.55	0.22
Hawasa	2.19	5.66	1.05	0.47	5.26	7.62	3.21	0.20
Ambo	2.29	5.27	1.10	0.54	5.30	8.14	3.09	0.21
Mekekle	2.63	6.76	1.54	0.37	5.49	7.92	3.49	0.21
W.sodo	1.02	1.57	0.67	0.18	1.01	1.35	0.83	0.10
Nekemt	1.98	4.52	0.86	0.49	4.48	6.82	3.06	0.24
Bahirdar	2.19	4.59	0.94	0.45	5.17	7.40	3.87	0.26
Gondar	2.67	5.52	0.96	0.52	5.39	7.94	3.20	0.24
Assela	2.36	5.22	0.72	0.55	5.44	8.03	3.15	0.20
Dessie	2.49	5.89	1.03	0.53	5.46	8.26	3.94	0.25
Adama	2.32	5.58	0.86	0.54	5.54	8.08	3.09	0.23
Harari	2.87	6.78	1.33	0.49	5.52	8.11	3.85	0.25
D.dawa	2.78	6.67	1.27	0.52	6.22	8.11	3.90	0.21

Source: author calculation from CSA data

4.1.6. Spatial price difference

Spatial price difference between two markets can be considered as an indicator for potential profit margin availability that invites traders to participate in trading products from one market to the other to grasp that price difference (profit). The extent of this price difference or availability of profit margin by trading between two spatially separated markets may show the level of market efficiency or the extent how much the two markets are integrated. Based on this the average price difference between the central market (Addis Ababa) and the selected regional markets is computed in table 4.6 below.

Based on this, the average price difference between Addis Ababa and the selected regional markets vary from the maximum of 1.4 birr per KG to 0.01 birr per KG. The values in parenthesis in table 4.6 shows higher price level in terminal (regional) markets than the central(Addis Ababa) market.

In the pre ICT expansion period, the price difference between regional markets and Addis Ababa is larger in surplus markets than that of deficit area markets: Nekemt (0.705 birr/kg), Welkite(0642 birr/kg), Bahirdar(0.594 birr/kg). where as in deficit markets the price difference is significantly lower or Harari (0.039 birr/kg), Mekelle (0.065 birr/kg) and Diredawa(0.088 birr/kg).

Table 4.6: spatial average price difference between Addis Ababa and selected markets before and after ICT expansion.

Markets	Before ICT expansion	After ICT expansion	The entire period
Mekele	(0.06)	0.84	1.02
Gondar	0.11	0.90	1.40
Dessie	0.29	0.82	0.56
Bahirdar	0.59	1.08	0.23
Nekemt	0.70	1.88	0.71
Ambo	0.31	1.06	1.09
Adama	0.45	0.74	0.59
Assela	0.42	0.92	0.38
Welkite	0.64	1.77	0.59
Hawasa	0.37	0.15	0.53
Welayta sodo	0.57	0.09	0.55
Harari	(0.08)	1.23	(0.01)
Dire dawa	0.03	0.97	0.07

Source: Author's calculation from CSA data (2003-2014)

4.2. ECONOMETRIC ANALYSIS

4.2.1. Pre estimation tests

As priori to econometric modeling, various pre estimation tests are required to avoid spurious regressions and misspecifications and to get a result that gives economic sense. Among these pre estimation test, unit root test or test of stationarity is the most common in time series data analysis which we can test it using Dicky Fuller test or recently modified to augmented Dicky Fuller test(ADF). And in this paper, unit root test is applied using augmented Dicky Fuller test as a pre estimation test to check co integration between markets and precede to auto regression and error correction models.

4.2.1.1. Augmented Dicky Fuller test

Based on ADF test, in the before and after ICT expansion periods, all the series of the variables are found non stationary or *I(1)* in level terms except Ambo, Assela, Dessie and Welayta sodo but these variables are stationary at 5% significance level but no variable is significant 1% percent level of significance. The automatic Schwarz criterion indicates the optimal lag is considered as ten for all variables.

After first differencing, all series of the variables in the before and after ICT expansion become stationary or *I(0)* at 1% level of significance.

Table 4.7. *Estimation of long run equilibrium (stationarity) test between Addis Ababa and the regional markets*

Markets	Before ICT period		After ICT period	
	Coefficients	ADF statistics(t-value	Coefficient	ADF statistics(t-value
Adama	1.11***	9.28	1.51***	6.61
Ambo	2.09***	10.42	1.28***	10.09
Assela	1.35***	11.14	1.39***	11.28
Bahirdar	1.27***	9.51	1.22***	9.36
Dessie	1.53***	10.48	1.57***	7.72
Dir dawa	1.11***	8.43	1.14***	8.62
Gondar	0.96***	8.70	1.69***	6.06
Harar	1.12***	12.20	1.35***	10.64
Hawasa	1.66***	12.40	1.12***	8.09
Mekele	1.14***	8.14	1.25***	9.72
Nekemt	1.14***	10.77	1.13***	8.50
W.sodo	1.90***	13.38	1.33***	10.30
Welkite	1.38***	12.86	1.41***	11.60

Source: Own computation from CSA data (2003-2014)

*** indicates level of significance at 1% significance level.

4.2.2. Co integration test

The approach for testing the integration of spatially separated markets is based on the fact that deviations from equilibrium conditions of two non-stationary variables should be stationary. This implies that, while price series may wander exten-sively, pairs should not diverge from one another in the long run (Tione , 2014).

As a result, the ADF test result for the residuals from the OLS result of Addis Ababa as dependent variable and the regional markets as independent variable is presented below in table 4.8.

Table 4.8.: residual based ADF test for cointegration

Cointegrating markets	Before ICT expansion	After ICT expansion
A.A and Adama	-4.55***	-3.41**
A.A and Ambo	-6.61***	-2.68*
A.A and Assela	-7.37***	-5.56***
A.A and Bahirdar	-8.51***	-5.01***
A.A and Dessie	-11.2***	-6.29***
A.A and Dire dawa	-8.05***	-6.09***
A.A and Gondar	-2.28	-3.54**
A.A and Harari	-6.04***	-5.40***
A.A and Hawassa	-5.94***	-4.47***
A.A and Mekele	-5.93***	-5.49***
A.A and Nekemt	-8.73***	-4.40***
A.A and Welaita sodo	-0.936	-2.03*
A.A and Welkite	-12.56***	-4.82***

Source: *Own computation from CSA data (2003-2014)*

*, **and *** indicate level of significance at 10%,5% and 1% respectively.

Table 4.8 shows the result of ADF test for residuals from OLS estimation, most of the markets show strong cointegration level or reject the null hypothesis at 1% and 5% significance level both in the pre and post ICT expansion periods.

Assela , Bahidar , Dessie , Dire Dawa , Harari , Hawassa , Mekelle , Nekemt and welkite markets reject the null hypothesis of no cointegration between markets at 1% significance level in both the pre and post ICT expansion periods which can be considered as indication for having better contegration level with Addis Ababa. On the contrary Welayta Sodo shows no significant integration with Addis Ababa or unable to reject the null hypothesis even at 10% significance level specially in the before ICT expansion period. It was however improved in the post expansion period and able to reject the null hypothesis at 10% significance level.

Although it shows some improvement in the after period, Welayta Sodo market is still weakly integrated with Addis Ababa market and the main reason for this can be the telecom network expansion project was completed in the late 2013 and become functional in 2014 according to the information obtained from an informal interview conducted with Ethio telecom staffs who were assigned in southern region network expansion project. Apart from the above reason, W.Sodo is found in southern region and Hawassa is the regional city (market) and has got Telecom infrastructure earlier than W.Sodo , because Ethio telecom has given priority to regional cities first, and this might resulted in W.Sodo market to be covered by Hawassa market and all the above reasons may be the main causes why W.Sodo market is segmented in the before period and weakly integrated in the after period with Addis Ababa market.

When we come to the case of Gondar market, it is segmented with the central market in the before period and weakly integrated although it shows some improvement in the after period. And the main reason for this assumed to be: (1) As Bahirdar market is in the way to Gondar from Addis Ababa and is among the top suppliers of maize from all the sample markets, Gondar market may be covered by Bahirdar. (2) Since Bahidar is regional city, next generation Telecom infrastructure which brings big transformation especially in data communication was first deployed in Bahidar and this may result in Godar market to covered by Bahidar.

Ambo market was highly integrated in the before period but declined in the after ICT period and to asses why this paradox happened, an informal discussion with Key informants from Ehil Berenda (Merkato) traders was conducted. And according to them, although it was obvious that East Welega is the main supplier of maize and Nekemt market is the main distribution center , due to lack of voice, SMS and data communication accessibility, the number of traders (merkato) was distributed almost equality in to both markets(Nekemt and Ambo) since Ambo was also preferable due to its proximity to Addis Ababa. But in the after ICT period , since they can easily communicate with Nekemt traders, most merkato traders focused on Nekemt market and Ambo market is currently or in the after period highly dominated by Nekemt.

The most interesting point from table 4.8 we can observe is, the variation in level of integration between Addis Ababa and the regional markets is very high in the pre ICT expansion period which ranges from maximum of 12.56 between Addis Ababa and Welkite to 0.96 between Addis Ababa and Welayta sodo. But in the post ICT expansion period, the range declines from the maximum of 6.29 between Addis Ababa and Dessie and minimum of 2.03 between Addis Ababa and Welayta Sodo. And this indicates there is a relatively balanced level of cointegration between Addis Ababa and the regional markets in the post ICT expansion period.
The existence of cointegration on the other hand allows us to test the existence of causality relationship between two markets.

4.2.3.Causality relation between integrating market

Co integration of markets is an indicative measure for non segmentation   between two price series and is a good tool to show whether there exist   relationship between two economic time series. In addition based on co integrating markets , the analysis allows for causality test to determine whether there is causal relationship between markets(Tion,2014).

Granger causality test observe two time series to identiy whether series X proceeds series Y, or Y proceeds X, or if the movements are contemporaneous. The notion of Grager causality does therefore not imply 'true causality' but instead identifies whether one variable proceeds another (Sims.C.A 1972).

Causal relationship between co integrating markets is shown in table 4.9 below using Granger causality test for both pre and post ICT expansion periods.

There are only three markets which have causality relationship with Addis Ababa in the before ICT period (Bahidar,Hawassa,Welayta sodo) and the causality with two of them is unidirectional or Addis Ababa Granger causes Bahidar and Hawassa. But the causality between Addis Ababa and Welayta Sodo is bidirectional or Granger causes one another (Table 4.9).

Table 4.9: Granger causality relationship between co integrating markets

Mare i	Market j	Before ICT expansion		Direction	After ICT expansion		Direction
		Prob>F $_1$	Prob>F $_2$		Prob> F $_1$	Prob>F $_2$	
A.A	Adama	0.3159	4.E-13	Independent	0.0001***	0.2965	Unidirectional
A.A	Ambo	0.4165	1.E-13	Independent	0.0006***	0.2336	Unidirectional
A.A	Assela	0.2134	5.E-13	Independent	0.0144**	0.6034	Unidirectional
A.A	Bahirdar	0.0012***	8.E-09	Unidirectional	0.3749	0.1146	Independent
A.A	Dessie	0.4824	2.E-15	Independent	0.0009***	0.3057	Unidirectional
A.A	Diredawa	0.2091	1.E-15	Independent	0.0029***	0.9224	Unidirectional
A.A	Gondar	0.7731	1.E-10	Independent	0.9634	0.2305	Independent
A.A	Harari	0.9116	5.E-20	Independent	0.0023***	0.1215	Unidirectional
A.A	Hawasa	0.0558*	3.E-12	Unidirectional	0.1288	0.2091	Independent
A.A	Mekele	0.3295	7.E-12	Independent	0.0253**	0.8640	Unidirectional
A.A	Nekemt	0.4602	5.E-13	Independent	0.2813	0.0297**	Unidirectional
A.A	W.sodo	0.0264**	0.0285**	Bi directional	0.2300	0.0398**	Unidirectional
A.A	Welkite	0.1279	3.E-16	Independent	0.5378	0.5394	Independent

***,**and * show availability of Granger causality between markets at 1%,5% and 10% respectively.

In the after ICT expansion period, the number of markets which have Granger causality relation increased to nine from the total of thirteen markets. That is Addis Ababa Granger causes Adama, Ambo, Assela, Dessie , Diredawa, Harari and Mekele, or their causality relationship is undirectional. And Nekemt and Welayta Sodo Granger cause Addis Ababa but still unidirectional.

Bahirdar and Hawassa changed from causality relation with Addis Ababa in before ICT expansion period to Independence in the after ICT period.

Only Welayta Sodo has causality relation with Addis Ababa in both periods and bi directional in before period and unidirectional in the after ICT period. This may imply that in the before period, data of both markets are important to explain each other or price of maize in Welayta Sodo is important to explain price of maize in Addis Ababa or vice versa. But in the after period, only price of in Welayta Sodo is important to explain price of maize of Addis Ababa market or price of Welayta Sodo market proceeds price of addis Ababa market.

Welkite and Gondar are independent in both periods, which means neither of the prices of the two markets proceed price of Addis Ababa or neither of the prices are important to explain price of Addis Ababa market and vice versa .

4.2.4.Threshold autoregressive error correction model

Before estimating the equation and conducting error correction model, variables must pass the test of cointegration which shows the long run relationship between variables or between the central market (Addis ababa) and the respective regional markets which otherwise may lead to spurious regression between variables. And as we can see from table 5.1, all markets are stationary 1% level of significance.

4.2.4.1. Results of Monte Carlo simulation

The threshold value is estimated based on equation (6) and (7) from the threshold value candidates through grid search using Monte Carlo simulation and from the regression, the threshold candidate that gives minimum residual sum of squares become the threshold value.

This process is repeated for all markets to find their respective threshold value and the error correction coefficients (δ_1 and δ_2).

Table 4.10: estimated threshold values between Addis Ababa and regional markets.

Cointegrating markets	Threshold value before ICT period	Threshold value after ICT period
A.A and Adama	-0.451	-0.545
A.A and Ambo	-0.316	-0.634
A.A and Assela	-0.344	-0.679
A.A and Bahirdar	-0.379	0.202
A.A and Dessie	0.355	-0.523
A.A and Diredawa	-0.103	-0.457
A.A and Gondar	0.466	0.454
A.A and Harar	0.225	0.940
A.A and Hawassa	-0.369	-0.540
A.A and Mekele	0.476	-0.491
A.A and Nekemt	0.287	-0.402
A.A and Welayta Sodo	2.031	-0.230
A.A and Welkite	-0.318	-0.159

Source: *Own computation from CSA data (2003-2014)*

As previously explained, the TAR regressions are unidentified under the standard tests and to overcome this problem, t and F critical values are estimated using the threshold values of each estimated equation from the previous simulation. The t statistics is to test for the null hypothesis of individual significance ($\delta_1 = 0$ and $\delta_2 = 0$) and the F test is for joint significance ($\delta_1 = \delta_2 = 0$). Both t and F critical values at 10%, 5% and 1% recorded and put in table 4.11 and 4.12(Annex 5).

4.2.4.2.Error correcting terms

The error correction term shows, the speed at which our model returns to its equilibrium point after exogenous shocks. Due to this error correcting terms are negatively signed to show their retuning back towards long run equilibrium point after certain deviation. If error correcting term has positive sign it shows moving away from the equilibrium. The coefficients lie between 0 and 1,in which 0 coefficient indicates no adjustment after one time period and 1 indicates full adjustment.

To show the validity of our model and to get economically intuitive result, various diagnostic tests are performed as an econometric modeling strategy.

Based on various residual diagnostic tests are performed and all do not reject the null hypothesis which shows the validity or absence of misspecification in our model. The Breusch Godfrey LM test of serial correlation does not reject the null hypothesis of no serial correlation and the Jarque Bera's test of normality (normal distribution of the error term) shows error terms are normally distributed. In addition to this, based white's test of hetrosckedasticity, there is no sign hetroicedasticity in our model. Similarly, based on Engle (1982) ARCH test for the existence of hetrocedastic autoregressive errors shows absence of such conditional hetrocedstic errors. Thus, based on the above diagnostic test, our model is reliable and well specified.

Regarding the error correction model between A.A and Adama, it shows there is a short run dynamic impacts as the coefficient of DAdama is significant at 1% level of significance in both pre and post ICT periods. The long run error correcting terms coefficients ($_1$ and $_2$) on the other hand show that over threshold (larger) deviations are insignificant in both pre and post ICT periods, whereas under the threshold(smaller) deviations are significant at 1% in the post ICT period but still insignificant in the pre ICT period. This indicates, larger deviations persist for longer period of time in both periods while the under threshold deviations arbitraged immediately in the post ICT period but stay for longer time in pre ICT period.

To check whether the above and below the threshold deviations are symmetric or asymmetric, we first need to check availability of co integration between markets. Thus, if we reject the null hypothesis of no co integration between markets, we can proceed to testing whether deviations are symmetric or not. Based on this we can test our null hypothesis of symmetric adjustment ($_1=$ $_2$), using the standard F statistic. Based this, the deviation from long run equilibrium (deviations above and below the threshold value) between A.A and Adama is tested using the normal F statistic and the result shows a rejection of the null hypothesis of symmetric adjustment at 1% significance level which indicates deviations above and below the threshold value are asymmetric. And the null hypothesis of no cointegration ($_1=$ $_2=0$) between A.A and Adama is rejected 1% significance level as the F calculated or from the regression is greater than f statistic from table (4.12) in both periods.

The short term coefficient between A.A and Ambo is insignificant in the pre ICT period but become significant at 1% significance level in the post ICT period. Similarly the long run error correcting coefficients both below and above the threshold value are insignificant in the pre ICT period which implies, adjustment towards the equilibrium is sluggish or stay longer period of time. But in the post ICT period, adjustment towards equilibrium under the threshold value is significant at 1% while over threshold adjustment is still remain insignificant. Thus, in post ICT period, the smaller deviations are adjusted immediately but large deviations stay longer. Regarding the symmetric adjustment of error correcting terms between A.A and Ambo shows that in both pre and post ICT periods, the null hypothesis of symmetric adjustment($_1=$ $_2$) safely rejected and accept the alternative hypothesis of asymmetric adjustment at 1% level of significance in both periods. In addition, the F statistics also rejects the null hypothesis for joint significance of error correcting terms ($_1=$ $_2=0$) or no co integration 1% significance level in both periods.

Table 4.11: estimation result of the error correction model

Dependent variable Addis Ababa and regional markets

Markets	Explanatory variables	Before ICT period		After ICT period	
		Coefficients	t-values	coefficients	t-values
A.A and Adama	DAdama	0.416***	2.76	0.391***	3.685

	IU$_{t-1}$	(0.133)	(1.209)	(0.403)***	(3.294)
	1-IU$_{t-1}$	(0.074)	(0963)	(0.217)	(2.751)
A.A and Ambo	DAmbo	0.23	1.45	0.386***	5.064
	IU$_{t-1}$	(0.103)	(0.93)	(0.405)***	(3.317)
	1-IU$_{t-1}$	(0.200)	(1.852)	(0.314)	(2.335)
A.A and Assela	DAssela	0.334**	2.12	0.402***	5.396
	IU$_{t-1}$	(0.100)	(0.90)	(0.087)	(0.652)
	1-IU$_{t-1}$	(0.583)	(0.35)	(0.977)	(0.862)
A.A and Bahirdar	DBahirdar	0.06	(0.15)	0.855***	9.592
	IU$_{t-1}$	(0.11)	(1.00)	(0.399)***	(3.275)
	1-IU$_{t-1}$	(0.159)	(0.145)	(0.814)**	(0.253)
A.A and Dessie	Ddessie	0.34	2.10	0.224	2.886
	IU$_{t-1}$	(0.16)	(1.49)	(0.202)	(1.550)
	1-IU$_{t-1}$	(0.351)	(1.53)	(1.180)**	(2.33)
A.A and Diredawa	Dd.dwa	0.51	2.87	0.127	0.550
	IU$_{t-1}$	(0.16)	(1.47)	(0.641)***	(6.042)
	1-IU$_{t-1}$	(0.376)	(0.255)	(0.525)	(0.695)
A.A and Gondar	DGondar	0.53	2.80	1.000***	3.18
	IU$_{t-1}$	(0.11)	(1.00)	0.053	0.405
	1-IU$_{t-1}$	(0.166)	(0.891)	(0.262)	(0.668)

A.A and Harar	DHarar IU_{t-1} $1-IU_{t-1}$	0.43 (0.15) (0.531)	2.82 (1.35) (0.452)	0.063 (0.108) (0.254)	0.669 (0.816) (0.962)
A.A and Hawasa	DHawasa IU_{t-1} $1-IU_{t-1}$	0.250** (0.165) (0.937)	2.111 (1.468) (1.521)	0.509*** (0.239)* (0.640)	3.986 (1.809) (0.652)
A.A and Mekele	DMekele IU_{t-1} $1-IU_{t-1}$	0.249 (0.127) (0.134)	1.509 (1.446) (1.856)	0.618*** (0.330)** (1.635)	6.068 (2.610) (0.963)
A.A and Nekemt	DNekemt IU_{t-1} $1-IU_{t-1}$	0.166 (0.125) (0.166)	0.934 (1.131) (0.687)	0.678*** (0.372)*** 0.610)	8.688 (2.988) (1.568)
A.A and W.sodo	DW.sodo IU_{t-1} $1-IU_{t-1}$	(0.212) (0.122) 0.003)	(0.733) (1.105) (1.325)	1.515** (0.176) (0.363)	2.480 (1.341) (0.324)
A.A and Welkite	DWelkite IU_{t-1} $1-IU_{t-1}$	0.203 (0.122) (0.241)	1.163 (1.104) (1.787)	0.704*** (0.023) (0.748)	8.795 (0.174) (2.536)

Source: *Own computation from CSA data (2003-2014)*

A.A and Assela have significant short term coefficients with DAssela coefficient is significant at 5% level of significance in the pre ICT period but become significant at 1% significance level in the post ICT period. Similarly the long run error correcting coefficients both below and above the threshold value are insignificant in both periods which implies, adjustment towards the equilibrium is sluggish or stay longer period of time in both periods.

Regarding the symmetric adjustment of error correcting terms between A.A and Assela shows that in both pre and post ICT periods, the null hypothesis of symmetric adjustment($\rho_1 = \rho_2$) safely rejected and accept the alternative hypothesis of asymmetric adjustment at 5 % level of significance in both periods. In addition, the F statistics also rejects the null hypothesis for joint insignificance of error correcting terms ($\rho_1 = \rho_2 = 0$) or no cointegration 1% significance level in both periods.

The short term coefficient between A.A and Bahirdar is insignificant in the before ICT period but in the after ICT period, the coefficient becomes significant at 1% level of significance. Regarding the long run error correcting coefficients, in the before ICT both the larger and smaller deviations from the threshold value are insignificant even at 10% level of significance which shows, the arbitrage persists for longer period of time or speed of adjustment is sluggish. But in the after ICT period, both coefficients of long run error correcting terms (above and below threshold) are significant at 5% and 1% significance level respectively which implies, the above and below threshold deviations from the long run equilibrium are instantly adjusted. The test of symmetric adjustment shows, the null hypothesis of symmetric adjustment is still rejected at 1% level of significance in both periods and the joint significance of error correcting terms rejects the null ($\rho_1 = \rho_2 = 0$) at 1% level of significance.

The Coefficient of DGondar is insignificant in the before ICT period when we come to short term behavior between A.A and Godar. But in the after ICT period the DGondar or short run coefficient becomes significant at 1% level of significance. Long run error correcting terms shows, there is a positive sign in the below threshold coefficient which implies drifting apart from the long run equilibrium although it is insignificant. This absence of adjustment towards long run equilibrium may be the result of Gondear market is covered by Bahirdar market, as Bahirdar and Gondar are in the same line and Bahirdar is also among the top maize supplier (surplus) markets.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study designed mainly to assess the contribution of modern information and communication infrastructure expansion for maize market integration in Ethiopia by comparing the before and after telecom expansion periods. In addition to this the study tries to assess if there is a difference in integration level between markets that are considered as deficit and surplus with central market (Addis ababa).

To support this assessment various descriptive analysis like: maize production trend at country and zone level, telecom expansion trends, maize price trends, price differentials and spatial price difference were used. In addition to this econometric model in the form of threshold autoregressive (TAR) and error correction model is used to the above descriptive analysis. Monthly maize retail price data starting from 2003 to 2014 is taken for thirteen markets for the descriptive analysis as well as econometric tests.

As we observe from the production trend, Bahirdar,Nekemt, Adama and Ambo respectively are the most dominant maize producer (surplus) areas from the sample markets taken and on the other side, Dire dawa, Harar and mekelle are the most least producers(deficit areas) respectively. Price volatility in maize price is higher in almost all market with higher coefficient variation in pre ICT expansion. This may imply that price was highly volatile in the sample markets before modern information and communication technology was properly expanded to between integrating markets. Regarding the spatial price variation, in the pre ICT period there is higher spatial price variation in the surplus areas between markets than that of the deficit areas.

In the pre ICT expansion period, the number of total mobile subscribers was only 6.5 million with an area coverage of 8.7% and fixed telephone subscribers was around one million with 1.36% density area. But after telecom expansion, the number of mobile subscribers increased to 25.65 million with area coverage increased to 29% and fixed line subscribers decreased to around 760 thousands and fixed telephone density decreased to 0.9%. This implies the shift of

customers from fixed telephone to mobile telephone may be due to maintenance delay of fixed telephone and the mobility and easily accessibility of mobile telephone.

On the other hand the area coverage for wireless CDMA in the before ICT period was 50% but at the after period it increased to 73%. The telecom service accessibility within 5 kilometer radius for rural kebeles increased from 62.14% to 87% and the global link capacity increased from 3.255 gigabite per second(GB/s) in the before ICT period to 11GB/s at the end of the after ICT period.

Our ADF based test of cointegration shows us that most of the markets are significantly co integrated in both periods with Addis ababa. That is Assela, Bahirdar, Dessie, Dire dawa, Harar,Hawasa,Mekele Nekemt and Welkite reject the null hypothesis of no cointegration at 1% significance level. But Wlayta sodo did not show any significant co integration with Addis Ababa in the before period but improved its integration with the central market in the after period by rejecting the null hypothesis at 10% significance level. Adama and Ambo show a decline in level of co integration in the after period though they are still significantly co integrated.

The variation in level of integration between Addis Ababa and the regional markets is very high in the pre ICT expansion period which ranges from maximum of 12.56 between addis ababa and Welkite to 0.96 between Addis Ababa and Welayta sodo. But in the post ICT expansion the range declines from the maximum of 6.29 between Addis Ababa and Dessie and minimum of 2.03 between Addis Ababa and Welayta Sodo. And this indicates there is relatively balanced level of co integration between Addis Ababa and the regional markets in the post ICT expansion period.

Regarding the TAR error correction model, it reveals that there exist a better adjustment speed and better short term error correction coefficient between markets in the post ICT periods in most of the markets. The above and below threshold adjustment of the deviation from the long run shows that , the under threshold deviations arbitraged away instantly than the over threshold deviations in both the pre and post ICT periods .but the overall arbitrage of the deviation from the long run equilibrium is improved in the post ICT period. And the adjustment factors are asymmetrically distributed in almost all markets both in the before and after ICT periods of the study.

Regarding the deficit and surplus areas, in the before ICT period, no deficit market shows significant short run error correcting coefficient between variables as well long run error correcting terms both below and above the threshold level. But in after ICT period there observed a significant short term coefficients between variables as well as long run error correcting terms both in the below and above the threshold level like the other surplus and medium supplier markets. This may have an implication that in the after ICT period, the level of integration between the central market (A.A) and the respective regional market is not highly determined by the amount of product they supply.

5.2 Recommendations

➢ As tried to discuss in the descriptive part of the study, price variation among the spatially separated sample markets is higher in periods before modern information and communication technology is better expanded. As large spatial price variation among markets is one of the simple indicator of lack market efficiency or lack of integration among markets, expansion of basic infrastructures like roads and communication are the basic determinants to enhance the level of integration among spatially separated markets.

➢ Not only in agricultural product marketing but in almost all sectors of the economy, the expansion of telecom infrastructure and keeping its network reliability and quality is one of the basic task of Ethiopian government to move the nation to better economic growth as the sector is solely owned by government. And although the government of Ethiopia trying to highly expand telecom net work accessibility by coordinating with various international telecom companies in all over the country but there is higher demand of the sector in various parts of the country where telecom network is not accessible and higher network quality complain from customers in almost all parts of the country. Thus higher investment on the sector to increase its accessibility and private sector participation to improve network quality is important.

➢ As explained in many articles, in agricultural product marketing, ``the cream of the cake is taken by the middle men'' which implies, producers and the end users benefit very little. Rather the main benefit is taken by brokers and other in the middle of transaction starting from the farm gate up the final consumers. The main reason for this in one way or another may rely on: lack of modern information and communication access, road

infrastructure, modern warehouse system, credit and finance availability, access to modern commodity exchange etc. Thus, to improve the benefit of producers by having a faire profit that can at least compensate their effort and risks and to provide the final users with original products with faire price, expansion and increasing accessibility of the above infrastructures important.

➢ The Ethiopian commodity exchange (ECX) is contributing a lot in reducing market inefficiency in certain products by enabling farmers to bargain on pricing of their products through provision of modern ware house and electronic payment system, providing latest information about price of their products through price tickers and mobile IVR and SMS system in certain parts of our country. Although its contribution is high for producers as well as the final user to interact easily, its accessibility is limited. To improve such an easy interaction between producers and final users, increasing its capacity and accessibility as well as expanding similar institution is important.

References

.Agricultural transformation agency , 2015

Agricultural outlook, October 1999; Assessing Agricultural commodity price variability-Economic Research service.not

Balke S. Nathan, and Thomas B. Fomby, Aug 1997; Threshold Cointegration. International Economic Review. Vol. 38, No. 3, pp 627-645.

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

 www.odi.org.uk/2004:INFORMATION AND COMMUNICATION TECHNOLOGY IN AGRICULTURAL DEVELOPMENT: A COMPARATIVE ANALYSIS OF THREE PROJECTS FROM INDIA

Gabre-Madhin, E.Z., 2001; Market institutions, Transaction costs, and social capital in Ethiopian Grain Market, International Food Policy Research Institute: Washington, DC.

Goodwin, B.K and Piggott, N.E, 2001; Spatial Market integration in the presence of Thershold effects. Journal of Agricultural Economics, 83:302-317.

Giovanni Federico, July 2004; Market Integration and Market Efficiency: the case of 19th Century Italy. European University Institute. Fackler, P.L and Goodwin, B.K, 2001; Spatial Price Analysis. In Gardner, B.L and Rausser,

G.C.(Eds), Handbook of Agricultural economics. Vol. 1B Marketing, Distribution and consumption, Elsevier North-Holland, 971-1024

Fafchamps, Eleni-Gabre-Madhin and Bart Minten, April 2003; Increasing returns and market efficiency in Agricultural Trade Market .

Fafchamps, M, and S.Gavian ,1996; The spatial integration of Livestock markets in Niger, Journal of African Economies, 5:366-405.

Ferral, Christopher 1995; Queen's University, Journal of Statistics Eduction V.3, n.3

G. Acquah and R. Owusu, Journal of Sustainable Development in Africa (Volume 14, No.5, 2012)

K.S Chan, Dec 1990; Testing for Threshold Autoregression, The Annals of statistics

Gabre-Madhin, E.Z., and Goggin, I., June 2006; Does Ethiopia Need a Commodity Exchange?

K.S Chan and Ruey S. Tsay, Jun. 1998; Limiting Properties of the Lease Squares estimator of continuos Threshold Autoregressive Model.

Niels Penzhorn and Channing Arndt(june 2002); MAIZE MARKETS IN MOZAMBIQUE: TESTING FOR MARKET INTEGRATION, *Agrekon, Vol 41, No 2*

Moser, B. Barrett, and Minten (2005) ;missed opportunities and missing markets: spatio-temporal arbitrage of rice in Madagascar

Marcel Fatchamps and Sarah Gavian (1995); the Spatial integration of

Goodwin, B.K and Schroeder, T.C ,1991; Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets. American Journal of Agricultural Economics

Livestock Markets in Niger,

Ravallion, Martin, Feb 1986; Testing Market integration; American Journal of agricultural Economies,

Seneshaw Tamuru (2006) Spatialintegration of white wheat market in Ethiopia: Along with improvements in transport infrastructure.

Sarah E. Tione (2014) analysis of the effectiveness of modern information and communication technologies on maize marketing efficiency in Malawi markets.

Sims.C.A 1972,money income and causality, the American economic review

Granger, F, W.J, Engle, R, 1987; Cointegration and Error Correction: Representation, Estimation and Testing", Econometrica,

Baulch, B. 1997."Transfer Costs, Spatial Arbitrage, and Testing for Food Market Integration." *American Journal of Agricultural Economics*. 79(2): 477-487.

Gbegbelegbe S. and de Groote H (2012) ; spatial and temporal maize price analysis in east Africa.

Mohammad Ismet (1998); Government intervention and market

integration in Indonesian rice markets.

Tong , H, 1983; Threshold Models in Non –linear Time Series Analysis. Lecture Notes in Statistics, 21, Berlin, Springer.
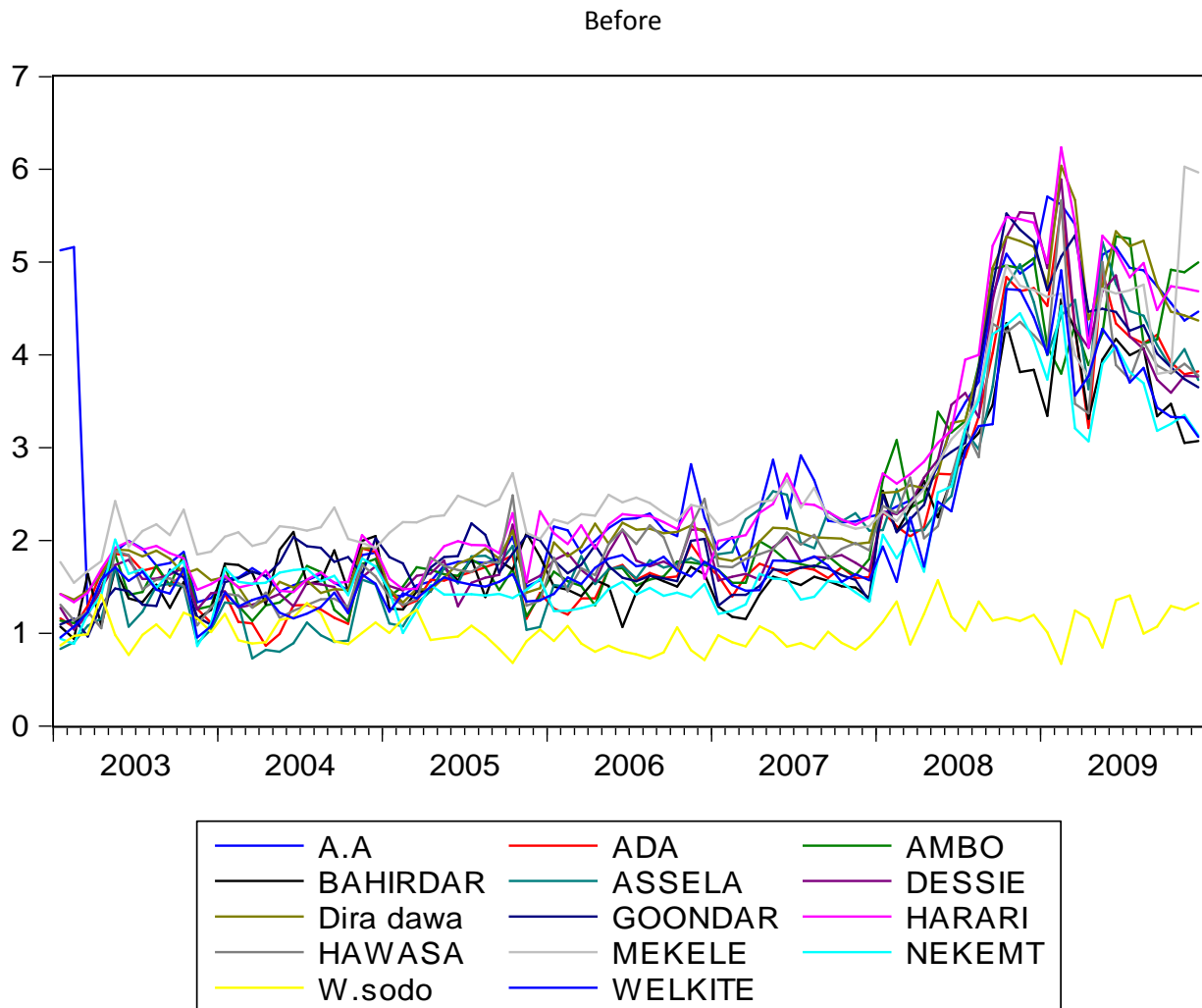
KVANLI.P.KEELING, 2003;introduction to business statistics. sixth edition

UNDP Ethiopia(NO>3/2012): Promoting ICT based agricultural knowledge management to increase

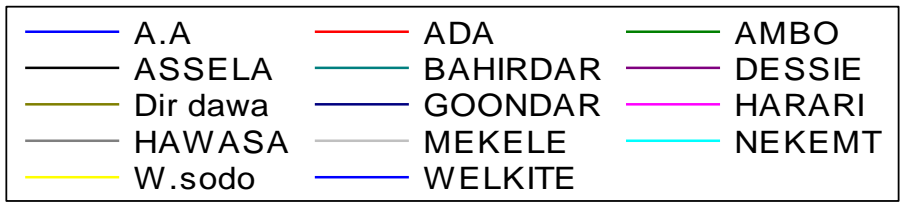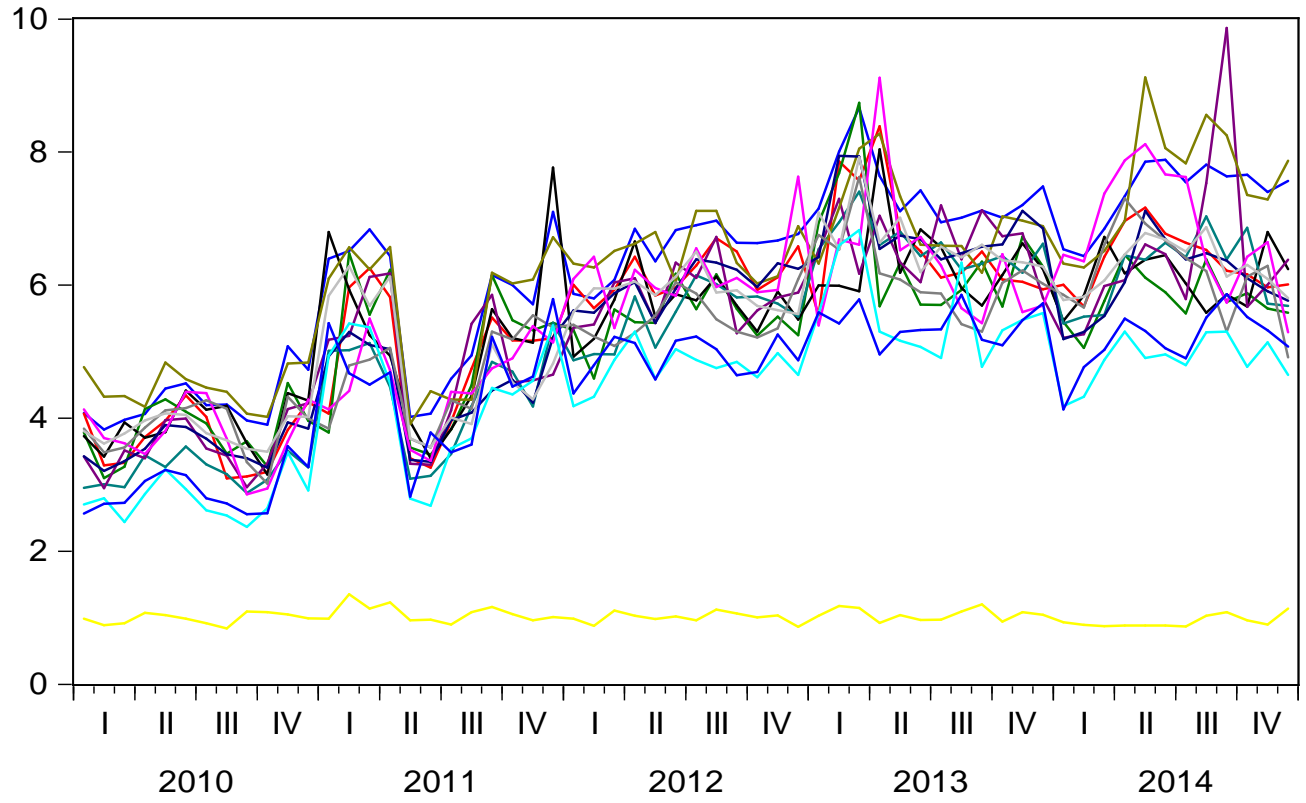production and productivity of smallholder farmers in Ethiopi

Annexes

Annex 1

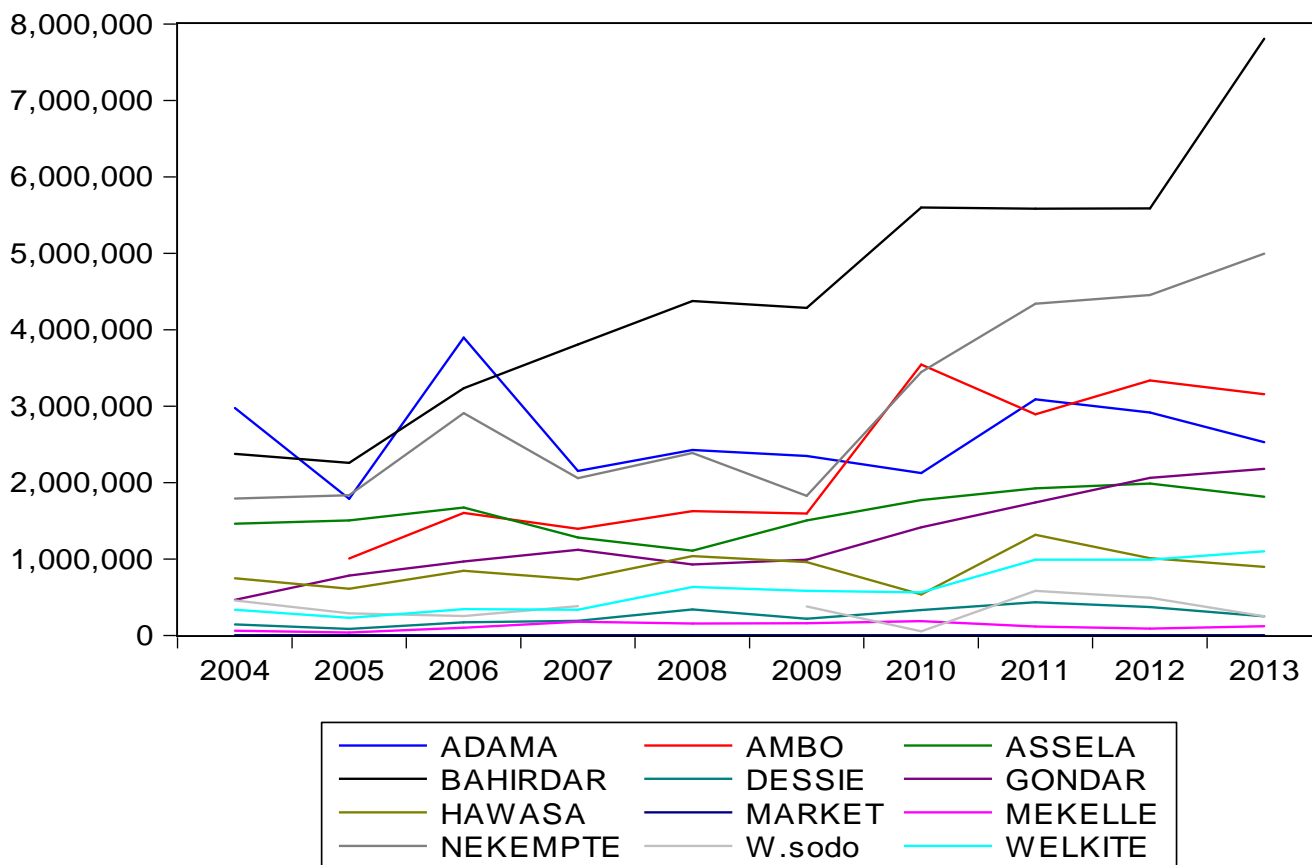**Deseasonalized price trend of selected markets in the before and after ICT periods.**

Before

After

Annex 2

Maize production trend of the sample markets for the whole study period

Annex 3

Cointegration tests

Dependent Variable:
A_A

Indp Variable ADA

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.558595	0.0004
Test critical values:	1% level	-3.513344	
	5% level	-2.897678	
	10% level	-2.586103	

Dependent Variable:
A_A

Indp Variable AMBO

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.611980	0.0000
Test critical values:	1% level	-3.511262	
	5% level	-2.896779	
	10% level	-2.585626	

Dependent Variable:
A_A

Indp variable ASSELA

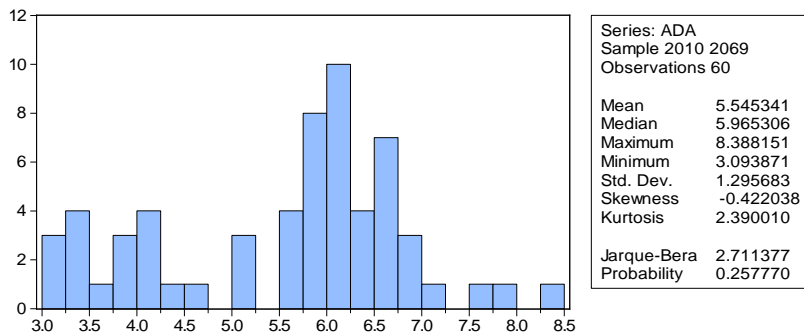|	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-7.377702	0.0000
Test critical values: 1% level	-3.511262	
5% level	-2.896779	
10% level	-2.585626	

Dependent Variable: D(A_A)
Method: Least Squares
Date: 06/24/15   Time: 23:17

Normality Test

Adama

Series: ADA	
Sample 2010 2069	
Observations 60	
Mean	5.545341
Median	5.965306
Maximum	8.388151
Minimum	3.093871
Std. Dev.	1.295683
Skewness	-0.422038
Kurtosis	2.390010
Jarque-Bera	2.711377
Probability	0.257770

Adama

Series: ADA	
Sample 2010 2069	
Observations 60	
Mean	5.545341
Median	5.965306
Maximum	8.388151
Minimum	3.093871
Std. Dev.	1.295683
Skewness	-0.422038
Kurtosis	2.390010
Jarque-Bera	2.711377
Probability	0.257770

Assela

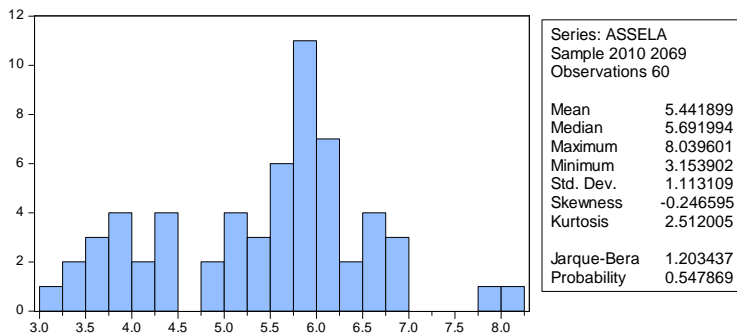| Series: ASSELA	
Sample 2010 2069	
Observations 60	
Mean	5.441899
Median	5.691994
Maximum	8.039601
Minimum	3.153902
Std. Dev.	1.113109
Skewness	-0.246595
Kurtosis	2.512005
Jarque-Bera	1.203437
Probability	0.547869

As we can see from the above histograms, the Jarque-Bera statistics accept the null hypothesis of normal distribution. And we coduct to all markets in similar fashion.

Heteroskedasticity Test

Adama

Heteroskedasticity Test: ARCH

F-statistic	0.137938	Prob. F(1,57)	0.7117
Obs*R-squared	0.142434	Prob. Chi-Square(1)	0.7059

Ambo

Heteroskedasticity Test: ARCH

F-statistic	2.691740	Prob. F(1,57)	0.1064
Obs*R-squared	2.660547	Prob. Chi-Square(1)	0.1029

As we can see from above test it accepts the null hypothesis of no Heteroskedasticity

Serial correlation test

Adama

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.861781	Prob. F(2,54)	0.4281
Obs*R-squared	1.824904	Prob. Chi-Square(2)	0.4015

Ambo
Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.251121	Prob. F(2,54)		0.1151
Obs*R-squared	4.540549	Prob. Chi-Square(2)		0.1033

As we can see above our test accepts the null hypothesis of no serial correlation.

Sample (adjusted): 2003M02 2009M12
Included observations: 83 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.019506	0.059496	-0.327843	0.7439
D(ASSELA)	0.330856	0.155626	2.125962	0.0366

R-squared	0.052850	Mean dependent var	-0.007951
Adjusted R-squared	0.041157	S.D. dependent var	0.551235
S.E. of regression	0.539772	Akaike info criterion	1.628463
Sum squared resid	23.59969	Schwarz criterion	1.686748
Log likelihood	-65.58120	Hannan-Quinn criter.	1.651878
F-statistic	4.519715	Durbin-Watson stat	2.198850
Prob(F-statistic)	0.036552		

Monte Carlo simulation practices and results

Endogenous variables: A_A
ADA
Exogenous variable(s): None
Method: Threshold (tau is determined by data)
Lags (determined by data): 2
Date: 06/28/15   Time: 13:28
Sample (adjusted): 2003M04 2007M12
Included observations: 57 after adjustments

Variable	Coefficient	Std. Error
Above Threshold	-0.675993	0.212326
Below Threshold	-0.217257	0.320870
Differenced Residuals(t-1)	-0.359879	0.191149
Differenced Residuals(t-2)	-0.028761	0.138746

Threshold value (tau):	-0.545238	
F-equal:	2.303583	(6.749063)*
T-max value:	-0.677089	(-1.934647)*
F-joint (Phi):	5.321586	(7.265376)*

Simulated critical values for 5% significance level.

Endogenous variables: A_A
    AMBO
Exogenous variable(s): None
Method: Threshold (tau is determined by data)
Lags (determined by data): 2
Date: 06/28/15 Time: 13:33
Sample (adjusted): 2003M04 2007M12
Included observations: 57 after adjustments

Variable	Coefficient	Std. Error
Above Threshold	-0.476575	0.190560
Below Threshold	-0.314559	0.274564
Differenced Residuals(t-1)	-0.433905	0.183663
Differenced Residuals(t-2)	0.009301	0.141554
Threshold value (tau):	-0.634467	
F-equal:	0.349785	(6.755655)*
T-max value:	-1.145668	(-1.932607)*
F-joint (Phi):	3.168731	(7.114761)*

*Simulated critical values for 5% significance level.
Number of simulations: 10000
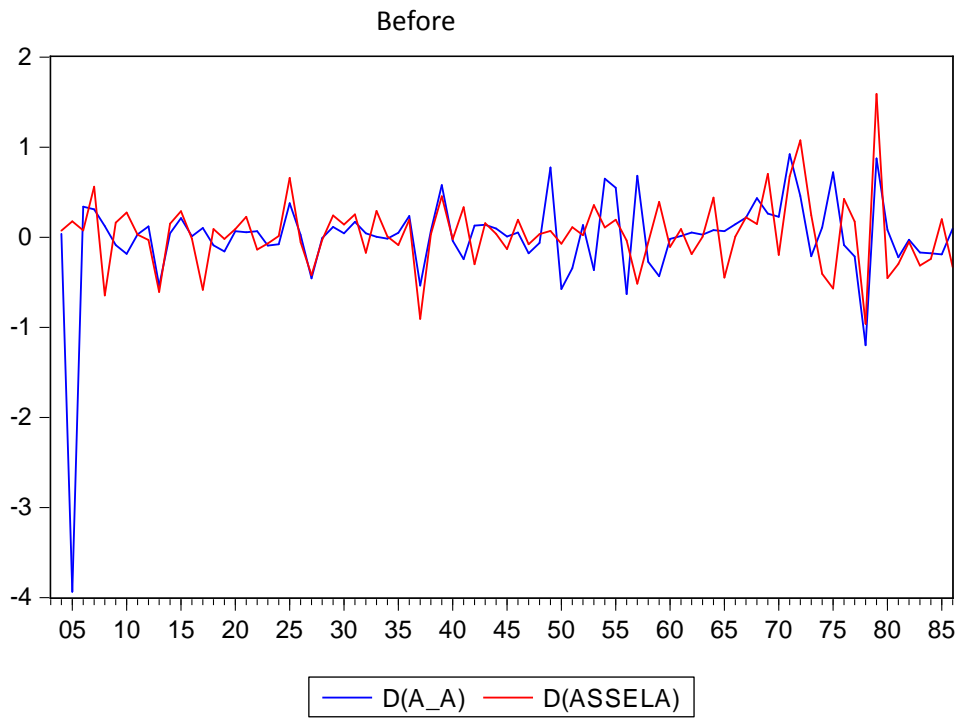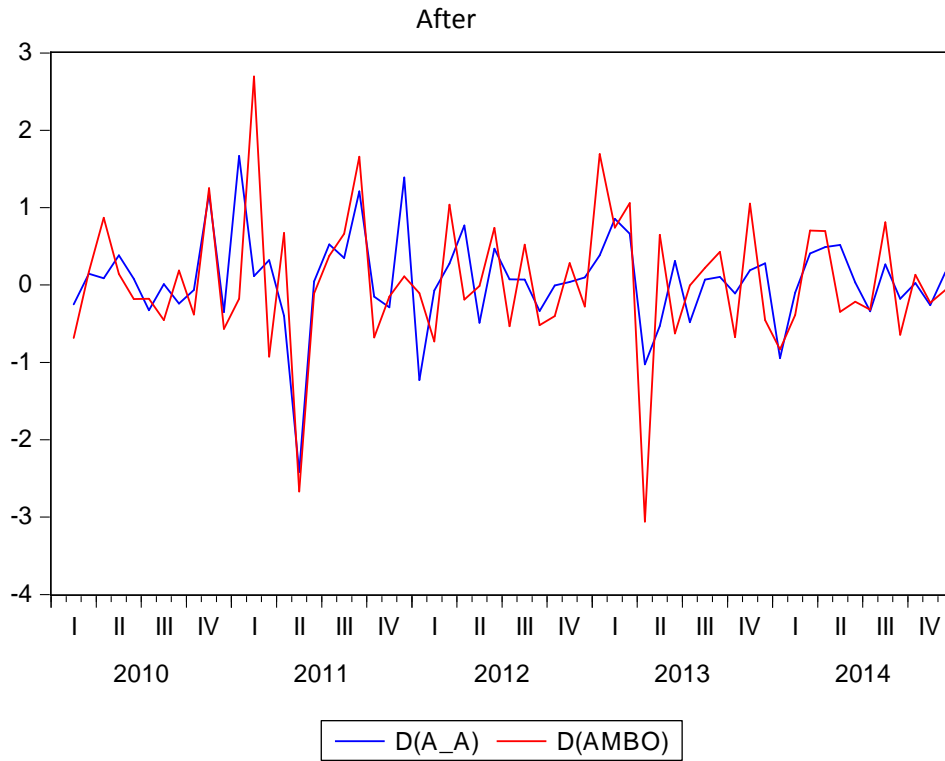*Elapsed simulation time: 0 hours 2 minutes 30 seconds.*

Annex 4

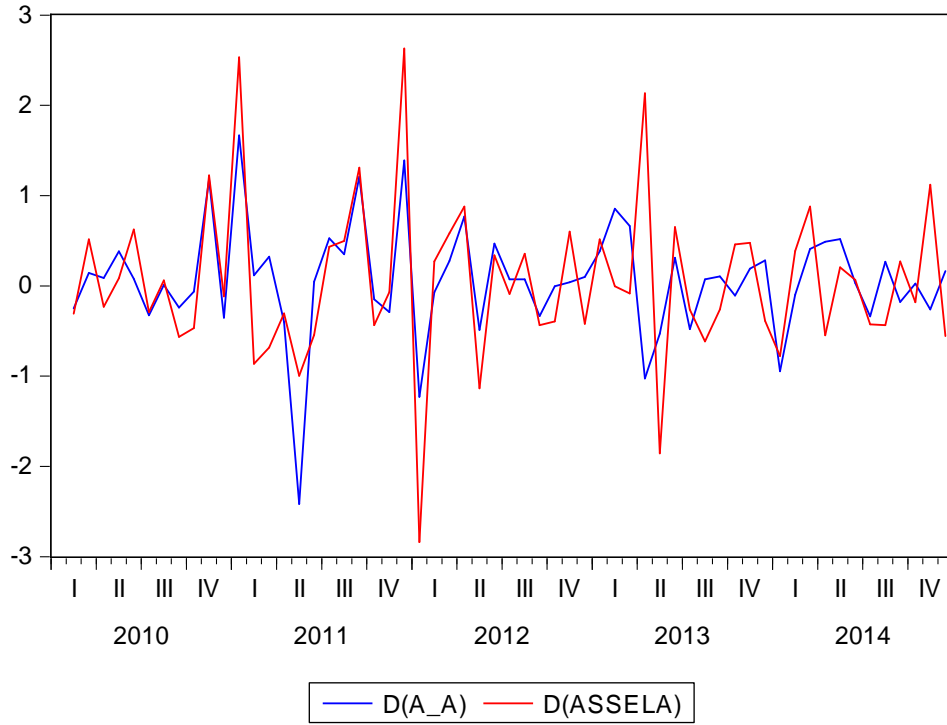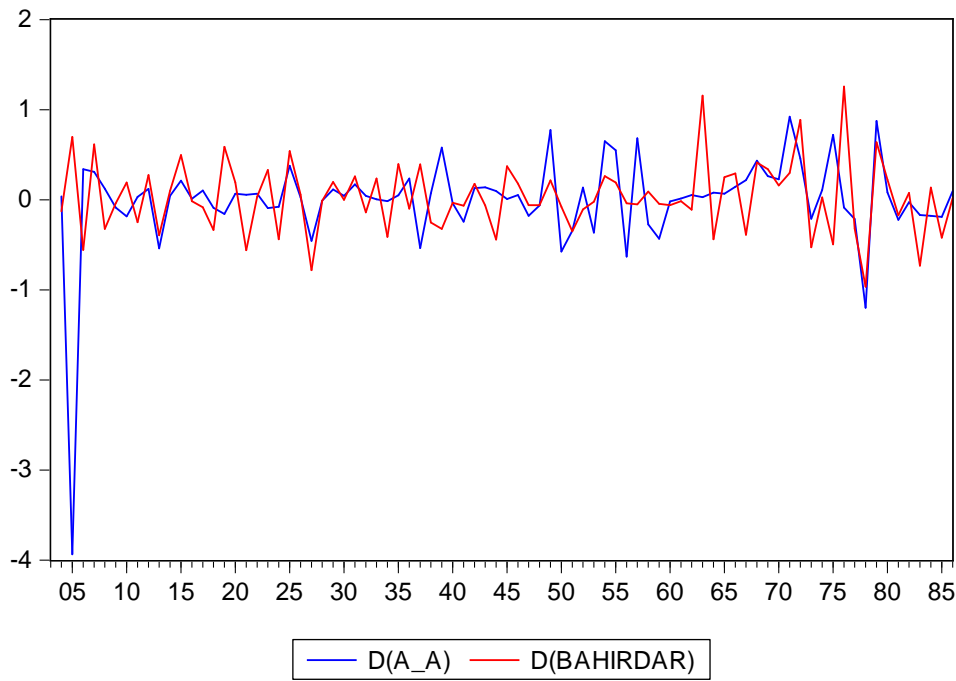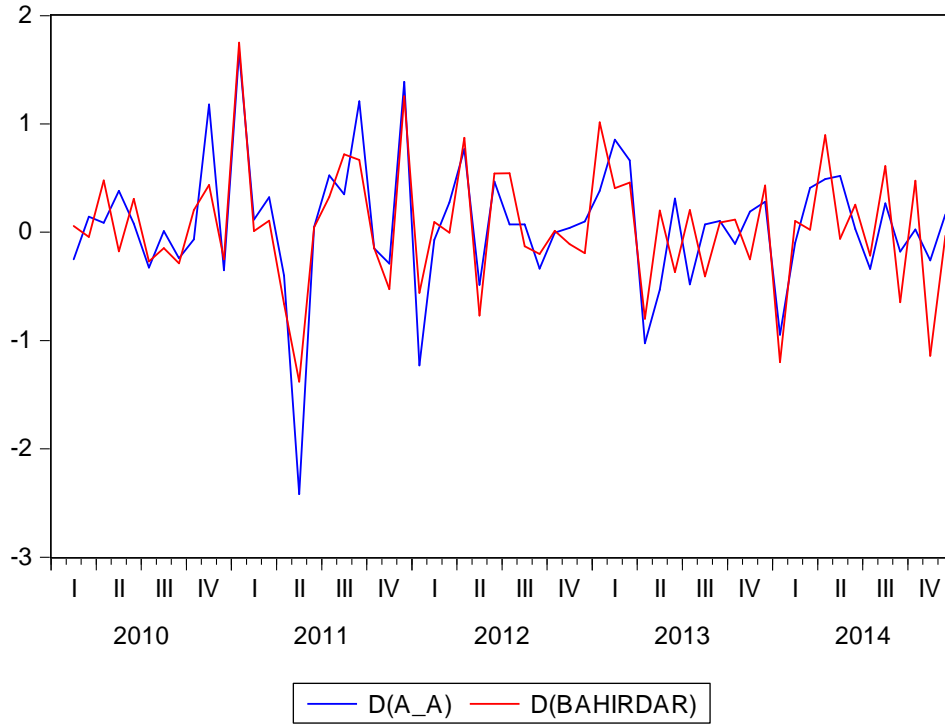**Differenced deseasonilized price of sample markets in the before and after periods**
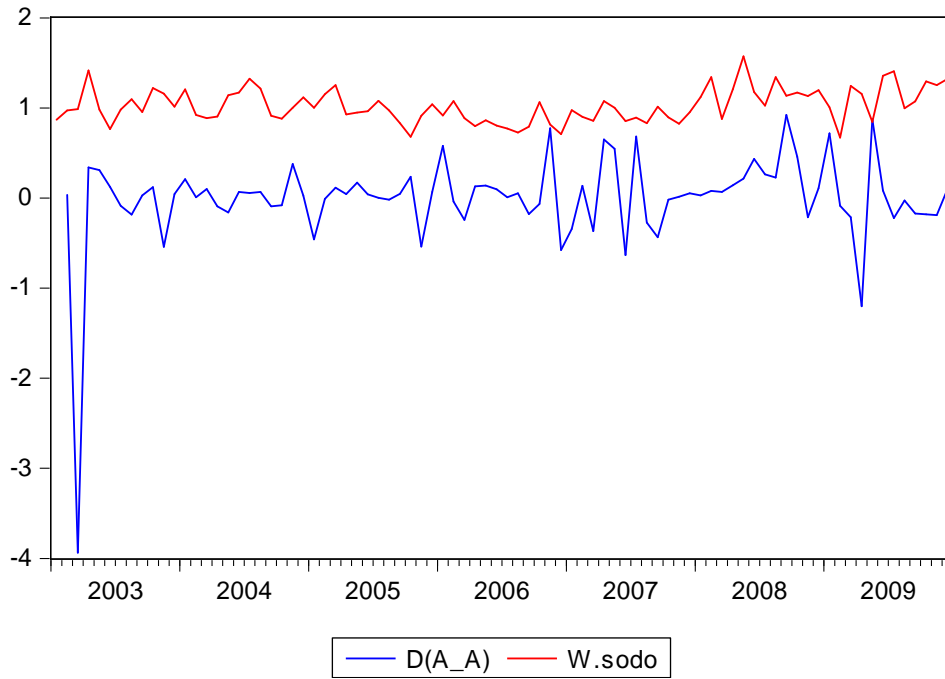
Before

After

Before

After

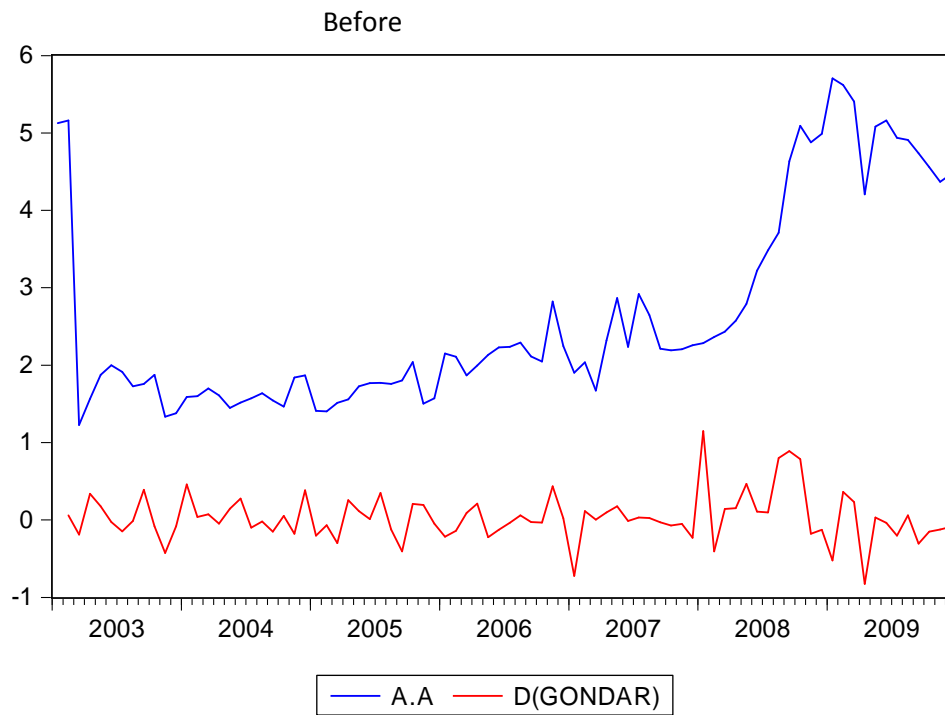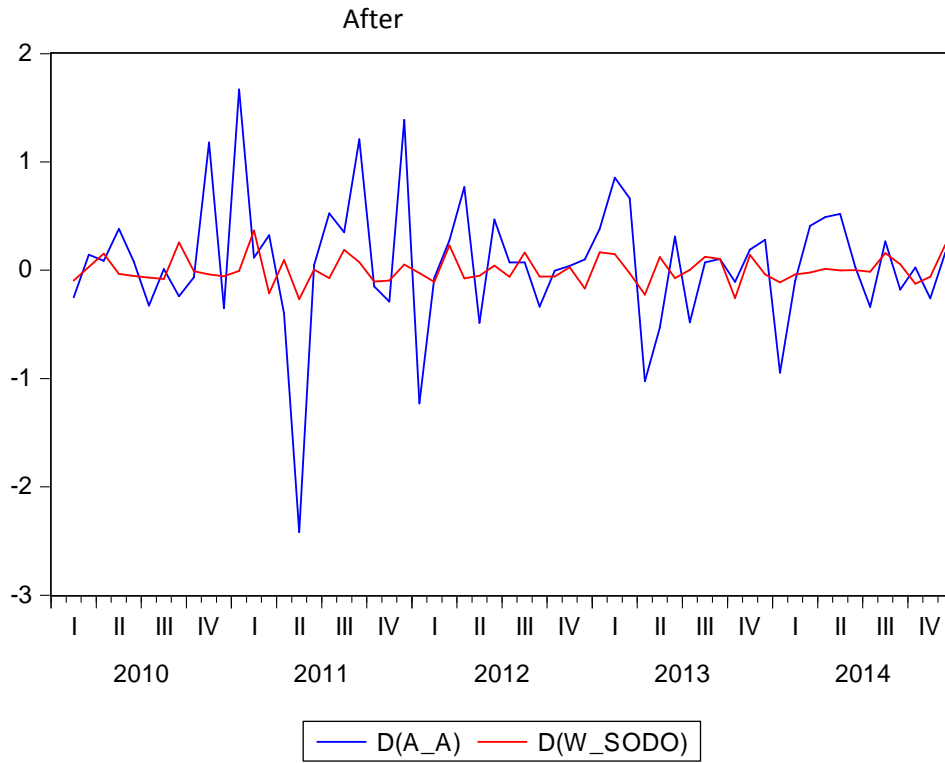Before

After

Before

79
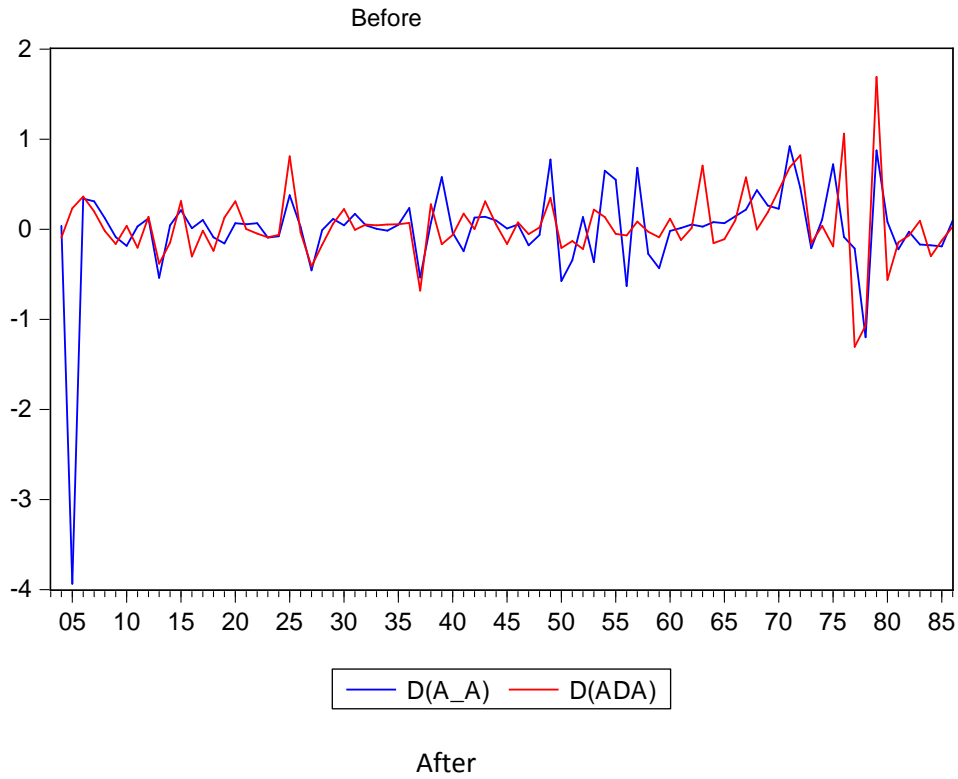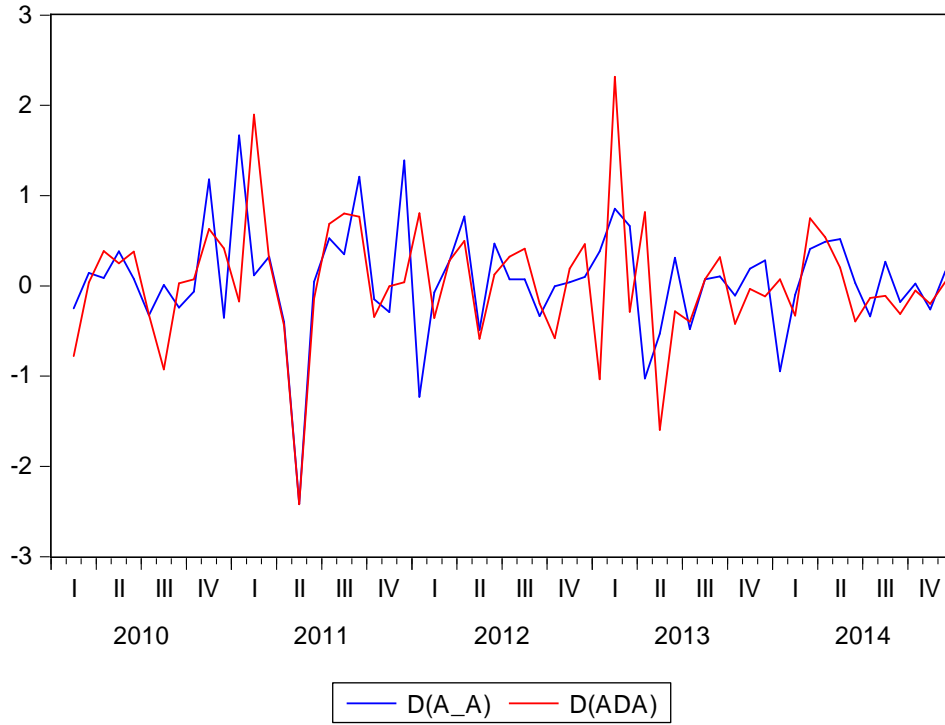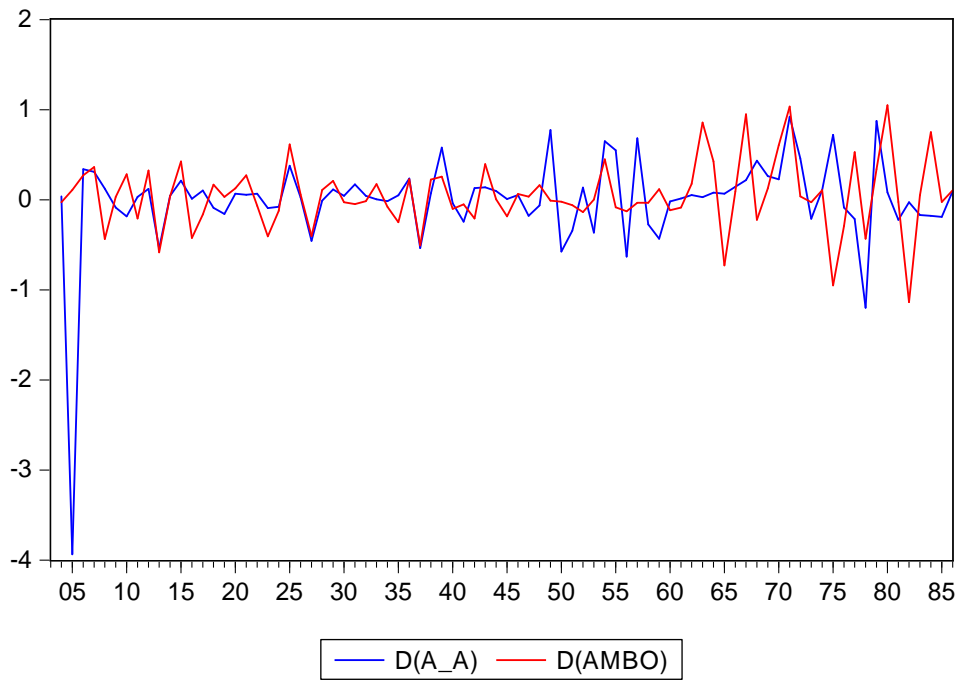
After

Before
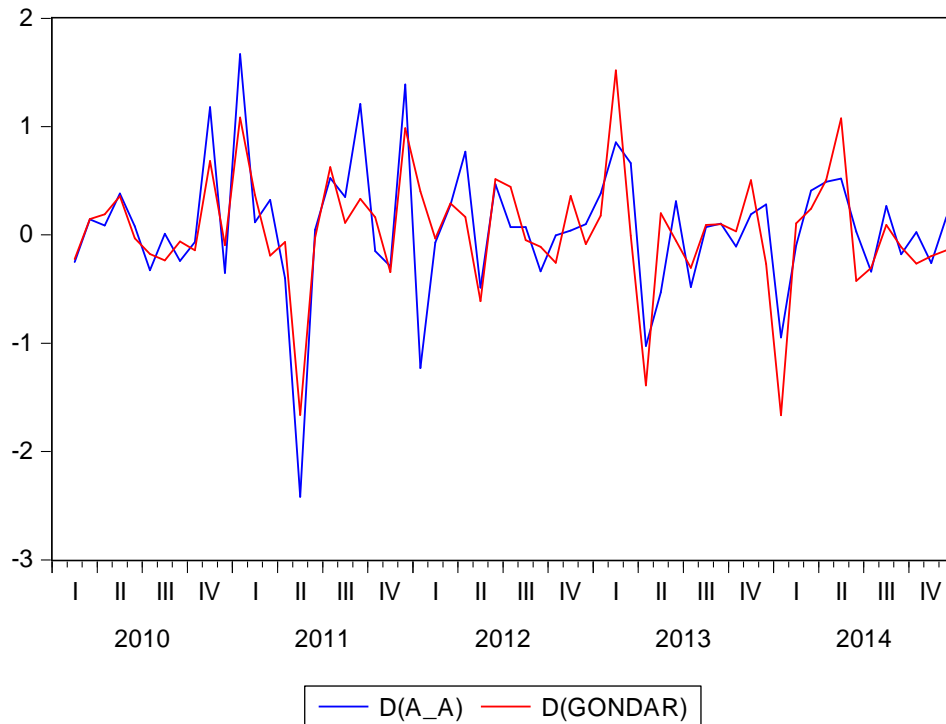
After

Before

After

Annex 5

Table 4.11: estimated critical value of t-max distribution

Markets		Before ICT period				After ICT period		
	observations	90%	95%	99%	observation	90%	95%	99%
A.A and Adama	80	-0.18	-0.39	-1..09	57	-0.23	-0.677	-1.47
A.A and Ambo	79	-1.02	-1.31	-2.91	57	-0.98	-1.145	-1.52
A.A and Assela	82	-1.22	-2.67	-2.88	58	-2.56	-3.42	-3.92
A.A and Bahirdar	80	-1.25	-1.44	-2.01	57	-1.02	-1.396	-2.09
A.A and Dessie	80	-1.92	-2.59	-3.05	58	-2.86	-3.207	-3.83
A.A and Dirdawa	80	-1.90	-2.48	-3.12	58	-1.94	-2.034	--2.62
A.A and Gondar	81	-1.12	-1.73	-3.16	58	-1.21	-1.546	-2.53
A.A and Harar	80	-2.01	-3.51	-3.96	58	-2.03	-2.595	-2.89
A.A and Hawasa	80	-3.69	-4.15	-4.62	58	-1.69	-2.41	-2.93
A.A and Mekele	82	-0.62	-1.04	-2.01	54	-1.88	-2.64	-3.02
A.A and Nekemt	80	-1.01	-1.45	-2.96	57	-0.62	-0.99	-1.52
A.A and W.sodo	80	-0.012	-0.061	-0.122	49	-0.14	0.39	-0.95

| A.A and Welkite | 78 | -0.84 | -1.22 | -1.63 | 57 | -1.04 | -1.55 | -2.03 |

Source: simulation result

Table 4.12: estimated critical values of probability distributions F-statistics for the estimated parameters.

Markets		Before ICT period			After ICT period			
	observations	90%	95%	99%	observations	90%	95%	99%
A.A and Adama	80	10.83	14.122	16.68	57	3.69	5.321	8.24
A.A and Ambo	79	5.86	7.251	10.02	57	2.59	3.16	6.89
A.A and Assela	82	7.21	10.081	12.28	58	8.69	10.293	12.85
A.A and Bahirdar	80	4.83	7.719	10.92	57	4.12	5.936	8.66
A.A and Dessie	80	6.72	8.510	11.02	58	11.82	14.528	17.23
A.A and Dirdawa	80	19.01	20.156	22.51	58	9.01	10.104	14.24
A.A and Gondar	81	5.11	6.345	9.41	58	1.63	4.411	7.36
A.A and Harar	80	14.36	17.049	19.23	58	6.21	9.336	11.68
A.A and Hawasa	80	15.11	16.514	18.69	58	2.53	5.724	8.65
A.A and Mekele	82	6.88	8.085	10.52	54	1.85	4.598	7.58
A.A and Nekemt	80	6.95	9.891	11.93	57	1.32	3.043	6.96
A.A and W.sodo	80	0.51	0.859	1.96	49	1.02	2.911	5.01
A.A and Welkite	78	18.68	20.725	23.27	57	3.26	6.435	9.12

Source: simulation result.