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

Medhin Haftom[1]

Abstract

This paper presents a research result on impact of modern information and communication technology on increasing the level of integration among spatially separated sample maize markets in Ethiopia. A total of 14 markets, including Addis Ababa central market, were selected from various parts of the country and monthly retail price data were collected beginning from January 2003 to December 2014 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 that the overall integration between Addis Ababa and the respective regional markets has increased after ICT period.

Regarding the deficit and surplus areas, the level of integration among markets is higher in surplus areas than in deficit areas before ICT period. However, after the ICT period, the level of integration was not determined by the amount of 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

---

[1] Medhin Haftom, Ethio-Telecom P.O.Box 1047 Addis Ababa, Ethiopia
e-mail medhin296@gmail.com. This work is an abridged version of his Agri-economics thesis submitted to St. Mary's University in 2015. The study was conducted under the supervision of Dr. Tesfaye Wolde.

Introduction

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 into 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 was also observed for livestock sector (ATA, 2016).

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 markets in Ethiopia. In addition, farmers do not have the option of getting market information of agricultural products in the major markets other than their localities. In spite of this fact, it is ironic that Ethiopia's economy depends mainly on agriculture.

If markets are not well integrated, local scarcities of grain products will emerge. This is because, distant markets that might supply grain products to local markets which faces shortage will not have information on availability and supplies as they do not communicate through price signals. Moreover, if markets are not spatially or inter-temporally integrated, it could be indicative of 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 exchange 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, and 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)).

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 of proper integration among spatially dispersed grain markets throughout the country.

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).

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 emerged as an important issue in Ethiopia (Negassa et.al., (2004).

In fact there are few articles which have focused on spatial market integration in Ethiopia (Negassa, 1997,Tamru, 2006). According to Seneshaw Tamru (2006), deficit areas are identified from Addis Ababa while the surplus areas were found to be well integrated and differences and distance are important factors affecting spatial markets integration between Addis Ababa and the regional markets. 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 that it focuses particularly on maize markets integration along with expansion of modern information and communication technology in Ethiopia.

This paper, therefore, targets mainly on assessment of the contribution of modern information and communication technology to spatial integration of maize markets in Ethiopia.

Research Methodology

Both descriptive and econometric analyses were used to assess ICT contribution to 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 was performed to evaluate the level of co-integration between markets, Granger causality test and error correction analysis was undertaken to see the speed of adjustment of the error correcting terms between co-integrating markets.

The Data

This research entirely depends on secondary price data collected from central statistical authority, from the year 2003 to 2014 divided into two categories. That is, the period 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 compares the level of spatial maize market 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 ,Dire Dawa and Harrar from eastern Ethiopia, Mekelle, Gondar, Dessie and Bahirdar, from northern Ethiopia , Welkite, Hawassa and Welytasodo from southern Ethiopia. The areas were selected purposively for their high production capacity, continuous transaction of maize, and data availability. Some of the markets were considered as they represent the deficit areas in order to compare the degree of integration between Addis Ababa and the surplus and deficit areas.

Stationarity 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 auto-correlated 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, σ^2) (Sineshaw, 2006). Auto-correlated errors would make the use of the DF distributions inappropriate, because the distributions are based on the assumption that $\boldsymbol{\eta}_t$ 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 auto-correlated omitted variables that would otherwise, by default, enter the error term.

Central to the ADF model is the selection of the appropriate lag-length; this is because, too few lags may result 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).

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 has applied TAR error correction model which enabled us to include transaction cost and analyze asymmetrical price adjustment.

The study has employed threshold autoregressive (TAR) model of co-integration in the form of error correction model of Engle Granger two step methodologies. 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 that 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 believed 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 usingOLS to estimate the long-run equilibrium relationship of two or more variables as:

$$X_{1t}= \beta_0+ \beta_2 X_{2t} + \beta_3 X_{3t} +\ldots\ldots+ \beta_n X_{nt}+ \boldsymbol{\eta}_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

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

The second-step focuses on the OLS estimate of $\boldsymbol{\eta}$ in the regression equation:

$$\Delta\boldsymbol{\eta}_t= p_1\boldsymbol{\eta}_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where: ε_t is a white noise disturbance, and the residuals from (1) are used to estimate (2).

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 $p \neq 0$, equation (1) and (2) jointly imply the existence of error correction representation of the variables as below:

$$\Delta X_{it}= \alpha(X_{it-1}- \beta_0- \beta_2X_{2t-1-}\ \beta_3X_{3t-1}-\ldots\ldots- \beta_{nt}X_{nt-1}) +\ldots\ldots+v_t\ldots\ldots\ldots(3)$$

The above equation is based on the assumption of symmetric adjustment. But the co-integration equations and their extension may mis-specify if adjustment towards long run equilibrium is asymmetric. To incorporate the above problem of EG model of co-integration, 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 (2) can be rewritten as:

$$\Delta \boldsymbol{\eta}_t = p_1 I \boldsymbol{\eta}_{t-1}+ p_2 (1-I)_{t-1}+ \varepsilon_t\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where I is the Heaviside indicator function such that:

$$I = \begin{cases} 1 \text{ if } \boldsymbol{\eta}_{t-1} \geq \tau \\ 0 \text{ if } \boldsymbol{\eta}_{t-1} < \tau \ldots\ldots\ldots\ldots\ldots\ldots(5) \end{cases}$$

Where τ = the threshold value.

The value of τ is unknown and needs to be estimated along with p_1 and p_2.

If the system is convergent, then the long run equilibrium value of the sequence is given by $\boldsymbol{\eta}_t = \tau$, 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 $_t$ are $p_1 < 0$, $p_2 < 0$ and $(1+ p_1)(1+ p_2) < 1$ [Petrucelli and Woolford: 1984]. In this case if $\boldsymbol{\eta}_{t-1}$ is above its long run equilibrium value, then adjustment is at the rate p_1 and if $\boldsymbol{\eta}_{t-1}$ is below long run equilibrium, then adjustment is at the rate p_2. The adjustment would be symmetric if $p_{1=}\ p_2$ (M. Reza, 2011).

Co -integration Test

In Egle Granger method or the ADF based method of testing co-integration, 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 co-integration vector and when all the right hand–side variables are weakly exogenous (Harris, 1995).

If there are n>2 variables in the model, there can be more than one co-integration vectors. It is possible for up to n-1 linearly independent co-integration vectors to exist, and this has implication for testing and estimating co-integration relationship. Only when n=2, it is possible to show that co-integration vector is unique. Though Johansen's method of co-integration 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 co-integration 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 co-integration 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.

To apply the above formulation equation (1) can be rewritten as:

$$X_{1t}= \beta_0+ \beta_2 X_{2t} + \beta_3 X_{3t} +\dots\dots+ \beta_n X_{nt}+ \eta_t \dots\dots\dots\dots\dots\dots\dots\dots(6)$$

Where X_{1t} represents price Addis Ababa maize and X_{2t} price of maize of the respective regional markets at time t. β_n are estimated parameters and η_t are the disturbance terms. The other explanatory variables $\beta_3 X_{3t} +\dots\dots+ \beta_n X_{nt}$ are nonexistent in the long run as our model is bivariate analysis.

Based on this, equation (8) can be rewritten as for any two markets in our model, as for example Addis Ababa and Adama as:

$$AAM_t = \beta_0 + \beta_2 ADAM_t + \eta_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6')$$

Where, AAM_t and $ADAM_t$ are de-seasonalized retail price of maize in Addis Ababa and Adama, respectively, and β_i are the estimated parameters and η_t is the disturbance term.

Accordingly, if the residuals in equation (6') are stationary using ADF test, the two markets can be considered as co-integrated.

What makes TAR model special from that of the normal auto-regression 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 would start if the local price shock goes beyond this band or threshold. This threshold value is estimated through grid search.

Result and Discussion

Trends of maize production at zone level

Major food crops in Ethiopia are produced in almost all regions of the country with 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 1).

Table 1: Average area cultivated, production and yield of maize per hectare at 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)

In table 1 average total area of maize cultivation, 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 average total production and percentage share from the largest to smallest.

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 hectares). In terms of average yield per hectare, it is dominated by Nekemt (East Wellega) and Adama (East Shewa), which yielded 28.998 and

27.454 quintals per hectare, respectively, while Bahirdar yielded 27 quintals per hectare.

In terms of total production and yield per hectare, Bahirdar , Nekemt , Adama and Ambo are the top four most surplus areas on the basis of all parameters used for evaluating maize production. . On the other hand, Dire Dawa, Harari and Mekelle are the least producers (Deficit areas) both in terms of average total production and yield per hectare (Table 1, Fig. 1).

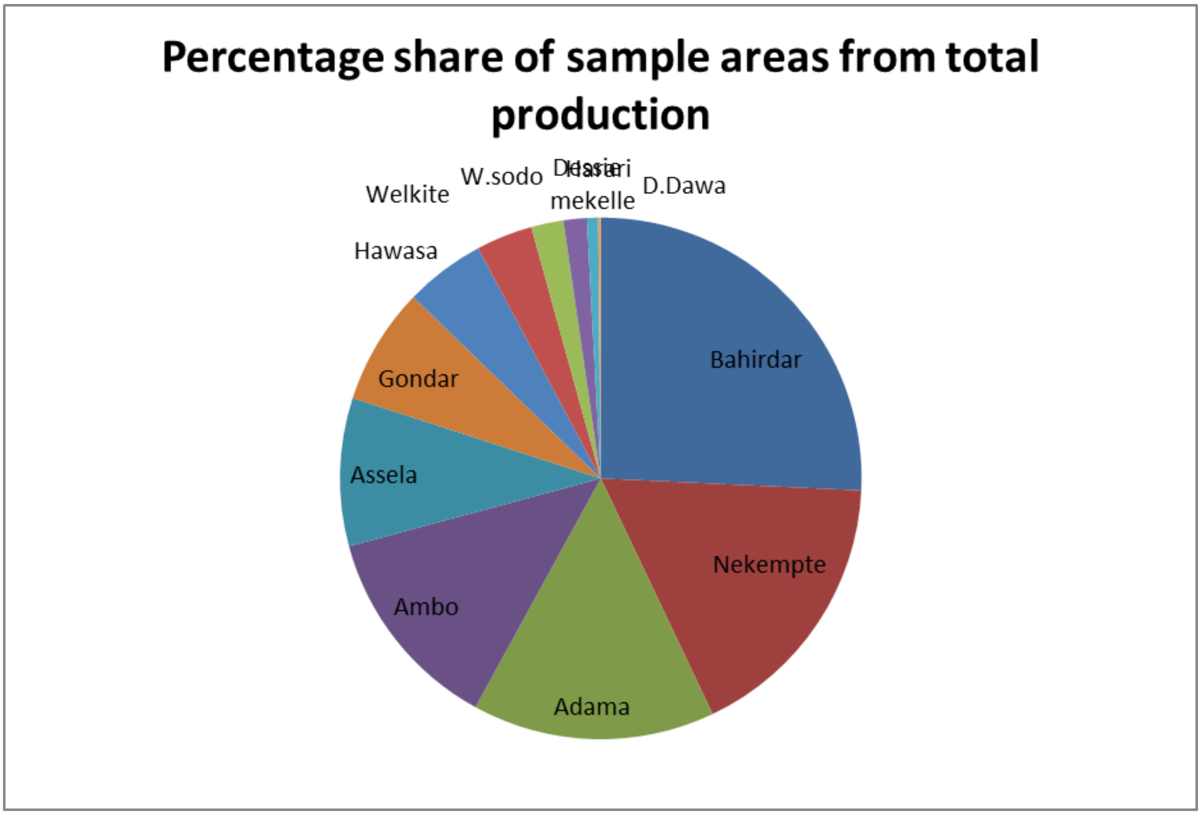


Figure 1: Average maize production share in percent at each zone assessed (2003-2014)

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

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 to the company growth and transformation plan, Ethiopian telecommunications corporation began to expand its network accessibility by signing 1.5 billion USD vender financing agreement with China's telecom company (ZTE) in 2009.

The expansion was divided into 9 projects which cover 14 major cities all over the country, including Addis Ababa. The first phase of the project work was implemented simultaneously in all big cities, and continue to zonal and Wereda towns during the second and third phases which were referred 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. These projects include: fixed line next generation project (FL NGN), mobile phone (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 telephones).

In addition to the network expansion, Ethiopian Telecommunications Corporation also launched some structural adjustments in its internal management by signing a contract management agreement for a term of two years with French international telecom company (ORANGE) which enables the company to get modern international standard telecom management experience and successful knowledge and technology transfer.

Along with this structural adjustment, the company changed its name from Ethiopian Telecommunications Corporation to ‘Ethio telecom’ in 2010.

The next generation network (NGN) built, by providing various new services like data, voice and various value added services enabling the society to get access of modern and improved telecom services and additional network coverage, and the company is able to significantly contribute to the economy (Ethio-telecom, 2014).

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 (Table 2). The increment of Global link in such a way enables not only satisfy the increasing number of internet users but also avoids the internet service interruption due to 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 within 5 km radius distance, increased from 62.14% in 2010/11 to 87% in 2014/15.

The GDP contribution of the company has increased from 1.76% in 2010/11 to 1.95% in 2014/15. But the GDP contribution of Ethio-telecom is less compared to other eastern Africa countries which is on average estimated to be 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..,(Ethio-telecom, 2014).

The number of mobile subscribers 40 million, fixed line telephone subscribers 3.05 million, number of data and internet subscribers3.69 million, wireless service national area coverage 90%, global link capacity 20 GB/s were the main goals set to be achieved at the end of 2014/15. And at the end of December 2013/14 the number of mobile subscribers has reached 25.65 million, fixed line telephone subscribers 761.5 thousands, data and internet 4.74 million, wireless (CDMA) national area coverage 73% and Global link capacity 11GB/ was achieved as compared to the GTP goal set, which was 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 was achieved (Table 2).

Table 2: 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

Service type	2009/10	2010/11	2011/12	2012/13	2013/14	Comparison to 2014/15 target	2014/15 target
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)

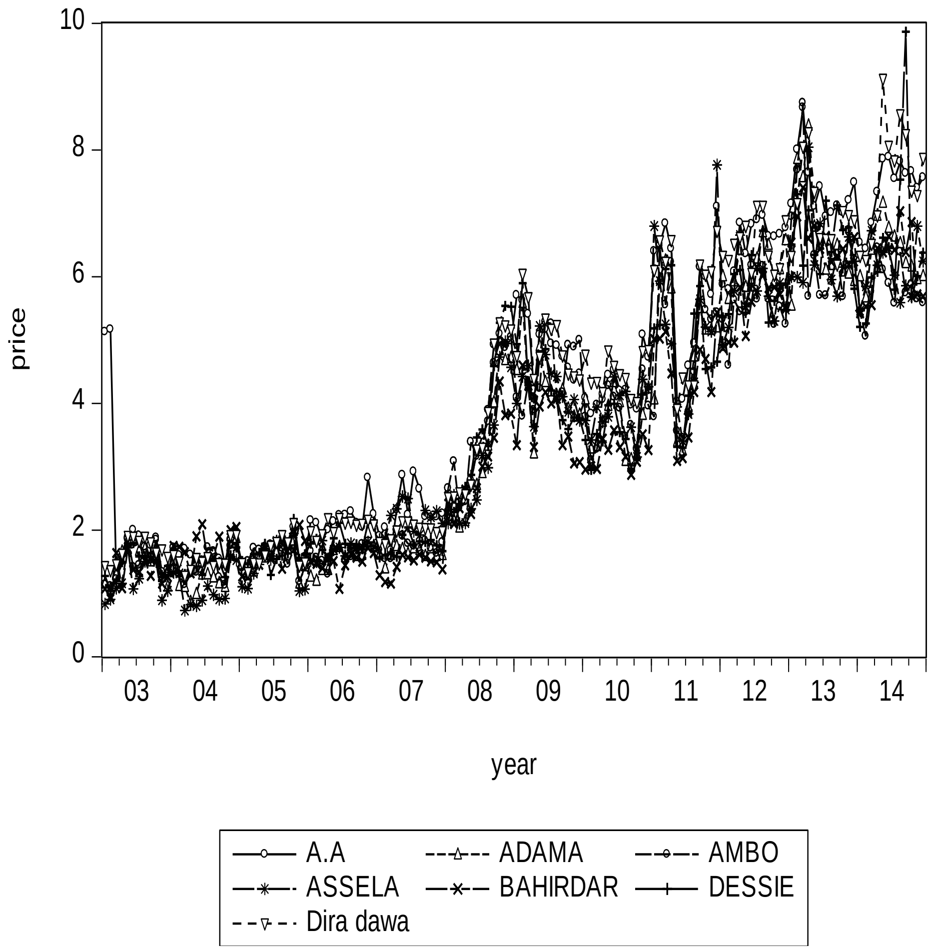
Maize Retail Price Trend

Figure 2 below shows the de-seasonalized 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 divided into two periods, the pre-ICT infrastructure expansion period from 2003 to 2009 and the post-ICT infrastructure expansion period from 2010 to 2014 in which Ethio-telecom has highly invested in various telecom expansion projects in coordinating with various international telecom companies.

When the de-seasonalized retail price trend of maize for 14 selected markets in Ethiopia was assessed for the study period between September 2003/04 and August 2013/14, there was a continuous increment in price of maize in the post-ICT period and there was a large variation or ups and downs from year to year within a given market. Excepting Welayta Sodo, which has a stagnant up and down movement and completely separated from the others, all markets have similar movement.

Welayta Sodo market, with smaller up and down movement in pre-ICT period, had continued its horizontal movement (smaller change in price) in the post-ICT period while others show higher up and down movement and move in similar direction. This shows that the degree of transmission of price signals from Welayta Sodo to other markets and vice versa was weak as compared to the others. An informal interview with Ethio- telecom staff who were assigned to southern region network expansion was conducted to assess why this happened. According to them, Based on the information provided the network expansion of Welaita Sodo was completed in late 2013 and began functioning in 2014. This might be the main reason why that market was weakly integrated with other markets, especially in the post-ICT period (Fig. 2 A and B).

Figure A



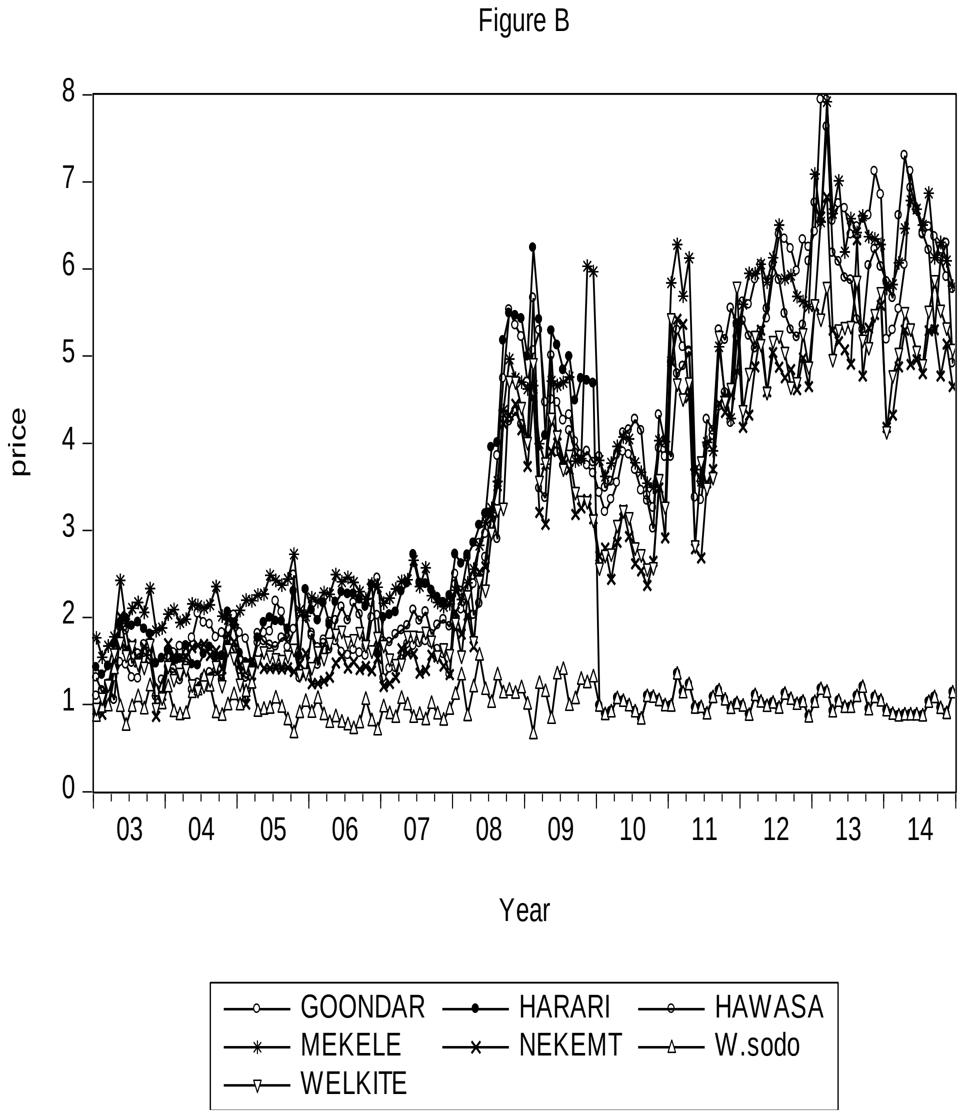


Figure 2: Retail maize price trend of the sample market from 2003 to 2014.
Source: Own computation from CSA data (2003-2014)

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 of integration of the two markets. Based on this, the average price difference between the central market (Addis Ababa) and the selected regional markets is shown on table 3.

Table 3: Spatial average price difference between Addis Ababa and selected markets pre- and post-ICT expansion.

Price in Birr/kg

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)

- Values in parenthesis shows higher price level in terminal (regional markets than the central (Addis Ababa) market.

Based on this market information, the average price differences between Addis Ababa and the selected regional markets vary from the maximum of 1.4 Birr/ kg to 0.01 Birr/kg.

In the pre-ICT expansion period, the price difference between regional markets and Addis Ababa was larger in surplus markets than that of deficit area markets: Nekemt (0.705 birr/kg), Welkite (0.642 birr/kg), Bahirdar (0.594 birr/kg). Whereas in deficit markets the price difference is significantly lower, Harari (0.039 birr/kg), Mekelle (0.065 birr/kg) and Dire Dawa (0.088 birr/kg).

Econometric analysis; Pre-estimation Tests; Augumented Dicky Fuller Test

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

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

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 extensively, pairs should not diverge from one another in the long run (Tione , 2014).

The ADF test result for the residuals from the OLS result of Addis Ababa as dependent variable and the regional markets as independent variables is shown below on table 4.

Table 4: Residual based ADF test for co- integration

Co-integrating markets	Pre-ICT expansion	Post-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*.

As the result of ADF test for residuals from OLS estimation indicates, most of the markets show strong co-integration level, thus reject the null hypothesis at 1% and 5% significance level both in the pre-and post-ICT expansion periods. Accordingly, Assela, Bahidar, Dessie, Dire Dawa, Harari, Hawassa, Mekelle, Nekemt and Welkite markets can be considered as having better co-integration 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, especially in the pre- 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 post-ICT period, Welayta Sodo market is still weakly integrated with Addis Ababa market and the main reason for this can be the delayed telecom network expansion project, which was completed in late 2013 and become functional in 2014 (personal communication with Ethio-telecom staff).

In the case of Gondar market, it is segmented with the central market in the pre-period and weakly integrated although it shows some improvement in the post period. The main reason for lack of integration is 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 a regional city, next generation Telecom infrastructure which brings bigger transformation, especially in data communication was first deployed at Bahidar and this may have resulted in Gondar market to be covered by Bahidar.

Ambo market was highly integrated in the pre-period but not in the post-ICT period. To assess the reason for this paradox, an informal discussion with Key informants from *Ehil Berenda* (Grain market at Merkato) traders was undertaken. According to them, it was known that East Welega is the main supplier of maize and Nekemt market is the main distribution center. Due to difficulty of communication, both SMS and data communication accessibility, traders at Merkato purchase maize either at Nekemt or Ambo though Ambo was preferable due to its proximity to Addis Ababa. But in post-ICT period, with ease of communication most Merkato traders focused on Nekemt market.

As indicated on table 4, 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 only 0.96 between Addis Ababa and Welayta sodo. But in the post-ICT expansion period, the range of variation 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 that there is a relatively balanced level of co-integration between Addis Ababa and the regional markets in the post-ICT expansion period.

The existence of co-integration on the other hand allows us to test the existence of causality relationship between two markets (Table 5).

Table 5: Granger causality relationship between co-integrating markets

		Pre-ICT expansion			**Post-ICT expansion**		
Mare *i*	**Market *j***	**Prob>F_1**	**Prob>F_2**	**Direction**	**Prob>F_1**	**Prob>F_2**	**Direction**
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 post-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 to be unidirectional (Table 5).

Bahirdar and Hawassa changed causality relation with Addis Ababa, from unidirectional in pre-ICT expansion period to Independence in the post-ICT period.

Only Welayta Sodo has causality relation with Addis Ababa, which was bi-directional in pre-period and unidirectional in the post-ICT period. This may imply that in the pre-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 post-period, only price of 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 (Table 5).

Welkite and Gondar are independent in both periods, which means that 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 (Table 5) .

Threshold auto-regressive error correction model

Before estimating the equation and conducting error correction model, variables must pass the test of co-integration 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 all markets are stationary at 1% level of significance.

The Threshold Values

The threshold value is estimated based on equation (4) and (5) 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 (Table 6).

This process is repeated for all markets to find their respective threshold value and the error correction coefficients (ρ_1 and ρ_2).

Table 6: Estimated threshold values between Addis Ababa and regional markets.

Co-integrating markets	Threshold value Pre-ICT period	Threshold value post-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 (p_1=0 and p_2 =0) and the F test is for joint significance (p_1= p_2 =0). Both t and F critical values at 10%, 5% and 1% recorded.

Error correcting terms

The error correcting term shows the speed at which our model returns to its equilibrium point after exogenous shocks. 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 the moving away from the equilibrium. The coefficients lie between 0 and 1, in which 0 coefficients 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 that are performed, all of them seem not to reject the null hypothesis which shows the validity or absence of misspecification in the 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 on White's test, there is no sign of hetroskedasticity in our model. Similarly, based on Engle (1982) ARCH test for the existence of hetroskedastic autoregressive errors, it shows the absence of such conditional errors. Thus, based on the above diagnostic test, this model is reliable and well specified.

Regarding the error correction model between A.A and Adama, it shows that there is a short-run dynamic impact as the coefficient of DAdama is significant at 1% level of significance in both pre- and post-ICT periods. The long-run error correcting term coefficients (p_1 and p_2), on the other hand, were insignificant in both pre- and post-ICT periods over larger threshold deviations, whereas, under smaller threshold deviations they were significant at 1% in the post-ICT period but insignificant in the pre-ICT period. This indicates that 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, one need to check the availability of co-integration between markets. Thus, if the null hypothesis of no co-integration between markets is rejected, one can proceed to testing whether deviations are symmetric or not. Based on this fact one can test the null hypothesis of symmetric adjustment ($p_1 = p_2$), using the standard F statistic. Based on 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. 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 co-integration ($p_1 = p_2 = 0$) between A.A and Adama is rejected at 1% significance level as the F calculated or from the regression is greater than F statistic 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 that 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% level while over threshold adjustment still remains 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 ($\rho_1 = \rho_2$) is safely rejected and the alternative hypothesis of asymmetric adjustment at 1% level of significance in both periods is accepted. In addition, the F statistics also rejects the null hypothesis for joint significance of error correcting terms ($\rho_1 = \rho_2 = 0$) or no co-integration at 1% significance level in both periods (Table 7).

Table 7: Estimation result of the error correction model

Dependent variables Addis Ababa and regional markets

Markets	Explanatory variables	Pre-ICT period		Post-ICT period	
		Coefficients	t-values	Coefficients	t-values
A.A and Adama	DAdama	0.416***	2.76	0.391***	3.685
	$I\eta_{t-1}$	(0.133)	(1.209)	(0.403)***	(3.294)
	$1-I\eta_{t-1}$	(0.074)	(0963)	(0.217)	(2.751)
A.A and Ambo	DAmbo	0.23	1.45	0.386***	5.064
	$I\eta_{t-1}$	(0.103)	(0.93)	(0.405)***	(3.317)
	$1-I\eta_{t-1}$	(0.200)	(1.852)	(0.314)	(2.335)
A.A and Assela	DAssela	0.334**	2.12	0.402***	5.396
	$I\eta_{t-1}$	(0.100)	(0.90)	(0.087)	(0.652)
	$1-I\eta_{t-1}$	(0.583)	(0.35)	(0.977)	(0.862)
A.A and Bahirdar	DBahirdar	0.06	(0.15)	0.855***	9.592
	$I\eta_{t-1}$	(0.11)	(1.00)	(0.399)***	(3.275)
	$1-I\eta_{t-1}$	(0.159)	(0.145)	(0.814)**	(0.253)
A.A and Dessie	Ddessie	0.34	2.10	0.224	2.886
	$I\eta_{t-1}$	(0.16)	(1.49)	(0.202)	(1.550)
	$1-I\eta_{t-1}$	(0.351)	(1.53)	(1.180)**	(2.33)
A.A and Diredawa	Dd.dwa	0.51	2.87	0.127	0.550

Markets	Explanatory variables	Pre-ICT period		Post-ICT period	
		Coefficients	t-values	Coefficients	t-values
	$I\eta_{t-1}$	(0.16)	(1.47)	(0.641)***	(6.042)
	$1\text{-}I\eta_{t-1}$	(0.376)	(0.255)	(0.525)	(0.695)
A.A and Gondar	DGondar	0.53	2.80	1.000***	3.18
	$I\eta_{t-1}$	(0.11)	(1.00)	0.053	0.405
	$1\text{-}I\eta_{t-1}$	(0.166)	(0.891)	(0.262)	(0.668)
A.A and Harar	DHarar	0.43	2.82	0.063	0.669
	$I\eta_{t-1}$	(0.15)	(1.35)	(0.108)	(0.816)
	$1\text{-}I\eta_{t-1}$	(0.531)	(0.452)	(0.254)	(0.962)
A.A and Hawasa	DHawasa	0.250**	2.111	0.509***	3.986
	$I\eta_{t-1}$	(0.165)	(1.468)	(0.239)*	(1.809)
	$1\text{-}I\eta_{t-1}$	(0.937)	(1.521)	(0.640)	(0.652)
A.A and Mekele	DMekele	0.249	1.509	0.618***	6.068
	$I\eta_{t-1}$	(0.127)	(1.446)	(0.330)**	(2.610)
	$1\text{-}I\eta_{t-1}$	(0.134)	(1.856)	(1.635)	(0.963)
A.A and Nekemt	DNekemt	0.166	0.934	0.678***	8.688
	$I\eta_{t-1}$	(0.125)	(1.131)	(0.372)***	(2.988)
	$1\text{-}I\eta_{t-1}$	(0.166)	(0.687)	0.610)	(1.568)
A.A and W.sodo	DW.sodo	(0.212)	(0.733)	1.515**	2.480
	$I\eta_{t-1}$	(0.122)	(1.105)	(0.176)	(1.341)
	$1\text{-}I\eta_{t-1}$	0.003)	(1.325)	(0.363)	(0.324)
A.A and Welkite	DWelkite	0.203	1.163	0.704***	8.795
	$I\eta_{t-1}$	(0.122)	(1.104)	(0.023)	(0.174)
	$1\text{-}I\eta_{t-1}$	(0.241)	(1.787)	(0.748)	(2.536)

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

A.A and Assela had significant short term coefficients, while DAssela coefficient was significant at 5% level of significance in the pre-ICT period but became 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 that adjustment towards the equilibrium was sluggish or stay longer period of time in both periods.

Regarding the symmetric adjustment of error correcting terms between A.A and Assela, in both pre- and post-ICT periods, the null hypothesis of symmetric adjustment ($p_1 = p_2$) was safely rejected and the alternative hypothesis of asymmetric adjustment at 5 % level of significance was accepted in both periods. In addition, the F statistics also rejects the null hypothesis for joint insignificance of error correcting terms ($p_1 = p_2 = 0$) or no co-integration at 1% significance level in both periods.

The short term coefficient between A.A and Bahirdar is insignificant in the pre-ICT period but the coefficient becomes significant at 1% level of significance in the post-ICT period. Regarding the long-run error correcting coefficients, both the larger and smaller deviations from the threshold value are insignificant in the pre-ICT period even at 10% level of significance, which shows that the arbitrage persists for longer period of time or speed of adjustment is sluggish. But in the post-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 that the above and below threshold deviations from the long-run equilibrium are instantly adjusted. The test of symmetric adjustment shows that the null hypothesis was rejected at 1% level of significance in both periods and the joint significance of error correcting terms rejects the null hypothesis ($p_1 = p_2 = 0$) at 1% level of significance.

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

Conclusion

This study was designed mainly to assess the contribution of modern information and communication infrastructure expansion to maize market integration in Ethiopia by comparing the pre- and post-telecom expansion periods. In addition, the study assessed the integration level between markets that are considered as deficit and surplus with the central market (Addis Ababa).

With regard to the production trend, Bahirdar, Nekemt, Adama and Ambo are the most dominant maize producers (surplus) cities. On the other side, Dire Dawa, Harar and Mekelle are the least producers (deficit areas).

Price volatility in maize price is higher in almost all markets with higher coefficient variation in pre-ICT expansion. In the pre-ICT period there is also higher spatial price variation in the surplus areas between markets than that of the deficit areas.

In the pre-ICT expansion period, the numbers of total mobile telephone subscribers were only 6.5 million with an area coverage of 8.7% and fixed telephone subscribers were 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 telephones to mobile telephones which may be due to maintenance delay of fixed telephone and the mobility and ease of accessibility of mobile telephones.

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.

The ADF based test of co-integration shows us that most of the markets are significantly co- integrated in both periods with Addis Ababa.

The variation in level of integration between Addis Ababa and the regional markets is very high in the pre-ICT expansion period. But in the post-ICT expansion the range of variation declines and this indicates that there is relatively balanced level of co-integration between Addis Ababa and the regional markets in the post-ICT expansion period.

In the post- ICT period, the level of integration between the central market (A.A) and the respective regional markets is not determined by the amount of product they supply.

References

Acquah, G. and R. Owusu. 2012. Spatial market integration and price transmission of selected plantain markets in Ghana ,Journal of Sustainable Development in Africa . Volume 14, No.5.

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

Barrett, C., and J. Li. 2002. Distinguishing between equilibrium and integration in spatial price analysis.*American Journal of Agricultural Economics*. 84 (2): 292-307

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

Centeral statistical agency agricultural sample survey, 2013/2014; Report on crop and livestock product utilization.

Century Italy. European University Institute. Fackler, P.L and Goodwin, B.K, 2001; Spatial Price Analysis.In Gardner, B.L and Rausser. Journal of explorations in economic history vol.44,(2) : 293-316.

Chan,K.S., andRuey S. Tsay. 1998. Limiting Properties of the Least Squares estimator of continuos Threshold Autoregressive Model. Department of statistics and actuarial science,university of Iowa,Vol 85,(2) :413-426.

Chan,K.S. 1990. Testing for Threshold Autoregression, The Annals of statistics Gabre-Madhin, E.Z., and Goggin, I., June 2005; Does Ethiopia Need a Commodity Exchange?, A concept note

Fafchamps, Eleni-Gabre-Madhin and Bart Minten. 2003. Increasing returns and market efficiency in Agricultural Trade Market .CSAE WPS/2002-18.

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

Fatchamps, Marcel and Sarah Gavian (1995); The spatial integration of Livestock markets in Niger, Journal of African Economies, 5:366-405.

Ferral, Christopher. 1995. Interactive statistics tutorial in stata, Queen's University, Journal of Statistical Eduction Vol.3, No.3

Gbegbelegbe, S. and de Groote H. 2012. Spatial and temporal maize price analysis in East Africa. International Association of Agricultural Economists Conference. Foz do Iguaçu, Brazil

Giovanni Federico. 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. Journal of explorations in economic history vol.44,(2) :293-316.

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

Goodwin, B.K and Schroeder, T.C ,1991; Cointegration Tests and Spatial Price Linkages in regional Cattle Markets. American Journal of Agricultural Economics.Vol. 73, No. 2: 452-464

Granger, F, W.J, Engle, R.1987. Cointegration and Error Correction: Representation, Estimation and Testing". Econometrica ,vol 55,(2) : 251-276

Ismet , Mohammad. 1998. Government intervention and marketintegration in Indonesian rice markets.Department of Agricultural Economics, Kansas State University, Manhattan, KS, USA .vol 19,(3) : 283-295

KEELING , KVANLI.P and R.Pavur. 2003. Introduction to business statistics. Thomson learning ,South Western, Sixth Edition.

Penzhorn, Nielsand, Channing Arndt. 2002.Maizemarkets in Mozambique: Testing for Market Integration. *Agrekon, Vol 41, No 2*

Ravallion, Martin.1986. Testing Market integration; American Journal of agricultural Economies, vol 68,(1).

Richard, ID Harris.1995. Usingcointegration analysis in econometric modeling.International Business & Economics Research Journal, vol 12, No.5

Sarah, E. Tione. 2014. Analysis of the effectiveness of modern information and communication technologies on maize marketing efficiency in Malawi markets. International Food Policy Research Institute, working paper 10.

SeneshawTamuru. 2006. Master's thesis, AAU: Spatial integration of white wheat market in Ethiopia along with improvements in transport infrastructure.

Shaik, N. M., Anita Jhamtani, and D.U.M. Rao. 2004. Information and communication technology in agricultural development . A comparative analysis of three projects from India.Network Paper No***.135***

Sims.C.A. 1972. Money income and causality. The American Economic Review, Vol. 62,(4) : 540-52

Tong , H, 1983; Threshold Models in Non –linear Time Series Analysis. Lecture Notes in Statistics 21, Berlin, Springer.

UNDP Ethiopia. 2012. Promoting ICT based agricultural knowledge management to increase production and productivity of smallholder farmers in Ethiopia.(report NO. 3)