Spatial Market Integration and Price Transmission for Papaya Markets in Ethiopia

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Abstract

Spatial market integration strengthens successful trade between food-deficit and food-surplus areas, which leads to specialization and economic growth. However, there is no empirical evidence about spatial market integration and its price transmission in Ethiopian papaya market. Information on market integration is useful in making agricultural policies, including policies and strategies for price stabilization, price risk management and food security. Thus, this study went through papaya market integration, price transmission and price causality patterns with the help of Johansen co-integration test, vector error correction model, and Granger causality test using 13 years average monthly papaya prices. Average monthly retailer's papaya prices per kilogram were compiled from Central Statistics Agency (CSA) for three regions: Addis Ababa, Oromia and SNNP (Southern Nations Nationalities and People). ADF test indicates that all variables were non-stationary at their levels and stationary at their first difference. Johansen co-integration tests indicate that four papaya markets significantly co-integrated each other. Vector error correction (*VEC) model test indicates that, speed of papaya price adjustment for Arbaminch market was statistically significant at 1% level, and the fastest as compared to other papaya price adjustments; its equilibrium price was stable. It indicates that price converged to equilibrium price over time. Whereas, speed of price adjustment for Adama market was insignificant and the slowest as compared to other market prices; its equilibrium was unstable because price change was away from equilibrium price. This implies that there was asymmetric information flow. The Granger causality test indicates that Arbaminch papaya price had bidirectional relationships with Addis Ababa- Merkato, and Shashamane markets. Concerned bodies should work on asymmetric information to address slow price adjustment between various papaya markets.*

Keywords: Ethiopia, market integration, papaya, vector error correction model and Granger causality

1. **Introduction**

Good food market integration can assure successful trade between food-deficit and food-surplus areas which results in specialization; which in turn act as a major source of economic growth. On the other hand, poor food price integration affects negatively the social welfare of both producers and consumers by increasing price of consumers in deficit areas and decreasing price of producers in surplus areas, as well as price volatility (Goletti, *et al*., 1995). If markets are not well integrated, this could reflect imprecise price information, presence of either government policies or infrastructural and institutional bottlenecks which may change producer marketing decisions and negatively affect the efficient flow of goods and prices between markets; then price signals could be evidence of market segmentation and/or potential manipulation; become distorted, leading to the inefficient allocation of resources. The marketable surplus generated by farmers could then result in depressed farm prices and diminishing income (Tahir and Riaz, 1997).

Moreover, market integration has great contribution for food security, and growth as well as producer's and consumer's welfare for particularly in a diverse and highly vulnerable country such as Ethiopia. Market integration is expected to ensure a more rapid and effective price adjustment between markets with help of market reforms (Golettie and Babu, 1994). Investigation of market integration is useful to understand the function of market and design and adopt most suitable agricultural price stabilization policies (Sineshaw, 2013).

Thus, the state in developing countries has provided great emphasis to agricultural market integration (Amikuzuno, 2009; Van Campenhout, 2006; Abdulai, 2000), illustrating its importance for researchers and policy makers alike. Strength and speed of price transmission between markets across various regions of a country can be used to measure market integration.

Price is a basic means to tie different stages of a market chain. Price shocks are passed on from one stage to next stage of market chain and the extent of adjustment to such shocks constitutes important factors reflecting the actions of market participants at different market levels. The price transmission that happens between producer and consumer highly relies upon the kind of product.

Vegetables and fruits are perishable products, and minimum processing products, are likely to have a relatively rapid price transmission mechanism. On other hands, products that can be processed in some extent and non-perishable are likely to have a slower price adjustment mechanism. It is commonly thought that price transmission between different stages in the market chain is not symmetric. This means that positive and negative price shocks are not transmitted in the same way (Reziti and Panagopoulos, 2008).

Moreover, in developing countries poor infrastructure and transport services result in large marketing margins due to high costs of delivering traded commodities. High transfer costs hinder the transmission of price signals, and they may prevent or discourage goods arbitrage (Sexton *et al.*, 1991).

Thus, it is crucial to conduct this research because; there is no empirical evidence about the strength and speed of spatial market integration in Ethiopian papaya prices. Information about market integration is thus, useful in making agricultural policies, including policies and strategies for price stabilization, price risk management, and food security. Though integration and causality are related concepts, knowledge about market integration does not by itself inform about the direction of causality.

It is, therefore, necessary to investigate the causality pattern of product prices in integrated markets. Thus, this paper is useful to measure the long run integration and short run price adjustment between spatially separated papaya markets with the help of Johnson co-integration test, vector error correction model, causality pattern of product prices in integrated markets. Moreover, this study helps to come up with the latest, accurate, reliable, and prompt information about market integration of papaya prices across markets and the speed of price transmission in Ethiopia. The result is constructive to generate useful information and fill the gaps in the spatial papaya market integration and its price transmission. This study, therefore, attempts to evaluate the degree of spatial domestic papaya market integration; and examines price adjustment.

2. Research Methodology

2.1 Source of Data

The study aimed to analyze the degree of market integration, and price adjustment of papaya markets among three regions in Ethiopia. Average monthly retailer prices with 156 total observations were gathered from CSA data bases from September 2002 to September 2014. Five markets for price of papaya were selected for this study based on the availability of data, surplus and deficit markets.

2.2 Methods of Analysis

2.2.1. Stationary

The time series data are stationary when conditional mean, variance, and auto-covariance are constant over time. If x and y have unit root, the standard *t*-test is invalid, which lead equation1 to come up with a spurious regression.

$$Yt = \alpha + \beta Xt + \varepsilon t \quad (1)$$

Time series is non-stationary; when conditional mean, variance and auto-correlation are not constant over time. If they are not constant over time, then the series is said to be a non-stationary process (i.e. a random walk/has unit root). Differencing a series using differencing operations produces other sets of observations such as the first-differenced values, the second-differenced values and so on.

If a series is stationary without any differencing, it is designated as I (0), or integrated of order 0. On the other hand, a series that has stationary first differences is designated I (1), or integrated of order one (1). Augmented Dickey-Fuller test has been suggested by (Dickey, D. and W. Fuller, 1979) while the Phillips-Perron test has been recommended by (Phillips, P.C. and P. Perron, 1988) has been used to test the stationary of the variables. The price variables have been tested for unit roots by the Augmented Dickey-Fuller (ADF) test with different specifications, with trend and constant:

$$\Delta Yt = \alpha + \beta Yt - 1 + \delta t + \zeta_1 \Delta Yt - 1 + \zeta 2\Delta Yt - 2 + \zeta k \Delta Yt - k + \varepsilon t \quad (2)$$

Where α, β and δ are coefficients, k is the number of lagged variables specified and εt is the random term to be estimated and tested. This test statistic is probably the best-known and most widely used unit root test. It is a one-sided test whose null hypothesis is $\beta = 0$ versus the alternative $\beta < 0$ (and hence large negative values of the test statistic lead to the rejection of the null). Under the null, y_t must be differenced at least once to achieve stationarity; under the alternative, y_t is already stationary and no differencing is required.

If all the variables are stationary, the VAR can be used, OLS can also be used to estimate each equation, and standard statistical methods can be employed. If some of the original variables have unit roots and are not co-integrated, then the ones with unit roots should be differenced and the resulting stationary variables should be used in the VAR. If the variables have unit roots and are co-integrated, the vector error correction model should be used.

2.2.2. Johansen and Juselius Co integration Test

Johansen and Juselius (1990), suggest Maximum Eigen value test and the Trace test to determine the number of co-integration vectors. The Maximum Eigen value statistic tests the null hypothesis of r co-integrating relations against the alternative of r+1 co-integrating relations for r = 0, 1, 2…k-1. This test statistics are computed as:

$$Jmax(r) = -T * ln(1 - \hat{\lambda}r + 1) \quad (3)$$

Where $\hat{\lambda}$ the estimated Maximum Eigen value, and T stands for the sample size.

The trace test conducts a joint test whereas the maximum Eigen value tests carry out separate tests for the individual Eigen values. Trace statistics examines the null hypothesis of r co-integrating relations against the alternative of n co-integrating relations, where n is the number of variables in the system for r = 0, 1, 2…k-1. It is formulated as follow:

$$Jtrace(r) = -T * \sum_{i=r+1}^{k} ln(1 - \hat{\lambda} i) \quad (4)$$

The results of trace test are preferred while Trace and Maximum Eigen value statistics come up with different results in some case (Alexander, 2001). If a long-term equilibrium relationship exists between time series data, price adjustment is conducted to evaluate the short run properties of the co-integrated series with the help of Vector Error Correction Model (VECM). VECM is not needed to carry out, if time series data not co-integrate.

2.2.3. Vector Error Correction Model (VECM)

VECM can be applied to measure price adjustment. Adjustment of prices induced by deviations from the long-term equilibrium (ECT) is assumed to be a continuous and linear function of the magnitude of the deviation from long-term equilibrium. Thus, even very small deviations from the long-term equilibrium will always lead to an adjustment process in each market.

If time series data are co-integrated, this implies that there exists a long-term equilibrium relationship between them. So VECM can be applied to evaluate the short run properties of the co-integrated series. If co-integration is not detected between series, VECM is no longer required and Granger causality tests are directly applied to see causal relationship between variables. Given the following general specification of the VECM model which considered with VAR p lags

$$Yt = \delta + A_1 Y_{t-1} + A_1 Y_{t-2} +, \dots, + A_{p-1} Y_{t-p+1} + \varepsilon t \quad (5)$$

Where Yt is an (n x 1) vector of endogenous variables (prices), δ is an (n x 1) vector of parameters, y and y_{t-p} are lagged values of prices; Ai represents (n x n) matrices of parameters, and εt is an (n x 1) vector of random variables. In this model, the price series for the five papaya markets were endogenous variables and as such no exogenous variable was used. To test the hypothesis of integration and co-integration in equation (6), we transform it into its vector error correction form.

$$\Delta Yt = \mu + \Gamma 1 \Delta Y_{t-1} + \Gamma 2 \Delta Y_{t-2}, \dots, + \Gamma k + 1 \Delta Y_{t-k+1} + \pi Y_{t-k} + \varepsilon t \quad (6)$$

Where y_t =[P1t, P2t]', vector of endogenous variables, which are I(1), $\Delta yt = yt - y_{t-1}$, μ is a (2×1) vector of parameters, $\Gamma_1, \dots, \Gamma_{k+1}$ and π are (2×2) matrices of parameters, and εt is a (2×1) vector of white noise errors.

Where π is of a reduced rank, that is r ≤ 1, it can be decomposed into π = αβ' and when r =1, α= $[\alpha_1, \alpha_2]'$ is the adjustment vector and β = $[\beta_1, \beta_2]'$ is the co-integrating vector.

Even when co-integration has been established within the series, there may still be disequilibrium in the short run, i.e., price adjustments across markets may not happen instantaneously; markets can take time to adjust. Another important implication of co-integration and the error correction representation is that co-integration between two variables implies the existence of causality (in the Granger sense) in at least one direction (Granger 1988). Nevertheless, if two markets are integrated, the price in one market, P_1, would commonly be found to Granger-cause the price in the other market, P_2 and/or vice versa. Therefore, Granger causality provides additional evidence as to whether and in which direction price transmission is occurring between two series. If the series P_{it} and P_{ij} are I (1) and co-integrated, then the ECM model is represented by the following equations.

$$\Delta Pi1 = \alpha 0 + \sum_{t=1}^{n} \beta i\, \Delta P(t-1)i + \sum_{t=1}^{n} \beta j\, \Delta P(t-1)j + \delta ECTt - 1 + \mu t + \quad (8)$$

$$\Delta Pj1 = \varphi 0 + \sum_{t=1}^{n} \sigma j\, \Delta P(t-1)j + \sum_{t=1}^{n} \sigma i\, \Delta P(t-1)i + \lambda ECTt - 1 + \varepsilon t + \quad (9)$$

Where Δ is the difference operator, P_{jt} is the price series in the Arbaminch market (i=1), P_{ij} is the price series in other markets (i=2-5) and are white noise error terms, ECT_{t-1} is the error correction term (adjustment vector) derived from the long-run co-integrating relationship, while n is the optimal lag length orders of the variables which are determined by using the general-to-specific modeling procedure (Hendry and Ericsson, 1991). The null hypotheses are: P *it* will Granger-cause P_{jt} if $\neq 0$. Similarly, P_{jt} will Granger - cause P_{it} if $\neq 0$. To implement the Granger causality test, F-statistics are calculated under the null hypothesis that all the coefficients are equal to zero. A the negative and significant coefficient of the ECM (i.e. ε_{t-1} in the above equations) indicates that any short-term fluctuations between the independent variables and the dependent variable will give rise to a stable long run relationship between the variables.

3. Results and Discussion

3.1 Stationary Test

For co-integration analysis, it is important to test the unit roots with the help of the Augmented Dickey- Fuller (ADF) at the beginning to check whether modeled variables I (0) at levels and I (1) at first differences were stationary or non stationary. The tests were applied to each variable over the period of 2001-2013 with and without constant at the variables level and at their first difference.

Table 1: ADF Unit Root Test Results for Papaya Prices

Papaya price	Level				Difference			
	Without constant		With constant		Without constant		With constant	
	Test statistic	P-value	Test statistic	P- value	Test statistic	P-value	Test statistic	P-value
Adama	0.9164^{ns}	0.904	-0.486	0.891	-4.778	0.000	-4.933	0.000
Shashamane	0.7639	0.878	0.655	0.855	-6.283	0.000	-6.431	0.000
Hawassa	3.196	0.999	1.734	0.999	-5.925	0.000	-6.428	0.000
Arbaminch	1.357	0.956	-0.594	0.869	-7.881	0.000	-8.294	0.000
Merkato	1.980	0.989	0.736	0.993	-5.935	0.000	-6.265	0.000

Source: Computed from data in Central Statistic Agency (CSA) of Ethiopia.

The result in Table1 indicates that the null hypothesis of no unit roots for all the time series were rejected at their levels. On the other hand, the all variables were stationary and integrated of same order, i.e., I (1) at their first difference for both with and without constant, which means unit roots in the first differences were rejected at 1 percent. Therefore, the results allow proceeding for co-integration tests for the testing of the long run equilibrium relationship.

Moreover, according to Mesike *et al*. (2010), any endeavor to determine the dynamic function of the variable in the level of the series based on results of the variables are I (1) and I (0) will be inappropriate and may lead to problems of spurious regression. The econometric results of the model cannot be used for prediction in the long-run in that level of series because it will not be ideal for policy making (Yusuf and Falusi, 1999).

ADF test results enable researcher to conduct Johansen co-integration test which is suitable to see the existence of long-run relationships among variables because they fulfill the precondition for co-integration analysis.

In this study, the optimal number of lag for VAR model was determined based on value of Akaike criterion (AIC), Schwarz Bayesian criterion (BIC) and Hannan-Quinn criterion (HQC).

Table 2: Lag-order Selection Criterion

lags	AIC	HQIC	SBIC
1	14.247	14.844*	14.489*
2	14.254	15.348	14.699
3	14.040	15.631	14.686
4	13.900*	15.989	14.749

Source: Compiled from data in Central Statistic Agency (CSA) of Ethiopia.

The result in Table 2 shows that candidate of optimal lag of the AIC is lag 4; optimal lag of SBIC and HQIC is lag 1. As we can see in Table 2, there is more than one candidate of optimal lag exist, so the value of R^2 from the VECM analysis was checked with lag 1 and lag 4. Based on the results of VECM analysis, lag 4 is found to be optimal lag for this model because it yields higher $R^{2.}$

3.2. Johansen Co-integration Tests

To state a co-integration model, Johansen's testing procedure was followed. Each co-integrating equation has an intercept and a slope coefficient. The null hypotheses for the trace test are rejected at the 10% level of significance, we reject the null hypotheses that r=0 and r $\leq$1, but we failed to reject the null hypothesis that the co-integrating rank of the system is at most two.
Johansen's the trace and λ-max tests rejected first four hypotheses (r = 0 to 3) of no co-integrating vector at 1% level of significant; Johansen trace statistic rejected 0-3 hypotheses(r=0, r=1 r=2, r=3) at 1% level of significant. In other words, this trace test result rejected the null hypotheses because these four variables were co-integrated (see Table 3). These results suggest that there are four long-run equilibrium relationships between the five price series.

Table 3: Results of Johansen Co-integration Tests for Five Papaya Market Prices

Sample : 2002:1 - 2014:01 Trend: trend			Number of observation =156 Lag=4		
Rank	Eigen value	Trace statistic	p-value	Lmax test	p-value
0	0.35575	172.13	0.0000	67.710	0.0000
1	0.25116	104.42	0.0000	44.542	0.0000
2	*0.20121*	59.876	0.0000	34.597	0.0002
3	0.14904	25.279	0.0009	24.854	0.0005
4	0.0027559	0.42500	0.5145	0.42500	0.5145

Source: Computed from data in Central Statistic Agency (CSA) of Ethiopia.

3.3. Vector Error Correction Model

The ADF test results approve that a VEC model is more pertinent than a vector auto regression model to distinguish the multivariate interactions among the three price series (Engle and Granger, 1987). That is, all price series data which have unit roots are more pertinently examined the existence of a number of long run co-integration vectors than a vector auto regression model.

The presence of co-integration between variables suggests a long term relationship among the variables under consideration. The coefficient of price adjustment with negative sign, indicating a move back towards equilibrium; a positive sign indicates movement away from equilibrium. The coefficient should lie between 0 and 1, 0 suggesting no adjustment one time period later, 1 indicates full adjustment. The coefficients of the error correction term show the speed of convergence to the long run equilibrium as a result of shock of their own prices.

Table 4: Result from Vector Error Correction Model for Adjustment vectors of papaya prices

	Co integrating vectors(β)		**Adjustment vectors**		**Adjusted R^2**	**Durbin Watson**
Arbaminch	1.0000 0.00000	(0.00000) (0.00000)	-0.47***	0.0425***	0.2095	2.1817
Merkato	0.00000 1.0000	(0.00000) (0.00000)	0.22591	-0.033019	-0.00553	2.0898
Adama	-0.010136 1.0898	(0.056557) (0.18389)	0.10344	-0.049172	-0.00324	2.6603
Shashamane	-0.31587 -4.0867	(0.094245) (0.30643)	0.35 ***	0.222***	0.41484	2.1112
Hawassa	-0.27085 0.49390	(0.099869) (0.32471)	0.427***	0.020635	0.1379	2.2619

Note: *** and ** indicate, respectively, for 1% and 5% significance levels (standard errors in parenthesis).
Source: Computed from data in Central Statistic Agency (CSA) of Ethiopia

In this study, coefficient of dynamic adjustments that is obtained with the help of the VEC model analysis is used to estimate the speeds of price transmission. The results of the speeds of adjustment/adjustment vectors are displayed in Table 4. The speeds of adjustment for Arbaminch retail papaya price were statistically significant at 1% level. The speeds of adjustment for Adama and Merkato the retail price were not statistically significant. The estimate of the error correction coefficients for the selected papaya markets indicate that the Shashamane market was significant at 1% with a wrong sign (positive) indicating any disequilibrium in the long run retailer price would be corrected in the short run thus, the short run price movements along the long run equilibrium path may be unstable (see Table 4). The coefficient of adjustment vector (α**)** for Hawassa market has a wrong sign (positive) and significant at 1% level showing that the short run price movements along the long run equilibrium path may be unstable.

The speed of adjustment for Arbaminch papaya price has the expected negative sign because of the overreaction of prices in the short run in response to an exogenous shock.
The dynamic speed of adjustment for the Arbaminch price was higher (0.47), in absolute value, than other papaya market prices, an indication of asymmetric price transmission with respect to speed. This is an interesting result suggesting that with the safety shock, Arbaminch prices adjust more quickly and are more flexible than farm prices to restoration in the long-run equilibrium. This result is also important for policy makers and agribusinesses and has clear implications for the efficiency and equity of the Ethiopia papaya marketing system. It indicates that the speeds of price adjustment are not the same in different markets. Prices in the Arbaminch market adjust more quickly than prices at other market in response to the safety shock.

Even if we demonstrate market integration through co-integration, there could be disequilibrium in the short run, i.e., price adjustment across markets may not happen instantaneously. It may take some time for spatial price adjustments to occur. The error correction model takes into account the adjustment of short-run and long-run disequilibrium in markets and time to remove disequilibrium in each period. In terms of efficiency, prices are transmitted fully and completely given efficient market conditions. The fact that price dynamics differ might point to noncompetitive market conditions that can lead to market inefficiencies. It is important to note that our analysis cannot directly test for imperfect competition and does not explicitly address imperfect competition. Future research and modeling efforts are required to address this hypothesis directly and appropriately.

3.4. Granger Causality Tests

Granger causality was also estimated between pairs of papaya market. Granger causality means the direction of price formation between two markets and related spatial arbitrage, i.e., physical movement of the commodity to adjust for these prices differences. Table-5 gives the results of the Granger causality test which show that, in one cases, i.e., there exists bidirectional causality between Arbaminch and Merkato market. On other hands, two pairs markets, Hawassa has unidirectional relationships with both Shashamane and Adama the base market. Arbaminch has also unidirectional relationships with Adama, Shashamane and Hawassa the base market. There exists bidirectional causality. In these cases, the Arbaminch Granger causes price formation in the concerned papaya markets which in turn provide feedback to the Arbaminch base market as well.
In the case of the other markets, i.e., Adama, and Hawassa, there exists an indirect relationship between the Arbaminch base market and concerned papaya markets. This implies that the Arbaminch market Granger causes price formation in these three markets but they do not provide any feedback to the Arbaminch base market.

Table 5: Granger Causality from Error Correction Model

Pair wise Granger causal test	F-Statistics	Probability
Merkato → Arbaminch	3.12	0.017
Arbaminch → Merkato	3.487	0.0095
Adama → Arbaminch	2.064	0.0885
Arbaminch → Adama	3.62	0.0077
Shashamane → Arbaminch	2.56	0.038
Arbaminch → Shashamane	5.31	0.0005
Hawassa → Arbaminch	2.345	0.0557
Arbaminch → Hawassa	4.41	0.0021
Adama → Merkato	4.46	0.002
Merkato → Adama	8.97	0.0000
Shashamane → Merkato	3.51	0.009
Merkato → Shashamane	9.333	0.0000
Hawassa → Merkato	4.46	0.002
Merkato → Hawassa	6.7	0.000
Shashamenie → Adama	6.033	0.0002
Adama — Shahemanie	1.712	0.149
Hawassa → Adama	3.654	0.0072
Adama → Hawassa	6.999	0.0000
Hawassa → Shashamane	0.827	0.509
Shashamane → Hawassa	6.82	0.000

Note: *** and ** indicate, respectively, for 1% and 5% significance levels (standard errors in parenthesis).

Source: Computed from data in Central Statistic Agency (CSA) of Ethiopia.

4. Conclusions and Recommendations

This paper investigates spatial market integration and price transmission in papaya markets by using monthly data from September 2002 to September, 2014 and with the help of co-integration and VECM. The results of ADF indicate that the all variables were non-stationary at their level and integrated of same order, i.e., I at their level for both without constant and with constant. Johansen's the trace and λ-max tests rejected first four null hypotheses of no co-integrating vector at 1% level of significant. In addition, the vector error correction model proved that most of the disequilibrium in the market is corrected within month. Papaya price for Arbaminch retail market removed 47% of the disequilibrium, and the remaining was corrected by the external and internal forces. This necessitates the need for future research, to investigate the influence of external and internal factors such as market infrastructure, government policy and other factors towards market integration.

The finding indicates that Adama Hawassa papaya prices did not granger cause Arbaminch papaya price. Arbaminch has only unidirectional with Adama Hawassa papaya prices. This indicates that the speeds of price adjustment were low almost for all market. In general, speeds of price transmission were slow for almost all papaya markets may be for various reasons such as transportation costs, imprecise price information, and lack of good government policies, infrastructure and institutional arrangements. So government should create conducive policy environments that improve good flow of price information; work on infrastructural accessibility and institutional arrangement to reduce transaction costs.

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