



Spatial Market Integration and Price transmission of Selected Sorghum market in Ethiopia

Abdi Mohammed^{a,*}, Mustefa Bati^b, Abera Gemechu^c and Gebregziabher Nigus^d

^aDepartment of Rural Development and Agricultural Extension, College of Dryland Agriculture, Jigjiga University, Jigjiga, Ethiopia

^bDepartment of Agriculture Economics, Haramaya University, Haramaya, Ethiopia

ABSTRACT

Ethiopian government has adopted various strategies in enhancing agricultural production and productivity. However, it has given a less attention for the marketing aspects. Hence, in order to improve marketing efficiency, it is important to conduct useful studies on market integration. Thus, this paper aimed at analyzing the degree of market integration, its price transmission and price causality patterns of selected sorghum market with the help of Johansen co-integration test, Vector error correction model and Granger causality test by using a 11 years' average monthly prices of sorghum over the period 2010 to 2020. The result of Johansen co-integration test clearly revealed that the null hypothesis of no co-integration is rejected by both max and the trace statistics at 1% and 5% level of significance with a minimum of at least 4 co-integrated sorghum markets. The result of vector error correction model also revealed that out of six selected markets of sorghum, only two sorghum retail markets of Adama and Diredawa have statistically significant speed of price adjustment at 1% and 5% respectively. Although the remaining four markets have an expected negative sign of speed of price adjustment, they are not statistically significant. Hence, the speed of price adjustment for Adama and Diredawa sorghum market were faster than the other four sorghum market of Addis Abeba, Bedesse, Abomsa and Jigjiga. The result of Granger causality test also indicated that there were bidirectional causality between sorghum price of Addis Abeba and Jigjiga, Adama and Abomsa, and Bedesse and Diredawa sorghum prices while there were unidirectional relationships between sorghum price of Addis Abeba and Adama, Diredawa with Addis Abeba and Adama, Jigjiga with Adama and Abomsa. The result also further indicated that there were independent causation between Addis Abeba and Bedesse, Addis Abeba and Abomsa, Bedesse and Abomsa, Bedesse and Jigjiga, Abomsa and Diredawa, Jigjiga and Diredawa market pairs. Hence, government and other concerned bodies should work on asymmetric information to address slow price adjustment between various sorghum markets.

Key Words: Market integration, Sorghum, Vector error correction model, Granger causality

1. Introduction

Sorghum is one of the principal warm weather grain crops grown in Ethiopia. It is a significant contributor to the economic and social development of the country (Gere-mew et al., 2004). It is also a drought resistance, crop of choice in dry regions, more dispersed and used for areas with unreliable rainfall that has a significant impact on the livelihood of smallholders' farmers in Ethiopia (Institute, 2014). As indicated in (CSA, 2020), it is a crop with the largest smallholder coverage next to maize and teff with 5.042 million holders. Similarly, among the regional states of Ethiopia, Oromia and Amhara regions have a greater

share of households with 2.250 and 1.23 million holders and productivity of 30.27 and 28.28 quintal/hectare respectively (CSA, 2020). Hence, sorghum production does not evenly distributed geographically among all regions of the country and most parts of the localities in the country are supplied through spatial arbitrage from these producing regions. However, such distribution of goods can be economical if spatial arbitrage is efficient (Degeye et al., 2009).

Market integration, which is the measure of the degree to which markets at geographically separated locations share common trade information on a homogenous commodity (Barrett and Li, 2002), is considered as an engine to assure food security, economic growth, improve producer's and consumer's welfare mainly in a diverse and highly vulnerable countries (Tamru et al., 2013). Besides, integration of market is also expected to ensure a more rapid and effective price adjustment between markets with help of market reforms (Goletti and Babu, 1994). Hence, efficient markets are integrated either spatially or temporally across different forms of products. Spatial market integration, which refers to the co-movement of prices across spatially separated markets (Ali et al., 2014), can be integrated poorly or in better ways. A market is poorly integrated if there are presence of inaccurate price information, high institutional and infrastructural constraints and inappropriate interference of governments in markets that may lead to market distortion

* Corresponding author: Abdi Mohammed: abdim1437@gmail.com

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and inefficient allocation of resources (Goletti and Christina-Tsigas, 1995). On the other hand, market can be integrated in better ways if market integration can realize effective trade between scarcity and affluent areas that induce specialization. Moreover, spatially efficient markets increase supply and decrease price of goods and services in deficit areas, and vice versa in surplus areas which further raises producers surplus in surplus areas and consumers surplus in deficit areas (Tschirley, 1995) as cited in

(Degye et al., 2009). Thus, in order to bridge the disparity gap, ensure food security through making sure food is made available from surplus to deficit areas, the availability of spatial market integration that act as a sign for market efficiency between regional markets is mandatory (Ayeduvor, 2014).

Price is a common tool that integrates different stages of a market chain (Lupiya, 2018). Prices of agricultural commodity explicitly show the step and direction of agricultural development. It also serves as market signals of the relative shortage or abundance of a given product (Akin-tunde et al., 2012). Prices of sorghum reveal variation nearly throughout the year and understanding the pattern of such disparities help the stakeholders, policy makers, traders, producers and consumers in setting feasible plan and designing better policies. In Ethiopia, there are various factors that contribute to price volatility of agricultural commodity including sorghum such as weather condition, discrepancies in bargaining power among consumers, Product homogeneity and differentiation, income fluctuations among sellers and consumers, and transaction costs (Rapsomanikis et al., 2006; Habte, 2016; Usman and Haile, 2017; Yami, 2020).

In Ethiopia, given the importance of the sorghum as a source of income and employment and its contribution to the food security of a million people, its marketing is often characterized by the problem of seasonality. Besides, many consumers do not have price information on the sorghum in various retail markets which might lead to exploitation due to insufficient price statistics. Furthermore, recently some researchers and scholars likes; (Worako, 2015), (Habte, 2016) and (Yami, 2020) were conducted their study on spatial market integration and price transmission of Vegetable and Fruit, Papaya and maize market in Ethiopia, respectively. However, there is no empirical evidence about spatial market integration and its price transmission of sorghum market in Ethiopia. Hence, to fill this gap, expand scope of knowledge, come up with the latest, accurate, reliable, and prompt information; this paper aims to analyze spatial market integration and price transmission of selected sorghum markets in Ethiopia. The specific objectives of this study are 1) to examine the degree of spatial market integration of sorghum 2) investigate the price transmission process and 3) Causality pattern using the Granger causality test.

2. Materials and Methods

2.1. Source of data and Sampling techniques

This study aimed to analyze the degree of market integration and price transmission of sorghum markets among three regions in Ethiopia. Average monthly retailer prices with 128 total observations were gathered from monthly retailer data in Ethiopian Grain Trade

Enterprise (EGTE) covering the period from September 2010 to December 2020. The sample markets were selected using a multi-stage sampling method. First, supply regional states were selected by their annual per capital sorghum production potential. Hence, two regional states (Oromia and Amhara) were selected and sorghum producing zones in these regions were identified by the same criterion. Then, the supply zones were selected to be West Hararge of Oromia Region and North Shewa of Amhara Region. Then, the markets in these supply zones were, in turn, selected by their (lowest) annual average retail price of wheat in 2019/20. Hence, Bedesse market of West Hararge and Abomsa market of North Shewa were selected as the supply markets. From a deficit market, Jiggiga market of Somale Region was selected. Finally, Addis Abeba was selected as a central market, Adama as the nearest market to the central market and Direedawa as the remotest market from the central market. Thus, a total of six markets for price of sorghum were selected for this study based on the availability of data, distance, surplus and deficit markets.

Furthermore, measures estimated from nominal prices are expected to be spurious and, hence, prices should be transformed to eliminate these spurious relationships. Variable transformation minimizes problem of multicollinearity, converts a nonstationary time series into stationary, changes nonlinear relationship into linear, and avoids problem of seasonality and other common macroeconomic factors such as inflation (Tschirley, 1995). Hence, to overcome the above estimation problems, monthly real retail price series were transformed to natural logarithms, and the differences of their natural logarithms were multiplied by 100 to avoid scaling problems. The parameters were estimated by percentage real price changes transformed as:

$$\Delta P_t = (\ln P_t - \ln P_{t-1}) \times 100 \quad (1)$$

Where ΔP_t is percentage real price change of sorghum at time t ; P_t is the real retail price of sorghum; \ln is the natural logarithm; P_{t-1} is lagged value of the real price; and t is the time period in months.

2.2. Methods of Data Analysis

Prior to estimation of the market integration, the price series and the market pairs were specified the lag structure, tested for stationarity, cointegration and causality pattern.

2.2.1. Stationarity Test

The time-series data are stationary when conditional mean, variance, and auto covariance are constant over time. If x and y have a unit root, the standard t-test is invalid.

$$Y_t = \alpha + \beta X_t + \epsilon_t \quad (2)$$

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 are designated I (1), or integrated of order one (1). Hence, Augmented Dickey-Fuller test which has been suggested by (Dickey and Fuller, 1979) were used for this study. The price variables have been tested for unit roots both at level and first difference form.

To distinguish the presence of a unit root in the percentage price changes of sorghum, the Augmented Dickey-Fuller (ADF) test was employed by estimating the following equation (with constant only and with constant and trend) and testing for the corresponding null hypothesis:

$$\Delta P_{i,t} = \beta_0 + \sigma \Delta P_{pi,t-1} + \sum \beta_i \Delta P_{pi,t-k} + \epsilon_i \quad (3)$$

H_0 : Percentage price change in the market I has a unit root. Where. ϵ_i is the random term and β_0 , σ and β_i are coefficients to be estimated and tested. The stationarity of the residuals from the individual time series is not sufficient to avoid spurious regressions. 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 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. If the variables have unit roots and are co-integrated, the vector error correction model should be used.

2.2.2. Lag length Determination

Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Criterion (HQC), are the most common techniques that were used to determine the lag length of a time series data. However, for this study, based on the monthly percentage price changes, the lag structure was identified using Akaike information criterion (AIC). The AIC procedure is one of the information based criterion most commonly used in econometrics, which suggests the choice of minimum number of explanatory variables to minimize the objective function that trades off parsimony against reduction in sum of squares (Akaike, 1969).

The lag identification procedure avoids the problem of the use of uniform lag length. The lag length for percentage

price changes in markets i and market j, was simultaneously estimated by the following objective function;

$$AIC_{ij} = In\sigma_{ij}^2 + \frac{2q}{N} \quad (4)$$

Where AIC_{ij} is the AIC statistic between prices of markets i and j; σ_{ij}^2 is estimated sample Variance; N is sample size of the time period; and q is the number of explanatory variables in the model including the intercept. Since both prices in market i and j respond to the same type of shock occurred in other markets, the problem of simultaneity is expected and that the error terms will be correlated with prices in market j. To overcome the problem of simultaneity, an instrumental variables estimation of $\Delta P_{j,t}$ was used, taking lagged values of the prices of all markets included in the study (Goletti and Christina-Tsigas, 1995).

2.2.3. Johansen and Juselius Co integration Test

(Johansen and Juselius, 1990), suggests the 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. These test statistics are computed as:

$$Jmax(r) = -T * In(1 - \lambda + 1) \quad (5)$$

Where r 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 cointegrating 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:

$$Jtrace(r) = -T * \sum_{i=r+1}^k In(1 - \chi_i) \quad (6)$$

The results of the trace test are preferred while Trace and Maximum Eigen value statistics come up with different results in some cases (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 the Vector Error Correction Model (VECM).

2.2.4. Vector Error Correction Model (VECM)

After establishing the presence of co-integration between the price series, the vector error correction model was estimated. Since co-integration regression on long-run relationships between the series of variables, the Error Correction Model (ECM) was developed to measure short-run dynamics between the first differences of the time series variables. (Ikudayisi and Salman, 2010) stated that VECM

examined the dynamic adjustment of time series variables towards their equilibrium. If the ECM has a negative and significant coefficient, this suggests that short-term fluctuations eventually culminate into a stable long-run association between the series. Thus, general representation of the Error Correction Model can be defined as:

$$\Delta Y_t = \alpha_1 + (1 - \alpha_2) \left[\frac{\alpha_0 + \alpha_1}{1 - \alpha_1} X_{t-1} - Y_{t-1} \right] + \epsilon_t \quad (7)$$

The generalized form of the equation for k lags and an intercept term is as follows:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{k=1} \alpha_{11} \Delta X_{t-i} + \sum_{i=1}^{k=1} \alpha_{12} \Delta Y_{t-i} + m_0(m_1 X_{t-k} - Y_{t-k}) + \epsilon_t \quad (8)$$

Where, $m_0 = \left(1 - \sum_{i=1}^k \alpha_{12}\right)$, and $m_1 = \sum_{i=1}^k \alpha_{11}$

The α_{ij} coefficients represent the short run effects and coefficients represent the stationary long run impacts of the right hand side variables. The parameter m_0 measures the rate of adjustment of the short run deviations towards the long run equilibrium. ϵ_t is independently and identically distributed error term.

2.2.5. Causality tests

Granger causality test was used to establish the existence of a central market (Granger, 1969). Unlike the expected commodity flows, the test for information flow was conducted in both directions for all selected market pairs. This is important because more than one mode of price formation could coexist in a marketing system. Prices could be formed by both the reference and the local markets because local markets could form prices based on the price formed in the reference market. Local markets could fix prices in collusion or cooperative ways (Palaskas and Harriss-White, 1993). This real situation calls for the need to analyze the impact of price shocks in both directions. The test involves estimating the following simple vector auto-regressions (VAR):

$$X_t = \sum_{i=1}^n \alpha_i Y_{t-i} + \sum_{j=1}^n \beta_j X_{t-j} + \mu_{1t} \quad (9)$$

$$Y_t = \sum_{i=1}^m \lambda_i X_{t-i} + \sum_{j=1}^m \delta_j Y_{t-j} + \mu_{2t} \quad (10)$$

Where it is assumed that the disturbances. μ_{1t} and μ_{2t} are uncorrelated. Equation 9 represents that variable X is decided by lagged variable Y and X, so does equation (10) except that its dependent variable is Y instead of X. Granger-Causality means the lagged Y influence X significantly in equation 9 and the lagged X influence Y significantly in

equation 10. In other words, researchers can jointly test if the estimated lagged coefficient $\sum \alpha_i$ and $\sum \lambda_j$ are different from zero with F-statistics. When the joint test reject the two null hypotheses that $\sum \alpha_i$ and $\sum \lambda_j$ both are not different from zero, causal relationships between X and Y are confirmed. The Granger-Causality test is easy to carry out and be able to apply in many kinds of empirical

studies. Based on this idea, markets were tested for their unidirectional, bilateral (interdependent), or independent (segmented) relationships by the following F-statistic.

$$F = \frac{(R_{ur}^2 - R_r^2)/m}{(1 - R_{ur}^2)/\frac{N}{k}} \quad (11)$$

Where, R_{ur}^2 is unadjusted coefficient of determination for unrestricted regression; R_r^2 is unadjusted coefficient of determination for restricted regression; k = number of parameters estimated in the unrestricted regression; m = number of linear restrictions (explanatory variables omitted in the restricted regression); and N =sample size in the unrestricted regression.

3. Results and Discussions

3.1. Unit root test

Prior to co-integration analysis, it is important to test for the unit roots. Hence, for this study, unit root test was conducted with the help of the Augmented Dickey-Fuller (ADF) test that

was proposed by (Dickey and Fuller, 1979). The tests were applied to each markets over the period of 2010-2020 both at level form and first difference.

The result of ADF test showed that for all markets the calculated value of F statistics is greater than the upper bound critical value at their level form and less than the critical value for the first difference. Hence, the series are non-stationary at level form and stationary at the first difference for all markets (Table 1). In another word, the ADF test of variables in their first difference shows that the null hypothesis of there is a unit root test can be rejected at the conventional 1%, 5% and 10% level of significance. Thus, since these variables become stationary after differencing once, they are said to be integration of level one (I (1)) order (Gangadharrao, 2004). Hence, the results allow proceeding for co-integration tests for the testing of the long run equilibrium relationship.

3.2. Lag-order selection criterion

Selection of appropriate lag is regarded as one of the crucial steps that must be done before running Co-integration and Granger Causality tests. Therefore, a multivariate lag selection criterion was used to determine the appropriate lag length. Hence, three criteria namely; Schwarz Bayesian information criterion (SBIC), Hannan-Quinn criterion (HQC) and Akaike

Table 1: Result of unit root test

Level form				First Difference				O. integration	
Markets	With constant Only		With constant and trend		With constant only		With constant and trend		
	Test Statist	P-value	Test Statist	P-value	Test Statist	P-value	Test Statist		P-value
Addis	0.193	0.455	-2.50	0.327	-4.878	0.000	-4.944	0.000	I(1)
Adama	-2.109	0.037	-4.55	0.001	-8.393	0.000	-8.328	0.000	I(1)
Diredawa	0.165	0.869	-2.81	0.191	-4.904	0.000	-4.949	0.000	I(1)
Bedesse	0.235	0.815	-2.83	0.183	-6.055	0.000	-6.056	0.000	I(1)
Abomsa	-0.234	0.816	-3.33	0.061	-4.808	0.000	-4.791	0.001	I(1)
Jigjiga	-0.132	0.895	-2.52	0.316	-5.704	0.000	-5.734	0.000	I(1)

Source: Computed from monthly retailer data in Ethiopian Grain Trade Enterprise (EGTE)

Table 2: Lag-order selection criterion

Lags	SBIC	HQIC	AIC
0	135.8111	134.7738	134.7738
1	137.3093*	135.6473	134.5099
2	137.3157	135.534	134.3148
3	137.3716	135.4968*	134.2139*
4	137.404	135.4627	134.1343
5	137.4437	135.4626	134.1068
6	137.4287	135.4342	134.0694

Source: Computed from monthly retailer data in Ethiopian Grain Trade Enterprise (EGTE)

information criterion(AIC) were used to determine the optimum lag length. The optimal number of lags was selected based on the value of those criterions as indicated by Table 2 below.

The result in Table 2 above shows that candidate of optimal lag of the AIC and HQIC is lag 3; optimal lag of SBIC is lag 1. However, since there is more than one candidate for optimal lag, the value of R2 from the VECM analysis was checked with lag 1 and lag 3. Based on the results of VECM analysis, lag 3 is found to be an optimal lag for this model because it yields higher R2. Besides, according to rule-of-thumb, since AIC generate the lowest values(134.21) compared to the value of HQIC(135.49), it is chosen as the better criterion with optimal lags of 3.

3.3. Johansen co-integration tests

A set of variables is defined as co-integrated if a linear combination of them is stationary (Brooks, 2008). Co-integrated variables may also be seen as constituting a long-term relationship or equilibrium relationship. This is because market forces, such as the arbitrage process among integrated markets, are expected to bring a price difference to an equilibrium position. Therefore, in co-integrated variables, a short-run deviation from a long-run equilibrium position is possible, but in the long term, arbitrage processes would restore the price difference to an equilibrium position. Since the price series is non-stationary and integrated of the same order, co-integration analysis is therefore appropriate to investigate the long-run relationship among sorghum market prices. Hence, for this study, Johansen co-integration test was examined in order to look at the existence of long run equilibrium

relationship between variables by trace static and maximum Eigen value test static. With these tests, the decision to reject or not to reject the null hypothesis is made by comparing the computed trace and maximum Eigen values with given critical values at 1% and 5% level of significance. Besides, given the large number of sorghum markets, co-integration tests are conducted in a pair-wise fashion.

The result of Johansen co-integration test clearly shows that the null hypothesis of no co-integration is rejected by both max and the trace statistics(Table3). While the trace statistics shows five co-integration equations at 5% level of significance, maximum Eigen value statistics shows 4 co-integration equations at 5% level of significance. According to Harris and Sollis(1995) in Johansen approach to co-integration max Eigen statistics rejects null hypothesis whenever it is true because of small sample size of the data. Thus, the rejection of one co-integration approach by max Eigen statistics may be due to small sample size. Moreover, although the result from max Eigen statistics shows no co-integration between Addis Abeba and the regional sorghum market of Diredawa, results from trace statistic of the Johansen cointegration tests shows that there was cointegration between Addis Ababa and the regional sorghum market of Diredawa. However, result from both trace and

max Eigen statistics shows that there was no co-integration between Addis Abeba and the regional sorghum market of Abomsa. Similarly, the existence of a long-run relationship between the remaining market pairs suggests that there was supply of sorghum from the surplus areas to deficit areas. These results are similar to those of (Ahmad and Gjøllberg, 2015), (Habte, 2016), (Lupiya, 2018) and (Yami, 2020), who found long-run relationship between market pairs.

3.4. Vector error correction model

The ADF test results approved that a vector error correction (VECM) model is more pertinent than a vector auto regression (VARM) model to distinguish the multivariate interactions among the price series (Engle and Granger, 1987). 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 indicates a backward movement towards equilibrium; a positive sign indicates movement away from equilibrium.

Table 3: Results of Johansen co-integration tests

Trend: trend		Number of observation = 128				
Sample: 2010m5 - 2020m12		Lags = 3				
Market pairs	Trace statistic	0.05 critical value	0.01 critical value	Max Eigen statistic	0.05 critical value	0.01 critical value
None	203.3060	104.94***	114.36***	87.4245	42.48***	48.17***
Addis- Adama	115.8815	77.74***	85.78***	45.6467	36.41***	41.58***
Addis-Dire	70.2348	54.64***	61.21***	27.8398	30.33	35.68
Addis-Bed	42.3950	34.55**	40.49***	25.2031	23.78***	24.43***
Addis- Abomsa	17.1919	18.17	23.46	12.2988	16.87	21.47
Addis- Jigjiga	4.8931	3.74**	6.40	4.8931	3.74**	6.40

Where ** and *** represents level of significance at 5% and 1% respectively
 Source: Computed from monthly retailer data in Ethiopian Grain Trade Enterprise (EGTE)

Table 4: Result from Vector Error Correction Model for the selected Sorghum markets

Variable	Paddis	Padama	Pbedesse	Pabomsa	Pjigjiga	Pdire
ECM	-0.0224 (0.0886) [0.800]	-0.4981*** (0.0772) [0.000]	-0.1322 (0.0879) [0.133]	-0.1310 (0.0885) [0.139]	-0.1047 (0.0882) [0.235]	-0.2114** (0.0867) [0.015]
Paddis (-1)	1*** (1.32e- 09) [0.000]	-0.1126*** 0.01652 [0.000]	1.3874*** (0.2745) [0.000]	0.8081*** (0.0789) [0.000]	0.4028*** (0.0627) [0.000]	0.6192*** (0.0484) [0.000]

Where () and [] are Standard errors and P-values
 Source: Computed from monthly retailer data in Ethiopian Grain Trade Enterprise (EGTE)

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 shows the speed of convergence to the long run equilibrium as a result of shock of their own prices. Hence, in this study, coefficient of error correction term 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/ECM/ are displayed in Table 4 below.

The value of R2 shows that when a percent change in price of Addis Abeba is the dependent variable, 95.97 percent of its price is explained by its previous price, the current and previous prices of all other markets as opposed to others markets. The coefficients of the error correction term (ECM) term shows the speed of convergence to the long run equilibrium as a result of shock of their own prices. The coefficient of the error correction term for Addis Abeba, Bedesse, Abomsa and Jigjiga markets have the expected negative sign. However, they are not statistically significant. This result is also consistent with the finding of Henry and Rebecca (2012). Besides, the estimate of the error correction coefficients for the selected sorghum markets indicate that the Adama and Diredawa markets are significant with expected negative sign indicating that any disequilibrium in the long run retail price would be corrected

in the short run. Thus, the short run price movements along the long run equilibrium path may be stable (Table 4). The significant value implies that there is a conservative force tendency to bring the model back into equilibrium whenever it strays too far.

The speed of adjustment for Adama retail sorghum price was statistically significant at 1% level with absolute value of 0.4981. This implies that 49.81 percent of the disequilibrium would be restored towards equilibrium within a month after a shock. Thus, it takes almost two months for the Adama price to fully adjust if there is no additional shock in retail price. Hence, its speed of adjustment was higher than other sorghum market prices which is the reflection of price transmission with respect to speed. Similarly, the speeds of adjustment for Diredawa retail sorghum price were also statistically significant at 5% level with absolute value of 0.2114 which implies that 21.14 percent of the disequilibrium would be restored towards equilibrium within a month after a shock. Thus, it takes more than four months for the Diredawa price to fully adjust if there is no additional shock in retail price. Although its value is less than that of Adama sorghum price, it is higher than other sorghum market prices which is an indication of price transmission with respect to speed. These an interesting result suggests that with the safety shock, Adama and Diredawa prices adjust more quickly and are more flexible than farm prices to restoration in the long-run equilibrium. This result is also consistent with the finding of (Habte, 2016), (Lupiya, 2018) and (Yami, 2020), who found a negative and statistically significant value for speed of adjustment among markets.

Although there were the existences of market integration from the result of co-integration test, the result of error correction model demonstrates that there could be disequilibrium in the short run. Hence, it may take some time for spatial price adjustments to occur. In terms of efficiency,

Table 5: Granger causality test

Pair wise Granger causal test		F-Statistics	Probability	Direction
Addis Abeba	Adama	288.21	0.000	Unidirectional
Adama	Addis Abeba	0.52953	0.467	Unidirectional
Addis Abeba	Bedesse	2.4135	0.120	Independent
Bedesse	Addis Abeba	0.84904	0.357	Independent
Addis Abeba	Abomsa	0.00119	0.972	Independent
Abomsa	Addis Abeba	1.6997	0.192	Independent
Addis Abeba	Jigjiga	22.715	0.000	Bidirectional
Jigjiga	Addis Abeba	15.035	0.000	Bidirectional
Addis Abeba	Diredawa	0.50608	0.477	Unidirectional
Diredawa	Addis Abeba	35.689	0.000	Unidirectional
Adama	Bedesse	0.10168	0.750	Unidirectional
Bedesse	Adama	22.671	0.000	Unidirectional
Adama	Abomsa	9.0859	0.003	Bidirectional
Abomsa	Adama	53.174	0.000	Bidirectional
Adama	Jigjiga	0.32489	0.569	Unidirectional
Jigjiga	Adama	83.576	0.000	Unidirectional
Adama	Diredawa	0.01801	0.893	Unidirectional
Diredawa	Adama	135.66	0.000	Unidirectional
Bedesse	Abomsa	0.09317	0.760	Independent
Abomsa	Bedesse	3.3368	0.118	Independent
Bedesse	Jigjiga	0.89376	0.344	Independent
Jigjiga	Bedesse	1.3281	0.249	Independent
Bedesse	Diredawa	3.0941	0.079	Bidirectional
Diredawa	Bedesse	6.0151	0.014	Bidirectional
Abomsa	Jigjiga	0.01316	0.909	Unidirectional
Jigjiga	Abomsa	6.5938	0.010	Unidirectional
Abomsa	Diredawa	1.0661	0.302	Independent
Diredawa	Abomsa	0.11605	0.733	Independent
Jigjiga	Diredawa	1.2384	0.266	Independent
Diredawa	Jigjiga	0.73535	0.391	Independent

Source: Computed from monthly retailer data in Ethiopian Grain Trade Enterprise (EGTE)

prices are transmitted fully and completely given efficient market conditions. The fact that price dynamics differ might point to imperfect market conditions that can lead to market inefficiencies.

3.5. Granger causality tests

The result of co-integration analysis does not show the direction of the relationship. Hence, it is important to run granger causality tests which shows the nature of the relationship among

the markets. Granger causality means the direction of price formation between two markets and related spatial arbitrage (Mtumbuka et al., 2014). It can be bidirectional causation when the shocks between the markets are transmitted in either direction or unidirectional causality when shocks are one-way and cannot be reversed between two markets(Table 5).

The findings in Table 5 above indicate that there was bidirectional causality between Addis Abeba and Jigjiga, Adama and Abomsa, and Bedesse and Diredawa sorghum prices. Hence, the Addis Abeba sorghum market Granger caused price formation in the Jigjiga sorghum

market which in turn provided feedback to the Addis Abeba base market as well. Similarly, Adama Granger caused price formation in the Abomsa sorghum market

which in turn provided feedback to the Adama base market as well. Consequently, Bedesse Granger caused price formation in the Diredawa sorghum market which in turn provided feedback to the Bedesse base market as well. Thus, the bidirectional causality between mentioned markets suggested that there was efficiency and market information among the market participants. It also implies that there is trade between the market pairs and price in Addis Abeba, Adama and Bedesse could be predicted using Jigjiga, Abomsa and Diredawa market prices and vice versa respectively. That is, any shock in either market is simultaneously translated to the other market pair. This result is also consistent with the finding of (Bannor and Sharma, 2015), (Worako, 2015), (Habte, 2016), (Lupiya, 2018) and (Yami, 2020), who found bidirectional causation between market pairs. On the other hand, the existence of independent causation between Addis Abeba and Bedesse, Addis Abeba and Abomsa, Bedesse and Abomsa, Bedesse and Jigjiga, Abomsa and Diredawa, Jigjiga and Diredawa market pairs meant lack of market information and lack of efficiency. This result is also consistent with the finding of (Ani, 2015). However, lack of causality could not mean an absence of price transmission in the long-run.

Furthermore, there were unidirectional relationships between Addis Abeba and Adama, Diredawa with Addis Abeba and Adama, Jigjiga with Adama and Abomsa markets. Hence, the Addis Abeba sorghum market relied on Adama sorghum price information to set its own price. However, Adama sorghum market prices did not depend on Addis Abeba sorghum price to fix price. Similarly, the Diredawa sorghum market relied on Addis Abeba and Adama sorghum price information to set its own price. However, Addis Abeba and Adama, sorghum market prices did not depend on Diredawa sorghum price to fix price. Similarly, the Jigjiga sorghum market relied on Adama and Abomsa sorghum price information to set its own price. However, Adama and Abomsa sorghum market prices did not depend on Jigjiga sorghum price to fix price. This result is also consistent with the finding of (Worako, 2015), (Habte, 2016) and (Lupiya, 2018), who found unidirectional relationships between market pairs.

4. Conclusion and Recommendations

Market integration is an engine to assure food security, economic growth, enhance producers and consumers surplus if applied and explained properly. Hence, this paper examines spatial market integration and price transmission of selected sorghum markets in Ethiopia. The Oromia and Amhara from surplus producing regions and Somali study region from deficit area were purposively selected based on their annual per capital sorghum production potential. A total of six markets were selected for the analysis by considering Addis Ababa as central market, Adama from the nearest market to the central market, Diredawa from the remotest market from the central market, Bedesse and Abomsa markets from surplus producing market and Jigjiga

market from deficit market. Besides, to analyze the market integration and price transmission of the selected markets, ADF test was applied for the stationarity test, Johansen co-integration tests for co-integration test, Engle-Granger test for causality and VEC model analysis was used to estimate the speeds of price transmission.

The result of Augmented Dickey fuller (ADF) test revealed that all selected markets price are non-stationary at level but stationary after the first difference. Johansen co-integration tests indicate that although there was long run co-integration of five sorghum prices at 5% level of significance in trace statistics, maximum Eigen value statistics revealed that four co-integration equations at 5% level of significance. The results of Granger causality indicated that there was bidirectional causality between Addis Abeba and Jigjiga, Adama and Abomsa and Bedesse and Diredawa sorghum prices which were the reflection of the existence of trade between the market pairs. However, there were unidirectional relationships between Addis Abeba and Adama, Diredawa with Addis Abeba and Adama, Jigjiga with both Adama and Abomsa markets. Similarly, the finding also revealed that there were independent causation between Addis Abeba and Bedesse, Addis Abeba and Abomsa, Bedesse and Abomsa, Bedesse and Jigjiga, Abomsa and Diredawa, Jigjiga and Diredawa market pairs, which was the indication of lack of market information and lack of efficiency.

The result of vector error correction model also pointed out that for the selected sorghum markets, the Adama and Diredawa markets are significant with a correct negative sign indicating any disequilibrium in the long run retail price would be corrected in the short run at

their respective speed of adjustment. However, in the short-run, the speed of adjustment for the remaining markets of sorghum prices were relatively low, implying that there were differences in arbitrage opportunities and which may be because of increased transportation costs, imperfect price information, lack of good governance and many other internal and external factors towards market integration.

Arising from the results of the study, the following recommendations were forwarded:

- The speeds of price transmission were slow for almost all sorghum prices. These may be because of increased transportation costs, imperfect price information and lack of good government, infrastructural and institutional arrangement. Hence, government should create conducive policy environments through improvement in free flow of price information, reduction of transaction costs, improvement in provision of quality infrastructures, improved institutional arrangement and encouraging farmers in production and marketing of sorghum.
- Further research is required to investigate the influence of external and internal factors such as market infrastructure, government policy and self sufficient production, product characteristics and utilization towards market integration.

- This paper focused on spatial market integration and price transmission among selected sorghum markets in Ethiopia using only six markets. Thus, future studies should include more than six markets to see the flow of market price information.

Conflict of Interest

The author declares that they don't have conflict of interest.

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