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# Market Integration For Oxen Prices Using Vector Error Correction Model (Vecm) In Ethiopia

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**Abstract**: This study attempts to analyse the degree of spatial domestic oxen market integration; and examines price adjustment and prices causality. The result of Augmented Dickey Fuller (ADF) test indicates that the three variables were non-stationary at their levels, and stationary at their first difference. The Johansen's co-integration test indicated that two co-integrating vectors implying that two oxen markets were linked together. The result of the VECM reveals that estimated adjustment vector coefficients have the correct signs (negative) at 1% significant level and imply moderate speed of price adjustment to ward equilibrium.

**Key Words:** Oxen Markets, Co-integration, Market integration, Price adjustment, VECM

## 1. INTRODUCTION

Spatial market integration refers to co-movements or the long-run relationship among prices. It is defined as the smooth transmission of price signals and information across spatially separated markets [1]. Two trading markets are assumed integrated if price changes in one market are manifested in an identical price response in the other market [2]. The greater degree of integration indicates efficient interaction among markets, movement of livestock more efficiently over space, and a better use of scarce resources [3]. In Ethiopia, livestock production is fountainhead of incomes and diets; however, its market is still deemed weakly integrated due to higher transportation cost. Therefore, traders could not move livestock from surplus (low price) to deficit (high price) areas, which lead to regional price differences [4]. Similarly, cattle volumes decline in some regions and increase in other regions, regional cattle prices could differ because of poor information flow across regions; in the presence of these influences, price changes across market regions may not fully reflect relevant economic conditions[5]. Thus, it is crucial to conduct the research because there is no empirical evidence about the strength and speed of spatial market integration in Ethiopian oxen markets. So, this study helps to come up with latest, accurate, reliable, and prompt information about market integration of oxen prices across markets in Ethiopia. This study, therefore, attempts to evaluate the degree of spatial domestic oxen market integration; and examines price adjustment and prices causality.

## 2. METHODS OF ANALYSIS

**Johansen and Juselius Co-integration Test:** the Maximum Eigenvalue test and the Trace test[6], are used as procedures to determine the number of co-integration vectors. The Maximum Eigenvalue statistic tests the null hypothesis of r co-integrating relations against the alternative of r+1 co-integrating relations for r = 0, 1, 2…n-1. This test statistics are computed as:

$$LR\left(\frac{r}{n+1}\right) = -T * log\left(1-\hat{\lambda}\right) \qquad (1)$$

Where $\hat{\lambda}$ is the estimated Maximum Eigenvalue and T stands for the sample size.

The main difference between the two test statistics is that the trace test is a joint test, whereas the maximum Eigenvalue test conducts separate tests on the individual eigenvalues. Trace statistics examines the null hypothesis of r co-integrating relations against the alternative of n cointegrating relations, where n is the number of variables in the system for r = 0, 1, 2…n-1. Its equation is computed according to the following formula:

$$TR\left(\frac{r}{n}\right) = -T * \sum_{i=r+1}^{n} log\left(1-\hat{\lambda}i\right) \qquad (2)$$

The results of trace test should be chosen where Trace and Maximum Eigenvalue statistics may yield different results in some case[7].

**Vector Error Correction Model (VECM)**

If a VECM is used to estimate price adjustment, one implicit assumption must be noted. 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. A specification of a VECM is given in the following equation:

$$LnYt = \delta + A_1 lnY_{t-1} + A_2 lnY_{t-2} +, \ldots, + A_{p-1} lnY_{t-p+1} + \varepsilon t \qquad (3)$$

Where Yt is an (n x 1) vector of endogenous variables(Ln of prices), δ is an (n x 1) vector of parameters, **y** and $\mathbf{y}_{t-p}$ 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 three oxen 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.

$$\Delta \ln Yt = \mu + \Gamma 1 \Delta \ln Y_{t-1} + \Gamma 2 \Delta \ln Y_{t-2}, \ldots, + \Gamma k + 1 \ \Delta \ln Y_{t-k+1} + \pi \ln Y_{t-k} + \varepsilon t \quad (4)$$

Where $y_t$ =[P1t, P2t]', vector of endogenous variables, which are I(1), $\Delta$ yt= yt- $y_{t-1}$, $\mu$ is a (2×1) vector of parameters, $\Gamma_1$,..., $\Gamma_{k+1}$ and $\pi$ are (2×2) matrices of parameters, and εt is a (2×1) vector of white noise errors. Where $\pi$ is of a reduced rank, that is r≤1, it can be decomposed into $\pi = \alpha\beta'$ and when r=1, α= $[\alpha_1, \alpha_2]'$ is the adjustment vector and β= $[\beta_1, \beta_2]'$ is the cointegrating vector. In this case, equation (5) can be restated as equation (6):

$$\begin{bmatrix} \Delta \ln P1t \\ \Delta \ln P2t \end{bmatrix} = \begin{bmatrix} \mu 1 \\ \mu 2 \end{bmatrix} + \sum_{i-1}^{k-1} \begin{bmatrix} \Gamma i, 11 & \Gamma i, 12 \\ \Gamma i, 21 & \Gamma i, 22 \end{bmatrix} \begin{bmatrix} \Delta \ln P1t - i \\ \Delta \ln P2t - i \end{bmatrix} + \begin{bmatrix} \alpha 1 \\ \alpha 2 \end{bmatrix} [\beta 1 \ \ \beta 2] \begin{bmatrix} \ln P1t - k \\ \ln P2t - k \end{bmatrix} + \begin{bmatrix} \varepsilon 1t \\ \varepsilon 2t \end{bmatrix} \quad (6)$$

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[8]. 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.

$$\Delta \ln Pi1 = \alpha o + \sum_{t=1}^{n} \beta i \, \Delta \ln P(t-1)i + \sum_{t=1}^{n} \beta i \, \Delta \ln P(t-1)j + \delta ECTt - 1 + \mu t + \quad (7)$$

$$\Delta \ln Pj1 = \varphi o + \sum_{t=1}^{n} \sigma j \, \Delta \ln P(t-1)j + \sum_{t=1}^{n} \sigma i \, \Delta \ln P(t-1)i + \lambda ECTt - 1 + \varepsilon t \quad (8)$$

Where Δ is the difference operator, P*jt* is the price series in the Addis Ababa market (i=1), P*ij* is the price series in Bodit and Addis Ababa markets (j=2,3) and are white noise error terms, *ECTt-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[9].

## 3. RESULTS AND DISCUSSIONS

Diagnostic tests The tests were applied to each variable over the period of 2006-2012 without and with drift at the variables level and at their first difference in Table1.

**Table 1:** ADF unit root test results for oxen prices

| Oxen price(Ln) | Without drift | | | With drift | | |
|---|---|---|---|---|---|---|
| | Lag length | ADF statistics | | Lag length | ADF statistics | |
| Levels | | | p-value | | | p-value |
| Sodo price(LnP1) | 1 | 1.798 | 0.983 | 1 | -0.929 | 0.779 |
| Bodit price(LnP2) | 1 | 2.373 | 0.996 | 1 | -2.960 | 0.038 |
| Addis Ababa price(LnP3) | 1 | 1.730 | 0.980 | 1 | -2.265 | 0.183 |
| First difference | | | | | | |
| Sodo price(LnP1) | 1 | -3.437*** | 0.0006 | 1 | -3.682*** | 0.0043 |
| Bodit price(LnP2) | 1 | -3.467*** | 0.0005 | 1 | -3.993*** | 0.0014 |
| Addis Ababa price(LnP3) | 1 | -3.470*** | 0.0005 | 1 | -3.993*** | 0.0014 |

Note: *** indicates that unit root in the first differences are rejected at 1% significance levels.
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 three variables were stationary and integrated of same order, i.e., I (1) at their first difference for both without drift and with drift, 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. Johansen's the trace and $\hat{\lambda}$-max tests rejected first hypothesis ($r$ = 0) of no co-integrating vector at 1% level of significant; Johansen trace statistic rejected third hypothesis(r=2) at 5% level of significant and the second hypothesis ($r$ = 1) was accepted by both tests. In other words, this trace test result rejected the null hypotheses (, $r$ = 0, $r$ = 2) because these two variables were co-integrated (see Table).

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**Table 2:** Results of Johansen co-integration tests for three market prices

| Sample : 2006:10 - 2012:08 | | number of observation =71<br>Lag=1 | |
|---|---|---|---|
| Maximum rank | Eigenvalue | Trace statistic | P value |
| 0 | 0.37727 | 48.162*** | 0.0009 |
| 1 | 0.12243 | 14.533 | 0.2602 |
| 2 | 0.071421 | 5.2611** | 0.0447 |
| Maximum rank | Eigenvalue | Lmax statistic | |
| 0 | 0.37727 | 33.628*** | 0.0005 |
| 1 | 0.12243 | 9.2723 | 0.4174 |
| 2 | 0.071421 | 5.2611 | 0.2648 |

Note: *** and ** indicate that no co-integrating vectors are rejected at 1% and 5% significance levels respectively.
Source: Computed from data in Central Statistic Agency (CSA) of Ethiopia.

**Table 3:** Co-integrating and adjustment vectors of the VEC model results

| Price | Co-integrating vectors (β) | | Adjustment vectors (**α**) | | Adjusted $R^2$ | Durbin Watson |
|---|---|---|---|---|---|---|
| Default 1 | | | | | | |
| Sodo price($LnP_1$) | 1.00 | 0.00 | -0.302** (0.116) | 0.135 (0.143) | 0.068 | 2.39 |
| Bodit price($LnP_2$) | 0.000 | 1.00 | 0.025 (0.119) | -0.458*** ( 0.148) | 0.128 | 2.40 |
| Addis Ababa price($LnP_3$) | -0.609 (0.162) | -0.779 (0.076) | -0.159 (0.135) | 0.419** (0.168) | 0.057 | 2.38 |
| Default 2 | | | | | | |
| Addis Ababa price($LnP_3$) | 1.00 | 0.000 | -0.229** (0.113) | -0.159 (0.135) | 0.057 | 2.38 |
| Sodo price($LnP_1$) | 0.000 | 1.000 | 0.079 (0.097 ) | -0.302** (0.116) | 0.067 | 2.39 |
| Bodit price($LnP_2$) | -1.283 (0.119) | -0.782 (0.157) | 0.341*** (0.0998) | 0.025 (0.119) | 0.128 | 2.40 |
| Log-likelihood = 65.418255 | | | | | | |
| Determinant of covariance matrix = 3.1788723e-005 | | | | | | |

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.

**Vector Error Correction 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 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. The estimate of the error correction coefficients for the selected oxen markets indicate that the Wolaita Sodo market is significant at 5 percent with a correct sign (negative) indicating any disequilibrium in the long run producer price would be corrected in the short run thus, the short run price movements along the long run equilibrium path may be stable (see Table 3). The coefficient of adjustment vector (**$\alpha_2$**) for Bodit was significant at 1% percent with the correct sign. The coefficient of adjustment vectors (**$\alpha_2$**) for Addis Ababa 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. About 30 percent of the disequilibrium corrected for each month in Wolaita Sodo market is by changes in its own prices and the remaining influenced by other internal and external market forces. Accordingly, 46 and 42 percent of disequilibrium corrected for each month in Bodit and Addis Ababa market respectively are by changes in their own prices and the remaining influenced by other internal and external market forces. The speed of adjustment of 30% from the short run to the long run equilibrium in the Wolaita Sodo market is relatively lower as compared to other markets. However, the speed of adjustment of 47% and 42% for Bodit and Addis Ababa markets is relatively moderate as compared to a perfect adjustment. Granger causality is also estimated between pairs of oxen markets. 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-4 gives the results of the Granger causality test which show that, in one cases, i.e., Wolaita Sodo and Bodit there exists bidirectional causality. On other hands, two pairs markets,

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Addis Ababa has unidirectional relationships with both Wolaita Sodo and, Bodit the base market.

**Table 4:** Granger Causality from Error Correction Model

| Causality | F-Statistics | P-Value | Direction |
|---|---|---|---|
| Sodo market → Bodit Market | 11.3112** | 0.00127 | Bidir |
| Bodit Market → Sodo market | 6.85207** | 0.01090 | ectional |
| Sodo market → Addis Ababa Market | 14.6147*** | 0.00029 | Unidirectional |
| Addis Ababa Market → Sodo market | 3.23004 | 0.07674 | |
| Bodit Bodit Market → Addis Ababa market | 14.9764*** | 0.00025 | Unidirectional |
| Addis Ababa market → Bodit Market | 0.19482 | 0.66034 | |

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.

## CONCLUSIONS

Johansen's the trace and $\hat{\lambda}$-max tests rejected first hypothesis ($r$ = 0) 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 a month. Prices correct a very small percentage of the disequilibrium in the markets with the greatest 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 self-sufficient production, product characteristics and utilization towards market integration. Results of the Granger causality test indicate that Wolaita Sodo and Bodit oxen market have bidirectional relationship.

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