Cointegration and causality analysis of tur (Pigeon pea) in neighboring states

Sudha Singh, KN Singh, Vishal Gurang, RS Shekhawat, Narinder Panotra and Amarjeet Singh

Abstract
The study has examined co-integration and causality between retail and wholesale market prices of tur crop in Karvi district of UP and Satna district of MP by adopting Johansen’s cointegration approach, Granger causality test. The study confirms the presence of cointegration among retail and wholesale markets prices of tur in Karvi market, indicating the long-run price association between them. Further Granger causality gave additional evidence about direction of price transmission between retail and wholesale market price in Karvi district. The test confirmed presence of bidirectional causality or price transmission. The wholesale price of tur in both i.e. Karvi and Satna market are cointegrated which shown that long term and spatial association of wholesale prices

Keywords: Cointegration, granger causality, price transmission, tur

Introduction
India has traditionally been a pulse importer country despite of the largest producer in the world. India accounts 27% of the total production and 30% of total consumption. India accounts 35% share of world area under pulses (FAOSTAT). Tur contributes second largest share of pulse production after gram. The market for tur is large and widely spread but less lucrative. However, fluctuations in prices often lead to inefficiency and adversely affect the efficient allocation of resources for farmers. If price volatility is higher and more unpredictable, there is greater risk of incurring losses or realizing gains on future sales. Agricultural price volatility and efficient price discovery has always remained a major concern of producers and consumers in a predominantly agrarian economy like India. It elevates the risk for producers who makes planting decision months prior to harvest and provides mixed signals to buyers of agricultural commodities. It is a major concern for the policy makers since volatility in commodities have determined the economic prospects of nations for eons and would continue to do so in the future (Dasgupta and Chakrabarty, 2009) [4]. Price discovery and price volatility could impede the flow of fundamental information across markets, when it reflects excessive speculative noise. (Arnade and Hoffman 2015) [1]. Prices of pulses in India have experienced a significant amount of volatility due to production variability, which has been problematic for various stakeholders.

Given the exposure of farmers to such risks and challenges, it makes their investment in farming an unprofitable proposition. Market based risk management tools for commodities have assumed special significance in the liberalisation era. There is a more important question to know regarding prices, both retail and wholesale, and it is also important to know efficiency of price discovery in both retail and wholesale prices along with their co-integration. Based on the above back ground, an effort has been made in the present study to empirically analyze how information is transmitted between retail and wholesale prices in different markets. Thus the present study makes a modest attempt to assess the retail and wholesale price linkages of tur through econometric evidence.

Materials and Methods
Monthly wholesale price was collected from www.agmarknet.nic for both Karwi and Satna districts from 2007 to 2016. Daily retail price was collected for Karwi district only from Karwi Mandi Samiti as well as from retailer’s shop. All the series were transformed into natural log form to eliminate variations in movement due to level differences.
The analytical techniques used in the study are described below.

**Augmented Dickey-Fuller (ADF) Unit Root Test**

An implicit assumption in Johansen’s cointegration approach is that the variables should be non-stationary at level, but stationary after first differencing. The Augmented Dickey-Fuller test is utilized to check the order of integration by using the model (1):

\[ \Delta Y_t = \alpha + \delta T + \beta_1 Y_{t-1} + \sum_{i=2}^p \beta_i \Delta Y_{t-i} + \varepsilon_t \]  

(1)

Where, \( Y_t \) stands for retail and wholesale market price series in logarithm form and \( \alpha \) is the constant-term, \( \delta \) is the time trend effect, and \( \beta_1 \) is the optimal lag value which is selected on the basis of Schwartz information criterion (SIC). The null hypothesis is that \( \beta_1 \), the coefficient of \( Y_{t-1} \), is zero. The alternative hypothesis is: \( \beta_1 < 0 \). A non-rejection of the null hypothesis suggests that the time series under consideration is non-stationary (Gujarati, 2010) [8].

**Cointegration Analysis Using Johansen Methodology**

The (Johansen 1988) [10] procedure relies on the relationship between the rank of a matrix and its characteristic roots. (Enders 2004) [5] notes that Johansen procedure could be viewed as a multivariate generalisation of the Dickey-Fuller test. Johansen suggests to start with a traditional vector autoregressive model (VAR), to select appropriate number of lags based on the likelihood ratio test or alternatively AIC statistics, to estimate the vector error correction model and determine the rank of the matrix of parameters. The cointegration of the system is tested using the maximum likelihood \( L_{\text{max}} \) which is a function of the cointegration rank. Johansen describes two test methods: (1) Trace Test and (2) Maximum eigen value Test. The trace test is based on the log-likelihood ratio \( \ln L_{\text{max}}(r)/\ln L_{\text{max}}(k) \) and is conducted sequentially for \( r = k-1,1,0 \). The trace test tests the null hypothesis that the cointegration rank is equal to the alternative that the cointegration rank is \( k \). The latter implies that \( \alpha \) is trend stationary. The maximum Eigen value test is based on the log-likelihood ratio \( \ln L_{\text{max}}(r)/\ln L_{\text{max}}(r+1) \), and is conducted sequentially for \( r = 0,1,1,0, \ldots, k-1,1. \) The test tests the null hypothesis that the cointegration rank is equal to the alternative that the cointegration rank is equal to \( r+1 \).

**Granger Causality Test**

The Granger causality test conducted within the framework of a VAR model is used to test the existence of the direction of long-run causal price relationship between the markets (Granger, 1969) [7]. The pattern of causality was identified by estimating regression of retail and wholesale price on all relevant variables including the current as well as past value of retail and wholesale prices respectively. It is an F-test of whether changes in one price series affect another price series. The causality relationship between retail and wholesale as an example, the test was based on the following pairs of OLS regression equations through a bivariate VAR:

\[ \ln S_t = \sum_{i=1}^m \alpha_i \ln S_{t-i} + \sum_{i=1}^m \beta_i \ln F_{t-j} + \varepsilon_t \]  

(2)

\[ \ln F_t = \sum_{i=1}^m \alpha_i \ln F_{t-i} + \sum_{i=1}^m \beta_i \ln S_{t-j} + \varepsilon_t \]  

(3)

Where, \( S \) and \( F \) are retail and wholesale market prices respectively. \( \varepsilon_t \) stands for price series in logarithm form and \( t \) is the time trend variable. The subscript stands for the number of lags of both variables in the system. The null hypothesis in Equation (2), i.e. \( H_0: \beta_1 = \beta_2 = \ldots = \beta_j = 0 \) against the alternative, i.e., \( H_1 \). Not \( H_0 \), is that in \( F \) does not Granger causel \( S \). Similarly, testing \( H_0: \delta_1 = \delta_2 = \ldots = \delta_l = 0 \) against \( H_1 \). Not \( H_0 \) in Equation (3) is a test that \( S \) does not Granger causel \( F \). In each case, a rejection of the null hypothesis will imply that there is Granger causality between the variables (Gujarati, 2010) [8].

**Results and Discussion**

**Retail and wholesale price linkages in Tur crop in Karvi and Satna markets**

**Unit root test**

Before determining the interdependence between retail and wholesale prices, the stationarity of these two series of tur for Karvi and Satna market was tested by using Augmented Dickey Fuller (ADF) and Philip-Perron (PP) tests. In both the series, neither constant or trend term was found to be significant, so it was not included in the equation. Schwarz information criterion (SIC) was used to determine the lag length. The result of the Augmented Dickey-Fuller (ADF) unit root test and Philip-Perron test applied at level and first difference to the logarithmically transformed prices of tur and empirical evidence suggests that both ADF and PP test did not reject the null hypothesis about the presence of unit root at the level form for both the series in Karvi and Satna market as the absolute values of the ADF and PP statistics are well below the critical values of the test statistics. Thus, it is concluded that both the price series (retail and wholesale) of tur are non-stationary at their level forms. So after confirming that both the series contain unit root at their level form, a unit root test of first difference was conducted to find the level or number of unit roots in the data. The unit root test of first difference in both the series confirms the presence of one unit root. The absolute value of ADF and PP statistics were found to be greater than the critical values of the test statistics. So, the unit root tests confirmed that both retail and wholesale price series of tur were non stationary at their level form and were integrated of same order, i.e. I(1). This confirmation suggest that the series must be cointegrated, so accordingly test for cointegration between retail and wholesale price using Johansen’s maximum likelihood approach was applied.

**Johansen’s cointegration test**

This estimation procedure was based on the methodology developed by Johansen (1991) and Johansen (1995). Johansen’s cointegration test was performed to examine the long-run relationship between retail and wholesale price in Karvi and Satna market. As there are only two series involved, the number of co integrating vectors can be at most one for tur crop. Firstly, we performed Johansen’s cointegration test between retail and wholesale price of tur in Karvi market then tested for cointegration between wholesale price of tur in Karvi and Satna market. The results of Johansen’s maximum likelihood tests (maximum eigen-value and trace test) are given in Table 1. To check first null hypothesis that the variables were not cointegrated, trace and max eigen value statistics were calculated, both of which rejected the null hypotheses as maximum eigen value and trace test statistics values were higher than 5 per cent critical values and accepted the alternative of at most one cointegrating vector from both the tests (trace test and maximum eigen-value test) as the trace value and maximum eigen-value were below than their corresponding critical values at 5 per cent level of significance.
Table 1: Johansen cointegration test between retail and wholesale price of tur in Karvi market

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value at 0.05</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.163229</td>
<td>21.6833</td>
<td>15.49471</td>
<td>0.0051</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.010292</td>
<td>1.189721</td>
<td>3.841466</td>
<td>0.2754</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>Critical Value at 0.05</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.163229</td>
<td>20.49358</td>
<td>14.2646</td>
<td>0.0046</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.010292</td>
<td>1.189721</td>
<td>3.841466</td>
<td>0.2754</td>
</tr>
</tbody>
</table>

Note: For Cointegration, it is required that Trace and Max-Eigen value should be less than critical value and p-value should be more than 5%. Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level.

These test provides confirmation that retail and wholesale price had at most one cointegrating vector indicating that they are well integrated with each other and price signals are transferred between them to ensure efficiency, demonstrating that the selected retail and corresponding wholesale price in Karvi market have long-run price association between them. This can be seen through Graph 1 between retail and wholesale price of tur in Karvi market.

The results of Johansen’s maximum likelihood tests (maximum eigen-value and trace test) between wholesale price of tur in Karvi and Satna market are given in Table 2 which is same as retail and wholesale price of tur in Karvi market.

Table 2: Johansen’s Co-integration test between wholesale price of tur in Karvi and Satna market

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>Critical Value at 0.05</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.132354</td>
<td>18.89173</td>
<td>15.49471</td>
<td>0.0148</td>
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<tr>
<td>At most 1</td>
<td>0.022057</td>
<td>2.565001</td>
<td>3.841466</td>
<td>0.1093</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>Critical Value at 0.05</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.132354</td>
<td>16.32673</td>
<td>14.2646</td>
<td>0.0233</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.022057</td>
<td>2.565001</td>
<td>3.841466</td>
<td>0.1093</td>
</tr>
</tbody>
</table>

Note: For Cointegration, it is required that Trace and Max-Eigen value should be less than critical value and p-value should be more than 5%. Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level.

To check first null hypothesis that the variables were not cointegrated, trace and max eigen value statistics were calculated, both of which rejected the null hypotheses as maximum eigen value and trace test statistics values were higher than 5 per cent critical values and accepted the alternative of at most one cointegrating vector from both the tests (trace test and maximum eigen-value test) as the trace value and maximum eigen-value were below than their corresponding critical values at 5 per cent level of significance.

This test provides confirmation that wholesale price of Satna and Karvi market had at most one cointegrating vector indicating that they are well integrated with each other and price signals are transferred between them to ensure efficiency, demonstrating that wholesale price in Karvi and Satnamarkets have long-run price association. This long run price association between both market ensure efficient price discovery, which is beneficial for overall marketing system of tur in Karvi and Satna market. This can be seen through Graph 2 between wholesale price of tur in Karvi and Satnamarkets.
Asymmetry in price transmission from wholesale to retail trade of tur in Karvi market.

After finding cointegration among different markets (Karvi and Satna) and prices (retail and wholesale), asymmetry in price transmission from wholesale to retail trade of tur in Karvi market was also estimated for tur. The Granger causality shows the direction of price formation between two market price. Symmetry in price transmission was tested by granger causality test. Asymmetry in price transmission is represented in Table 3.

Table 3: Price transmission from wholesale to retail trade of tur in Karvi market.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>55.3259</td>
<td>73.6262</td>
<td>0.751443</td>
<td>0.4539</td>
</tr>
<tr>
<td>β1 (upward movement)</td>
<td>0.454966</td>
<td>0.249298</td>
<td>1.824985</td>
<td>0.0706</td>
</tr>
<tr>
<td>β2 (Downward movement)</td>
<td>0.41611</td>
<td>0.238831</td>
<td>1.742277</td>
<td>0.0841</td>
</tr>
<tr>
<td>λ (adjustment coefficient)</td>
<td>0.126741</td>
<td>0.056729</td>
<td>2.234138</td>
<td>0.0274</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.045124</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For existence of Asymmetry</td>
<td>β1 ≠ β2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It was found that price transmission from wholesale price to retail price was symmetric and it was bi-directional which means both the prices affects each other. The symmetric price transmission leads to efficient price discovery which is useful for all the stakeholders of marketing system. β1 (upward movement) and β2 (downward movement) was approximately equal and non-significant at 5 per cent level of significance. When upward and downward movement coefficient is equal and non-significant than adjustment coefficient must be significant. If the Graphical representation of asymmetry in price transmission from wholesale to retail trade is represented by Graph 3.

Graph 3: Error correction graph of wholesale and retail price of tur in Karvi market

In this study, an attempt has been made to look into the cointegration and mechanism of movement of retail and wholesale prices for tur traded in Karvi and Satna market. This study examines the causal relationship between retail and wholesale price in Karvi market and also to verify whether wholesale prices of both (Karvi and Satna) markets were cointegrated or not. The ADF and Philip-Perron test used to test the stationarity of the time series data confirmed that all the retail and wholesale price series of corresponding markets are integrated of order one. Johanson cointegration test has been attempted to find out whether there exists a long-run relationship between retail and wholesale prices of tur in Karvi. Result from maximum eigen value and trace statistics confirmed that there exits at least one cointegrating equation in both retail and wholesale price series of tur in Karvi and Satna market were co integrated with each other. Causality relationship between two prices or market (retail and wholesale market) was confirmed by Granger causality test which indicated presence of bidirectional causality between retail and wholesale price in Karvi market. This provides indication of efficient price discovery among both market. Wholesale prices of both market was also cointegrated. Along with this the gap between retail and wholesale needs to be narrowed so that it may not be exploited by the speculators and the beneficiaries get their respective share.

References