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Price Transmission and Causality in major onion markets of India

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ABSTRACT

To investigate the interdependence between Indian onion markets in terms of wholesale price, the present study was conducted in three major onion markets in India viz., Mumbai, Nashik and Delhi. The long term monthly data, from March, 2003 to September, 2015has been collected from the Agriculture Marketing Information System Network. The current study focuses to explore the degree of market integration through cointegration analysis on the wholesale monthly prices of onion in three markets.The direction of information flow was determined by using Granger Causality test. It is found that in Delhi and Mumbai markets, price transmissions were bi-directional. The study reveals that Nashik market is dominating in terms of price determination. The empirical investigation also suggests for a very close observation on different market behavioural pattern since, "news" in one market may impact other market through the number of interdependencies.

Keywords: Granger Causality,Market Behaviour, Price transmission, Stationarity test, VECM

1. Introduction

Onion is one of the most important vegetable crops for household consumption and also for foreign exchange earner among the vegetables in India. Onion is considered as a most sensitive commodity due to sudden price fluctuation (Chengappa *et al*., 2012). Among the agricultural products, prices of onionsare more volatile than those of the non-farmcommodities due to inherently unstable production.India covers an area of around 1.064 Million hectare (Mha), with production of 15.118 Million tons (MT) and is the 2nd largest producer of onion, next only to China. In India, Maharashtra (4.9 MT) is the largest onion producing state followed by Karnataka (2.5 MT), Gujarat (1.5MT), Bihar (1.08 MT), Madhya Pradesh (1.02 MT) and Andhra Pradesh (0.8 MT). Around 97% of the country's onion harvest is sold in 50 major onion market yards, regulated under the Agricultural Price Monitoring Act (APMC)-2003.The sudden increase in onion market price affects both producers as well as consumers through a spillover effect to the other onion markets which leads to high inflation in the economy. For the market participants, one of the important tasks is to know about price transmission mechanism which can spread instantaneously from one market to another market for price regulation and policy formulation. In this background, an attempt has been made to examine price transmission mechanism among major Indian onion markets.

Marketing of onion in the country is characterised by poor market intelligence coupled with uncertainty in the future prices,has all through been a concern for producers and consumers. A reasonable idea about future prices to prevail at a future date could prove helpful for producers to rationalise their resources for profit maximization. In this regard, market integration and price forecasting could help in stabilising the prices by removing the market imperfections, and attain market efficiency. In literature, Granger (1981, 1986), Granger and Weiss (1983), Engle and Granger (1987), Johansen (1988, 1995 and 1996), Myers (1994) and others, established the basis for cointegration analysis in econometric modelling. Accordingly, more recent research on agricultural economics using this broad class of vector error correction (VEC) models has been producing importantadvances in overcoming the modelling faults and resulting forecast failures. Paul *et al*. (2015) investigated, structural breaks in price volatility and linkages between domestic & export prices of onion in India. Paul *et al*. (2016) studied the effectiveness of integration in price forecasting for onion in selected markets of Delhi. Wani *et al*. (2015a,b,c) reported that market integration can be defined as a measure of the extent to which demand and supply in one location are transmitted to another.The price transmission mechanism is well explained in major coffee markets of India by Paul and Sinha (2016).

The present study uses vector autoregressive (VAR) and vector error correction model (VECM) for estimating price behaviour in selected markets.The rest of the paper is constructed as follows. Section 2 presents the modeling strategy. Section 3 includes the results and discussion and finally section 4 contains the conclusion.

2. Methodology

The methodological approach has been started by testing for stationarity using Augmented Dickey Fuller (ADF) test given by Said and Dickey (1984). The test for the variable y_t can be expressed in following manner :

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$$\Delta y_t = \alpha + \gamma t + \rho y_{t-1} + \beta \sum_{i=1}^{p} \Delta y_{t-i} + e_t \quad (1)$$

where, y_t is a vector to be tested for cointegration, t is time or trend variable, $\Delta y_t = y_t - y_{t-1}$ and e_t is a white noise process. The null hypothesis that $\rho = 0$; signifying presence of unit root, *i.e.*, the time series is non-stationary and the alternative hypothesis is $\rho < 0$ signifying the time series is stationary, therefore, rejecting the null hypothesis.

After taking the nonstationarity into account, we need to identify the optimal length for an unrestricted vector autoregressive (VAR) model (with a maximum lag number of eight) on the basis of suitable information criteria. A VAR model is a generalization of univariate autoregressive model that is a vector of time series. The right hand side of each equation in a VAR model includes a constant and lags of all the variables in the system. A three variables VAR with one lag can be written as:

$$x_{1,t} = C_1 + \varphi_{11,1} x_{1,t-1} + \varphi_{12,1} x_{2,t-1} + \varphi_{13,1} x_{3,t-1} + \varepsilon_{1,t} \quad (2)$$

$$x_{2,t} = C_2 + \varphi_{21,1} x_{1,t-1} + \varphi_{22,1} x_{2,t-1} + \varphi_{23,1} x_{3,t-1} + \varepsilon_{2,t} \quad (3)$$

$$x_{3,t} = C_3 + \varphi_{31,1} x_{1,t-1} + \varphi_{32,1} x_{2,t-1} + \varphi_{33,1} x_{3,t-1} + \varepsilon_{3,t} \quad (4)$$

where ε_{1t} , ε_{2t} and $\varepsilon_{3,t}$ are white noise processes that may be contemporaneously correlated. Coefficient $\varphi_{ii,t}$ captures the influence of l^{th} lag of variable x_i on itself. While coefficient $\varphi_{ij,t}$ captures the influence of l^{th}lag of variable x_j on x_i.

After that, to identify the cointegration relation among the price series, two likelihood ratio tests as given in equation 5 and 6 are employed *viz.* λ_{trace} and λ_{max} respectively.

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln\left(1-\hat{\lambda}_i\right) \; for = 0, 1....n\text{-}1 \quad (5)$$

$$\lambda_{max} = -T \ln\left(1-\hat{\lambda}_{r+1}\right) \quad (6)$$

where, T is the number of usable observations and $\hat{\lambda}_i$ are the estimated eigen values (also called characteristics roots). The trace test statistic (λ_{trace}) tests the null hypothesis of r cointegrating relation against the alternative hypothesis of less than or greater than r cointegrating relation while, the λ_{max} test statistic tests the null hypothesis of r cointegrating relation against $r+1$ cointegrating relations.

If the three markets prices are integrated then it is reasonable to conduct cointegration and vector error correction analysis (VEC) to examine the joint properties between them.The vector error correction model (VECM) (Johansen, 1988) can be seen as a restricted VAR model including a variable representing the deviations from the long-run equilibrium. Equation 7 shows a VECM for three variables including a constant, the error correction term and a lagged term.

$$\begin{bmatrix} \Delta p_t^1 \\ \Delta p_t^2 \\ \Delta p_t^3 \end{bmatrix} = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \end{bmatrix} + \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} ECT_{-1} + \begin{bmatrix} b_{11} & b_{12} b_{13} \\ b_{21} & b_{22} b_{23} \\ b_{31} b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} \Delta p_{t-1}^1 \\ \Delta p_{t-1}^2 \\ \Delta p_{t-1}^3 \end{bmatrix} + \begin{bmatrix} \varepsilon_t^1 \\ \varepsilon_t^1 \\ \varepsilon_t^3 \end{bmatrix} \quad (7)$$

Here p_t^1, p_t^2 and p_t^3 stand for three different price markets at time t. Equation 7 allows for estimating how the variables adjust deviations towards the long-run equilibrium along with error correction coefficient (a_i). The negative coefficients of error correction term (ECT) for the market prices indicate that the deviations would be recovered in the following period.The error correction coefficient (a_i) reflects the speed of adjustment.If two markets are integrated, then price in one market would commonly found to Granger cause the price in other market and/or vice versa. Granger causality provides additional evidence as to whether and in which direction price transmission is occurred between two series.

2.2 Data

Monthly wholesale price of Mumbai, Nashik and Delhi were collected from the website of Agriculture Marketing Information System Network, Ministry of Agriculture, Government of India for the period March, 2003 to September, 2015.

3. Results and Discussions

The descriptive statistics of the selected markets prices are reported in table 1. It can be seen that there is a significant difference between average price of Nashik and other markets prices. In case of Nashik market the price ranges in between 8 to 9 Rs per kg whereas it is 10 to 11 Rs per kg in other markets. High instability/ volatility of prices has been remained in case of Nashik market (C.V. 87%) followed by Mumbai and Delhi market. Among these three markets the lowest and the highest price occurred in Nashik (Rs. 2.16 per kg during March 2003) and Delhi (Rs. 49.22 per kg during September 2013) in the entire duration of March, 2003 to September, 2013 respectively. The skewness value for all the markets show presence of asymmetric behavior in them and also the coefficient of kurtosis is very high in Nashik followed by Delhi and Mumbai which reflect the leptokurtic distribution and high degree of extreme values.

In order to eliminate the influence of seasonality, all the market prices have been seasonally adjusted. The seasonal indices are reported in table 2. The recent trend of area and production of onion market has been depicted in figure 1. A perusal of figure 1 reflects around 50% increase in area and 90% increase in production over the last thirteen years while increasing rate in area and production has been found after 2003-04 and 2009-10.

As required for cointegration analysis, all the markets should be integrated of same order. In order to check for stationarity, ADF test has been employed to the seasonally adjusted data. The ADF test confirms the presence of unit root in the level series.After first differencing of seasonally adjusted series, these are found to be stationary and therefore, these are integrated of order one *i.e.*, I(1) at 5% significant level (Table 3). This situation allowed proceeding for Johansen's cointegration test.

In order to examine the cointegrating relationship, appropriate VAR order has been identified for all the markets together on the basis of minimum value of Schwartz criteria (SC) and Hannan Quinn (HQ) criteria. The optimum order for VAR model has been identified as two. According to the Trace test statistics and Eigen value statistics it is found that there are two cointegration relationships among the three studied markets of onion (Table 4). The presence of cointegrating vector reflected the existence of long run relationship among market prices. So there is the presence of information flow among them. The ECT for all markets have been obtained and found significant for Nashik market. In this case the speed of recovery to equilibrium for onion price in Nashik market is found to be 54.5 % per month. The estimated VECM equations for three markets are given below:

$$D(MUM) = -0.051*ECT_{t-1} \mathbf{-0.519}*D(MUM(-1)) \mathbf{-0.556}*D(MUM(-2)) + \mathbf{0.769}*D(NAS(-1)) + \mathbf{0.452}*D(NAS(-2)) + \mathbf{0.266}*D(DEL(-1)) -0.010*D(DEL(-2)) +17.288$$

$$D(NAS) = \mathbf{0.545}*ECT_{t-1} \mathbf{-0.589}*D(MUM(-1)) \mathbf{-0.467}*D(MUM(-2)) + \mathbf{0.702}*D(NAS(-1)) + \mathbf{0.622}*D(NAS(-2)) + \mathbf{0.352}*D(DEL(-1)) \mathbf{-0.235}*D(DEL(-2)) + 16.504$$

$$D(DEL) = 0.176*ECT_{t-1} -0.037*D(MUM(-1)-0.248*D(MUM(-2)) + \mathbf{0.608}*D(NAS(-1)) + \mathbf{0.644}*D(NAS(-2)) - 0.101*D(DEL(-1)) \mathbf{-0.438}*D(DEL(-2)) + 9.914$$

Note: Here D refers to differenced series; DEL, MUM and NAS indicate Delhi, Mumbai and Nashik market respectively and ECT refers to error correction term. The value in parenthesis refers to lag period.The coefficientswhich are significant at 5% level are marked as bold.

To this end, the Granger causality test is applied in order to find out the dominating market for price formulation as well as the direction of information flow. The results are reported in table 5. The direction of the price transmission is also reported in table 5.

Table 1: Descriptive statistics of selected onion markets

Statistics	Mumbai	Nashik	Delhi
Mean (Rs/Quintal)	1035.102	873.283	1053.121
Median (Rs/Quintal)	767.940	646.040	807.790
Std. Deviation (Rs/Quintal)	811.125	759.784	780.317
Skewness	2.455	2.869	2.489
Kurtosis	7.331	10.097	7.673
Maximum(Rs/Quintal)	4744.97	4648.89	4922.26
Minimum(Rs/Quintal)	236.35	216.75	315.12
C.V. (%)	78.36	87.01	74.09

Table 2: Seasonal indices of selected onion markets prices

Month	Mumbai	Nashik	Delhi
January	1.109	1.151	1.144
February	0.877	0.949	0.975
March	0.668	0.663	0.840
April	0.641	0.609	0.704
May	0.644	0.598	0.634
June	0.807	0.793	0.696
July	0.886	0.915	0.893
August	1.082	1.193	1.101
September	1.194	1.248	1.217
October	1.424	1.454	1.441
November	1.432	1.281	1.277
December	1.251	1.158	1.092

Table 3: Stationarity test results

Markets	Seasonally Adjusted Series		1st Difference of Seasonally Adjusted Series	
	ADF test statistics	P-value	Unit root statistics	P-value
Mumbai	-1.623	0.468	-8.275	<0.001
Nashik	-2.570	0.101	-8.045	<0.001
Delhi	-2.799	0.070	-8.408	<0.001

Table 4: Cointegration test for three markets together

No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.	Max-Eigen Statistic	5% Critical Value	Prob.
None	0.228	65.643	29.797	< 0.001	38.213	21.131	< 0.001
At most 1	0.165	27.430	15.494	< 0.001	26.624	14.264	< 0.001
At most 2	0.005	0.805	3.841	0.369	0.805	3.841	0.369

Table 5. Granger causality test

Null Hypothesis:	F-Statistic	Prob.	Direction
Delhi does not Granger Cause Nashik	2.308	0.103	No causality
Nashik does not Granger Cause Delhi	12.907	< 0.001	Nashik $\longrightarrow$ Delhi
Mumbai does not Granger Cause Nashik	2.591	0.078	No causality
Nashik does not Granger Cause Mumbai	28.918	< 0.001	Nashik $\longrightarrow$ Mumbai
Mumbai does not Granger Cause Delhi	11.144	< 0.001	Mumbai $\longrightarrow$ Delhi
Delhi does not Granger Cause Mumbai	10.996	< 0.001	Delhi $\longrightarrow$ Mumbai

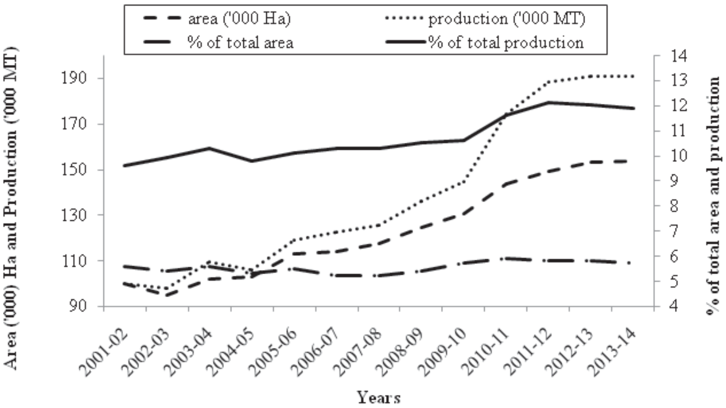

Fig. 1: Area and production trend of onion in India (*data source: NHB*, 2014)

4. Conclusion

In this study an attempt has been made to examine the cointegration and price transmission for wholesale price of onion in three major markets of India namelyMumbai, Nashik and Delhi.It is seen that, Nashik market causes the prices of both the Delhi and Mumbai markets where as bi-directional causality has been found between Delhi and Mumbai markets. It indicates that Nashik is a dominating market in the price channel. The main reason behind the domination of Nashik market is because it is the main production hub in comparison to other two markets. The empirical results suggest for a very close observation on different marketsbehavioural pattern since, price information in one market may impact the price in other markets.The present study also has a direct impact on market participants in order to profit maximization.

REFERENCES

Chengappa,P.G.,Manjunatha, A.V.,Dimble, V. and Shah, K. (2012). Competitive Assessment of Onion Markets in India. Report Prepared for Competition Commission of India, Government of India.

Engle, R.F., and C.W.J. Granger (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*,**55** : 251–76.

Granger, C. W. J. (1981). The comparison of time series and econometric forecasting strategies, in Large Scale Macro-Econometric Models, Theory and Practice, edited by J. Kmenta and J.B. Ramsey, North Holland: 123-28.

Granger, C. W. J. (1986).Developments in the study of cointegrated economic variables, *Oxford Bulletin of Economics and Statistics*, **48**: 213-28.

Granger, C. W. J., and Andrew A. Weiss. (1983). Time series analysis of error-correction models, in Karlin, Samuel, Takeshi Amemiya and Leo A. Goodman (eds.), *Studies in Econometrics, Time Series, and Multivariate Statistics*. New York, Academic Press: 255–78.

Myers, R.(1994). Time series econometrics and commodity price analysis: a review, *Review of Marketing and Agricultural Economics*, **62**: 167-82.

Johansen, S. (1991). Estimation and hypotheses testing of cointegrating vectors in Gaussian vector autoregressive models, *Econometrica*, **59**, 1551-80.

Johansen, S (1995). Identifying restrictions of linear equations with applications to simultaneous equations and cointegration. *J. Econometrics*, **69**, 111-33.

Johansen, S (1996).*Likelihood-based inference in cointegration vector autoregressive models*, 2nd edition, OUP, Oxford.

Paul, R. K., Saxena, R., Chaurasia, S., Zeeshan and Rana,S. (2015). Examining export volatility, structural breaks in price volatility and linkages between domestic & export prices of onion in India. *Agric. Econ. Res. Review*, **28**, 101-16.

Paul, R. K., Rana, S. and Saxena, R. (2016). Effectiveness of price forecasting techniques for capturing asymmetric volatility for onion in selected markets of Delhi. *Indian J. Agric. Sci.*, **86** (3): 303–309.

Paul, R. K., Sinha, K. (2015). Spatial Market Integration among Major Coffee Markets in India, *J. Indian Society of Agric. Statistics*, **69(3)**, 281-287.

Said, E. S., Dickey, D. A. (1984). Testing for unit roots in autoregressive moving average models of unknown order, *Biometrika*, **713 :** 599-607.

Wani, M. H., Paul, R. K., Bazaz, N. H. and Manzoor, M. (2015a). Market Integration and Price Forecasting of Apple in India. *Indian J. Agricultural Economics*, **70** (2), 169-81.

Wani, M.H., Paul, R.K., Bazaz, N. H. and Bhat, A. (2015b). Market Integration and Causality in Pear in India. *Economic Affairs*, **60** (4), 735-40.

Wani, M.H., Bazaz, N. H., Paul, R.K., Showkat A. I. and Bhat, A. (2015c). Inter-Sectoral Linkages in Jammu & Kashmir Economy — An Econometric Analysis.*Agricu. Econ. Res. Review*,**28**, 11-24.