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JOURNAL OF THE INDIAN SOCIETY OF AGRICULTURAL STATISTICS 69(3) 2015 281-287

Spatial Market Integration among Major Coffee Markets in India

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Received 02 July 2014; Revised 01 July 2015; Accepted 31 December 2015

SUMMARY

The price signals of agricultural commodities from markets located in different locations play a very important role in the economy. The price signals guide and regulate production, consumption and marketing decisions over time. Therefore, if markets are not well integrated, the price signals are distorted, which will lead to inefficient resource allocation and hamper sustainable agricultural development. This paper employs an econometric modeling for estimating a vector error correction model (VECM) to investigate the degree of spatial market integration and price transmission between the important coffee consuming centers in India (viz. Bangalore, Chennai and Hyderabad) using month-wise wholesale prices of coffee seeds. The cointegration analysis reveals long run equilibrium subject to price transmission among the markets. The out of sample forecasting performance of VECM model is also computed for cointegrated markets. The degree of integration and price adjustment to deviations from long run equilibrium ranges between 12 to 52%. The results obtained are expected to contribute in the field of planning and forecasting.

Keywords: Cointegration, Error correction model, Forecasting, Price transmission.

1. INTRODUCTION

The market integration can be measured in terms of the strength and speed of price transmission between markets across various regions of a country (Ghafoor *et al.*, 2009). The degree to which consumers and producers can benefit, depends on how domestic markets are integrated with world markets and how integrated the different regional markets with each other (Varela *et al.*, 2012). Earlier, the price correlation coefficients (Timmer, 1984; Dadi *et al.*, 1992) and regression analysis (Alexander and Wyeth, 1994) were used to explore whether or not markets were connected by price changes. However, price correlation coefficients can be misleading due to the existence of trends or unit roots in the data. The regression analysis in measuring market integration was customized using the time series variables in their first difference order, but this caused the loss of long-run information. Cointegration analysis, on the other hand, allows eliminating the presence of unit roots and permits to stay away from specious results, thus enhancing the accuracy of research findings. Cointegration implies for Granger causality between the variables, meaning that if two markets are integrated, the price in one market, would commonly be found to Granger-cause the price in the other market, and/or vice versa (Fackler and Goodwin, 2001). Therefore, Granger causality provides additional evidence as to whether and in which direction price transmission is occurring between two markets. Although, several studies have been done empirically using cointegration techniques which concerns the market integration of agricultural commodities in India (Ghosh, 2011; Sekhar, 2012; Reddy *et al.*, 2012; Bhardwaj *et al.*, 2015

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and Wani *et al.*, 2015), however, a little work has been carried out in the way of empirically evaluating coffee market integration in India.

Coffee is world famous beverage and is widely drunk almost every part of the world. This drink is made from coffee seeds which are also referred to as “beans”. The total coffee production in the world is around six million tons and India share 4.5% of total production in the world. Coffee production in India is mainly concentrated in the southern part of the country in which Karnataka is the leading coffee producer with 56.9% of total production followed by Kerala 28% and Tamil Nadu 11%. Almost 80% of country’s coffee production is exported to different country. In our country, mainly two types of coffee varieties are cultivated. Robusta coffee or *Coffea robusta* is grown around 52% of total coffee area and arabica coffee or *Coffea arabica* is grown around 48% of the total coffee area. In last three years, average export of coffee has been around 3 lakh tons; which is highest since 1990-91. Considering the sustainable source of foreign exchange earnings to Indian economy, it is therefore important to analyze countries major coffee marketing system so that countries coffee production as well as export is efficiently managed. Presence of perfect market integration and price transmission are very important phenomenon to be considered for efficient management of marketing system. In an efficient marketing system, new information is confounded simultaneously into markets when they are cointegrated. This type of system has a considerable significance for deriving maximum gains for producers, consumers and middleman in the marketing chain.

This paper has highlighted the degree of market integration among major coffee centers in India such as Bangalore, Chennai and Hyderabad. The nature of cointegration and extent of price adjustment for different markets has been evaluated. Depending on the market structure, the direction of price transmission among different markets has been investigated as it provides valuable information on the degree of integration and efficiency of markets. Finally an effort is made for forecasting the performance of spatially separated markets.

2. VECTOR AUTOREGRESSIVE (VAR) PROCESS

Let us consider a univariate time series y_t, $t = 1,2, \ldots, T$arising from the model

$$y_t = \upsilon + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_k y_{t-k} + u_t, u_t \sim IN(0, \sigma) \quad (1)$$

where, u_t is a sequence of uncorrelated error terms and $\phi_j, j = 1,2, \ldots, k$ are the constant parameters. This is a sequentially defined model; y_t is generated as a function of its own past values. This is a standard autoregressive framework or AR(k), where k is the order of the autoregression.

If a multiple time series y_t of n endogenous variables is considered, the extension of (1) will give the VAR(k) model (VAR model of order k), i.e. it is possible to specify the following data generating procedure and model y_t as an unrestricted VAR involving up to k lags of y_t and can be expressed as,

$$y_t = \upsilon + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_k y_{t-k} + u_t, u_t \sim IN(0, \Sigma) \quad (2)$$

where, $y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})'$is (n×1) random vector, each of the A_i is an (n×n) matrix of parameters, υ is a fixed (n×1) vector of intercept terms. Finally, $u_t = (u_{1t}, u_{2t}, \ldots, u_{nt})$is a n-dimensional white noise or innovation process, i.e., $E(u_t) = 0, E(u_t u_t') = \Sigma \textit{ and } E(u_t u_s') = 0$ for s≠t. The covariance matrix Σ is assumed to be non-singular. Using lag operator (L), (2) can be written as,.

$$(I_n - A_1 L - \cdots - A_k L^k) y_t = \upsilon + u_t$$

The process y_t is said to be stable if the roots of the polynomial, $|I_n - A_1 L - \cdots - A_k L^k| = 0$ lie outside the complex unit circle i.e. have modulus greater than one.

3. COINTEGRATION PROCESS

Cointegration analysis is used to examine whether long-run equilibrium relationships exist between markets. The long-run relationship is given as:

$$P_t^1 = \alpha_0 + \alpha_1 P_t^2 + \varepsilon_t \quad (3)$$

where, P_t^1 is the price of a commodity in one market and P_t^2 is the price in another market. If ε_t is stationary, then market prices are said to be cointegrated. The cointegration analysis reflects the long-run movement of price, although in the short run they may drift apart. Johansen's (1988) multivariate cointegration approach was used to examine cointegration between two prices. Before conducting cointegration test, it is mandatory to perform stationarity test. Augmented Dickey-Fuller (ADF) unit root test (Dickey and Fuller, 1979) was performed in this study to check stationarity for both the series. The ADF test is based on the regression of original price series including the intercept and trend and regression of first difference series by including only intercept term. The variables that are integrated of the same order may be cointegrated, while the unit root test finds out which variables are integrated of same order, for example; if integrated by order one then it is denoted as I(1) and if integrated of order p then it is denoted as I(p). The ADF unit root test equation can be expressed as follows:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta y_{t-i} + \varepsilon_t \quad (4)$$

where, is a vector to be tested for cointegration, t is time or trend variable. Δy_t is the first difference ie. ($\Delta y_t = y_t - y_{t-1}$), ε_t is a white noise term. The null hypothesis that, $H_0: \delta = 0$; signifying unit root, states that the time series is non-stationary while the alternative hypothesis, $H_1: \delta < 0$, signifies that the time series is stationary, thereby rejecting the null hypothesis. Since the DF or ADF tests tell us whether a time series is integrated or not, it is known as a "test for integration".

3.1 Johansen's Cointegration Tests

A cointegrated system can be written as:

$$\Delta y_t = \sum_{i=1}^{k} \Gamma_i \Delta y_{t-i} + \alpha\beta' y_{t-k} + \varepsilon_t \quad (5)$$

where, y_t is the price series, Δy_t is the first difference i.e., ($\Delta y_t = y_t - y_{t-1}$), and the matrix $\alpha\beta'$ is of order n x n with rank ($0 \le r < n$), which is the rank of linear independent cointegration relations in the vector space of matrix. The Johansen's method of cointegrated system is a restricted maximum likelihood method with rank restriction on matrix $\Pi = \alpha\beta'$. The rank of can be obtained by using λ_{trace} or λ_{max} test statistics. The test statistics can be given as:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \ \forall r = 0, 1, \dots, n-1 \quad (6)$$

where $\hat{\lambda}_i$'s are the Eigen values representing the strength of the correlation between the first difference part and the error-correction part. Now the following hypotheses are tested, under null hypothesis, H_0: *rank of* $\Pi = r$ and under alternative hypothesis, H_1: *rank of* II > r. Where r is the number of cointegration equations. The above test is carried out under the condition of cointegrating equation has only intercept (no trend) and the original price series follows a trend since the mean and variance are non-constant over a period of time (non-stationary).

If price series are cointegrated we can estimate the following vector error correction model that can be seen as a 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.

$$\begin{bmatrix} \Delta P_t^B \\ \Delta P_t^C \\ \Delta P_t^H \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} + \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} ECT_{-1} + \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} \Delta P_{t-1}^B \\ \Delta P_{t-1}^C \\ \Delta P_{t-1}^H \end{bmatrix} + \begin{bmatrix} \varepsilon_t^{P^B} \\ \varepsilon_t^{P^C} \\ \varepsilon_t^{P^H} \end{bmatrix} \quad (7)$$

Here the superscripts B stands for Bangalore, C stands for Chennai and H stands for Hyderabad Market. This VECM representation is particularly interesting as it allows estimating how the variables adjust deviations towards the long-run equilibrium. 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 (Granger, 1980, 2004). Akaike Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC) were used to select the best model for the data under consideration. A VAR (2) model is applied in order to assess the causality of the price series.

$$\begin{pmatrix} y_t \\ x_t \end{pmatrix} = \begin{pmatrix} a \\ b \end{pmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix} + \begin{bmatrix} y_{t-2} \\ x_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (8)$$

The matrix relation can be written in individual form as:

$$y_t = a + c_{11}y_{t-1} + c_{12}x_{t-1} + d_{11}y_{t-2} + d_{12}x_{t-2} + \varepsilon_{1t} \quad (9)$$

$$x_t = b + c_{21}y_{t-1} + c_{22}x_{t-1} + d_{21}y_{t-2} + d_{22}x_{t-2} + \varepsilon_{2t} \quad (10)$$

The restrictions imposed to test the causality can be described as:

lags of y do not explain the value of x so, $c_{21} = 0$ and $d_{21} = 0$

lags of x do not explain the value of y so, $c_{12} = 0$ and $d_{12} = 0$

Hence, The null hypothesis for Granger causality test is defined as:

$$H_0: c_{21} = d_{21} = 0 \ (y_t \text{ does not Granger cause } x_t)$$

In the present investigation, VECM model was also used to forecast the price series in different markets. The forecast accuracy was measured in terms of relative mean absolute prediction error (RMAPE) which was computed by using the following formula

$$\text{RMAPE} = 1/h\sum_{i=1}^{h}\left\{\left|y_{t+i} - \hat{y}_{t+i}\right| / y_{t+i}\right\} \times 100, \ h \text{ is the forecast horizon.}$$

The analysis was done using SAS Software Package Version 9.3.

4. RESULTS AND DISCUSSIONS

4.1 Data

The present study is based on the data from the Coffee Board of India which is obtained from the website www.indiastat.com. The sample analyzed in this study utilizes month-wise wholesale prices of coffee seeds in important coffee consuming centers such as Bangalore, Chennai and Hyderabad. There are total 150 data points in each series and data available from the month of January, 2001 to June, 2013. Time plot for each price series is displayed in Figures 1-3. The Table 1 summarizes the simple descriptive statistics and variability of prices in various markets in terms of co-efficient of variation. A perusal of Table 1 indicates that the maximum price is observed in Hyderabad Market in April, 2010 (210/kg), whereas the minimum price is observed in Bangalore market in March, 2002 (29/kg). The results reveal the variability as explained by the coefficient of variation ranges between 47.52 to 50.03%, respectively in the Chennai and Bangalore market. The hypothesis that the price series are non-stationary is tested using augmented Dickey-Fuller (ADF) test. The ADF test confirms the presence of unit root in the price series. But after first differencing, all the series were found to be stationary and therefore, were integrated of order one i.e. I(1). The conformation that each level series is of I(1) allowed to proceed for Johansen's cointegration test. The result of the stationarity test is reported in Table 2.

Table 1. Descriptive Statistics of Coffee Seed Price in Selected Markets

Statistics	Markets		
	Bangalore	**Chennai**	**Hyderabad**
Mean	81.79	86.36	90.58
Median	80	85	80
Maximum	184	185	210
Minimum	29	33	33
Std. Dev.	40.92	41.04	44.65
Skewness	0.51	0.61	0.62
Kurtosis	2.37	2.60	2.57
CV (%)	50.03	47.52	49.30

Table 2. Unit Root Test for Level and Differenced Series of Wholesale Price of Coffee Seed Markets

Markets	Level		Differenced		Order of Integration
	Unit Root Statistics	**P-Value**	**Unit Root Statistics**	**P-Value**	**Unit Root Statistics**
Bangalore	-2.98	0.14	-8.64	<0.001	I(1)
Chennai	-2.90	0.17	-7.97	<0.001	I(1)
Hyderabad	-2.82	0.19	- 8.97	<0.001	I(1)

The cointegration relation between wholesale price of coffee seeds of Bangalore, Chennai and Hyderabad markets were examined and presented in Table 3. Since there are three price series, therefore we can have at most two cointegrating relationships. The trace statistic and eigen value test statistic are very useful to examine cointegration relationship between different variables. In case of trace statistic, r denotes the number of cointegration vectors. According to the results, the null hypothesis of no cointegration against the alternative hypothesis of one or more cointegration is rejected. Trace statistic results indicate that the null hypothesis (r=1) is rejected against the alternative hypothesis (r>1) at 5% level of significance. From Table 3, it is clear that there exist more than one (i.e., 2) cointegration relationship between different market prices. The presence of cointegrating vector shows that, there exists long run relationship between different wholesale coffee market prices. As these markets are cointegrated among themselves therefore information flow (price transmission) occurs among them.

Table 3. Results of Cointegration Test

Cointegration Rank Test Using Trace						
H0: Rank=r	**H1: Rank>r**	**Eigenvalue**	**Trace**	**5% Critical Value**	**Drift in ECM**	**Drift in Process**
0	0	0.351	108.59	29.38	Constant	Linear
1	1	0.252	43.20	15.34		
2	2	0.002	0.002	3.84		

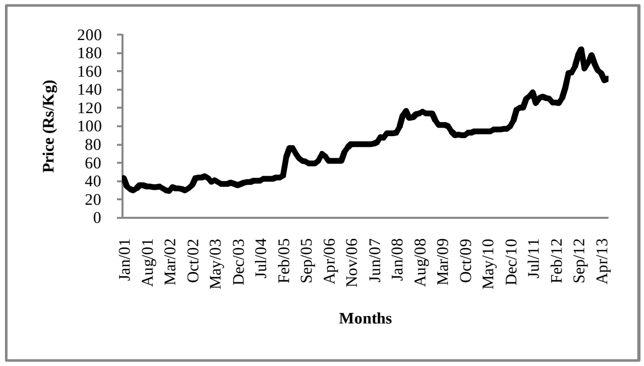

Fig. 1. Month-wise Wholesale Prices of Coffee Seeds in Bangalore

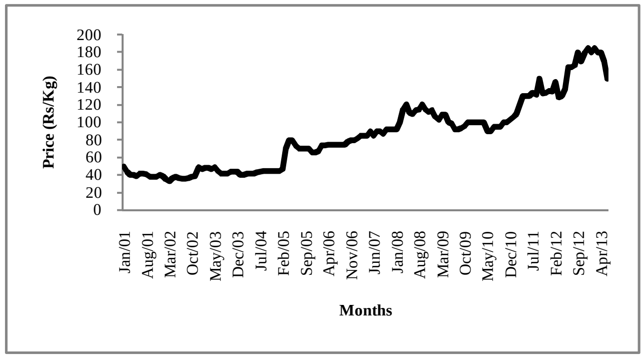

Fig. 2. Month-wise Wholesale Prices of Coffee Seeds in Chennai

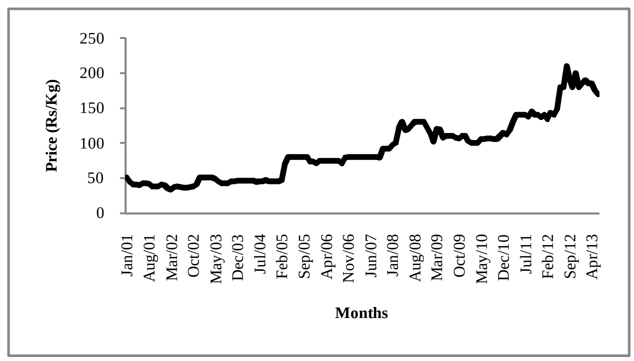

Fig. 3. Month-wise Wholesale Prices of Coffee Seeds in Hyderabad

4.2 Error Correction Mechanism

The long run equilibrium of wholesale coffee seed market prices justifies the use of vector error correction model (VECM) for showing the short run dynamics. The result of the VECM model in Table 4 shows that most of the estimated coefficients turn positive for those three markets. The estimated value of vector error correction coefficients are -0.12, 0.52 and 0.51 for Bangalore, Chennai and Hyderabad market respectively. These coefficients measure the ability of the prices for adjustment to deviation from the long run equilibrium. In this case, Bangalore, Chennai and Hyderabad market absorb 12%, 52% and 51%

respectively to bring about the equilibrium in prices. The information flow is more in Chennai and Hyderabad market which are 52% and 51% respectively as compared to Bangalore market (12%). Price adjustment according to the estimated VECM model occurs more quickly for Chennai and Hyderabad market compared to Bangalore market.

Table 4. Estimates of Parameters of Vector Error Correction Model (VECM)

Markets	Constant	Coefficient	Error Correction Estimates
Bangalore	0.44(0.38)	0.19(0.11) 0.10(0.09) 0.07(0.06)	-0.12(0.09)
Chennai	0.85(0.42)	-0.04(0.11) -0.16(0.09) 0.36(0.07)	0.52(0.10)
Hyderabad	1.00(0.50)	0.23(0.14) 0.07(0.11) -0.12(0.08)	0.51(0.12)

Values in the parenthesis denote standard error

The integration among these markets confirms the presence of Granger Causality effects among them. Accordingly, Granger causality test is performed to see the direction of price transmission between pairs of coffee markets and related spatial arbitrage, i.e., physical movement of the commodity to adjust for these prices differences.

Table 5 gives the results of the Granger causality test which show that, in three cases, i.e., Bangalore, Chennai and Hyderabad, there exist unidirectional causality. In these cases, the Bangalore market Granger causes price formation in the Chennai and Hyderabad market. It should be noted here that the Granger causality results may vary for different number of lags or time horizon included in the models. The trade-off is between bias and power. Too few lags indicate a biased test due to residual auto-correlation and too many lags allow for potentially spurious rejections of the null hypothesis. The optimum lag is selected based on the lowest Information criteria. In the present investigation, it is found that the AIC and BIC values are minimum at lag two. Accordingly, specific lag length was used for testing the causality. There is no causal relationship between the Chennai and Hyderabad market. This implies that the Bangalore market Granger causes price formation in these two markets but individually they do not Granger causes each other in price formation.

Table 5. Granger Causality Test of Error Correction Model

Markets	Chi-square	P-value	Direction
Bangalore -> Chennai	0.01	0.9315	Unidirectional
Chennai -> Bangalore	51.24	<.0001	Unidirectional
Bangalore -> Hyderabad	1.34	0.2472	Unidirectional
Hyderabad -> Bangalore	47.68	<.0001	Unidirectional
Chennai -> Hyderabad	11.69	0.0006	No causality
Hyderabad -> Chennai	7.26	0.0070	No causality

4.3 Forecasting with VECM

Table 6. Forecast Results of VECM Model

Variable (Price)	OBS	Forecast	Standard Error	95% Confidence Limits	
Bangalore	151	153.45	4.80	144.04	162.85
	152	154.58	6.71	141.43	167.73
	153	155.52	8.17	139.50	171.55
	154	156.37	9.41	137.92	174.83
	155	157.17	10.51	136.57	177.78
Chennai	151	155.35	4.97	145.61	165.10
	152	158.19	6.48	145.49	170.89
	153	159.88	7.79	144.61	175.16
	154	161.06	9.01	143.40	178.72
	155	162.00	10.12	142.16	181.85
Hyderabad	151	170.94	5.78	159.62	182.27
	152	171.46	7.54	156.68	186.24
	153	171.97	9.02	154.30	189.67
	154	172.57	10.34	152.31	192.82
	155	173.25	11.53	150.65	195.84

VECMs are used to produce forecasts of different markets. One step ahead forecast of price of coffee seed for three markets for next five observations are computed. The forecast values along with the standard error of forecasts and 95% lower and upper confidence interval are reported in Table 6. A perusal of Table 6 reveals that as the forecasting horizon increases, the forecasting performance for VECM model decreases. VECM model is therefore suitable for short term forecasting. For measuring the accuracy in the fitted VECM, RMAPE was computed. Out of total data available, last ten observations were kept aside for validation purposes. Here we computed the RMAPE for the last ten observations for different markets. The values of RMAPE are found to be 6.0, 6.7 and 6.8% in Bangalore, Chennai and Hyderabad market respectively. The residuals of fitted models were examined for presence of autocorrelations and it is found that the residuals are not autocorelated thereby confirming the adequacy of the models.

5. CONCLUSION

The study made an assessment of the degree of the spatial market integration in distantly located three regional coffee markets in India, using co-integration and error correction model to the monthly wholesale price from January 2001 to June 2013. The results revealed that the selected markets are strongly integrated and converged to the long run equilibrium. The rate of price transmission differs significantly between them. The price changes in Bangalore market has been found to be transmitted to Chennai and Hyderabad market. The formation of price for Chennai and Hyderabad market is considerably affected by Bangalore market. As Karnataka is major coffee producing state and maximum amount of production is supplied to different markets, therefore price formation is entirely governed by Bangalore market. The forecast model applied to the study revealed that there was less than 7 per cent deviation in the prices forecasted from the actual market prices confirming the validity of the model. The study suggests that the market integration and forecasts of prices in different markets will be a guiding principle for selecting the most efficient/ remunerative market and accordingly the policy makers and the producers will find it most useful.

ACKNOWLEDGEMENT

The authors are grateful to the anonymous referee(s) for their valuable suggestions for its improvement.

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