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Wholesale Milk Markets: A Study of Market Integration in Indian Markets

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Abstract:
Market integration is an important determinant of responsiveness and behavior of the markets needed to formulate price policies. Indian wholesale milk markets are correlated with varying degrees of integration. Paper uses monthly wholesale prices of milk for the period from April 1997 to December 2009 for 5 major market centres viz. Chennai, Delhi, Kolkata, Mumbai, and Kanpur. Prices were converted into real prices by deflating with wholesale price index of all commodities. Extent of integration among different markets is tested using method and procedure for testing co-integration suggested by Johansen (1991, 1995), and Johansen and Juselius (1990) and Engle and Granger (1987). Results reveal that milk markets of Kolkata and Mumbai are critical to sustaining long-run equilibrium which had strong bearings on the prices of other three markets viz, Delhi, Kanpur and Chennai. The speed of error correction for Kolkata and Mumbai markets are relatively faster than that of others and Kolkata and Mumbai markets can reinstate the long-run equilibrium quickly if appropriate error correction measures are taken.

Introduction

Markets play an important role in economic development by equating aggregate demand and aggregate supply. Well-integrated markets allow price signals pass freely from one market to other. Efficacy of macroeconomic policies largely depends on how quickly and strongly markets transmit the signals across spatially distributed markets (Barrett 2005). Markets also have a critical role in technological change. Unless the markets are able to accommodate excess local supply benefits of technological change are bound to get eroded. This happens because the technological change leads to enhanced supply that lowers the producer prices as and when the improved technology is adopted without sufficient access to markets. Hence access to markets is imperative to provide impetus to the adoption of improved technologies.

Market integration is an important determinant of responsiveness and behavior of the spatially or vertically related markets in response to price movements and market shocks in one or some of the markets. The extent, to which two or more markets are integrated, often determines the level of efficiency, and therefore assumes significant importance in guiding macro and micro policies. The 'Law of One Price' postulates that at any given time the prevalent prices

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of a homogenous product in two distinct but economically related markets should be equal. One price is a necessary condition for a perfectly integrated market. This condition, in general, is often not met in short-run. Markets in long-run usually satisfy the law with varying degree of integration depending on the nature of market, information flow, available infrastructure, policies, etcetera.

Spatial market integration is important for understanding the intricacies of market mechanism and behavior. It helps us understand how the markets work and to what extent markets should be supported to achieve various social objectives. It is established that the spatial extent of markets has strong bearings on anti-trust policy (Stigler and Sherwin, 1985). Well integrated spatial markets attain a unique equilibrium because of competition among arbitrageurs and the local prices in regional markets vary only upto the extent to which transportation and transaction costs differ. Hence, in well integrated markets scope for arbitrage in long run is virtually zero. Extent of spatial market integration is also an indicator of competitiveness, efficacy of arbitrage and price efficiency (Sexton et al., 1991).

Spatial markets are said to be integrated if movement in price in one market is also observed in other markets (Goodwin and Schroder, 1991). In well integrated markets prices are determined simultaneously at different locations and information of change in price in one market is transmitted to other markets (Gonazale-Rivera and Helfand, 2001). Weak or nonintegrated markets often send misleading signals and lead to market imperfections, distortions and inefficiencies. Nonintegrated markets often lag in responding to the price signals of other markets and therefore fail to take advantage of the opportunities in other markets. This may leads to local scarcity that tends to persist due to lack of befitting response from the markets having excess supply (Dreze and Sen, 1995; Currey and Hugo, 1985).

India is a vast country and its markets are widely spread over large geographical area.. The absence of integration among markets will encourage arbitrageurs and induce unwarranted practices in the markets. Analysis of market integration is, therefore, imperative to formulate and target relevant price policies in short run and strengthen market integration in long run to harness the benefits of a large market. The estimates of co-integration elucidate joint-price behavior and help identify integrated and non-integrated markets

Overview of Dairy Sector

Dairying is an important activity for about two-third of the rural households in India. The country has enormous population of dairy animals and produced 97 million tonnes of milk in 2005-06. Moreover, milk production in the country has been growing steadily at a rate of 4.5 percent for the last two decades (Taneja and Birthal, 2006). Rapid urbanization, income growth and globalization have increased the demand for livestock products in general and milk in particular. The demand for milk is expected to touch the heights of 132 – 140 million by the year 2020 (Delgardo et al (1999).Globalization of livestock product markets have open new vistas of opportunities as well as threats. Indian exporters can penetrate into the global markets which are full of demands for various livestock products. In contrary, cheap imports from heavily subsidized and protected global markets pose insuperable threats before the domestic markets. The share of dairy products in country's export is about 6.5 percent (FAOSTAT 2003). This clearly shows the importance of domestic market for the dairy products. A high level of market integration in milk is essential to safeguard the interests of both consumers and producers.

Milk is an extremely perishable commodity, which can not be stored raw for a long without appropriate cooling facilities/ pasteurization or transformation into some less perishable form. It is, therefore, supplied to the market in a very short time period after milking. Most of the milk producers are smallholders who generate small surpluses and often sell them in informal milk markets in the hands of milk dealers or milk venders who procure milks from the farmers and sell them in big cities or wholesale markets. Though dairy cooperatives have emerged as good alternatives as they are able to provide assured markets and stable prices but they are more successful in the areas having good roads and transport facilities. Their reach in the remote and secluded places is still insufficient.

In recent years, new institutional linkages have emerged. Contract farming in milk production has open up new markets for the milk producers. Abolition of Milk and Milk Produce Order (MMPO) 1992, which was based on milk shed area approach and had restrictive nature for the development of new milk sheds and setting up of new capacity for milk processing, has provided congenial environment for the entry of new players in this sector. Now compliance with food-safety and sanitary measures, hygiene, and quality are becoming the core issues and with improvement in the quality and standard of milk many more new markets will come up. There is likelihood that milk markets will be heading towards a long run equilibrium.

Data and Methodology

This paper uses monthly wholesale prices of milk for the period from April 1994 to December 2009 for major market centres viz. Chennai, Delhi, Kolkata, Mumbai, and Kanpur. The information was compiled from 'Agricultural Prices in India'. The prices were converted into real prices by deflating with wholesale price index of all commodities.

The extent of integration among different markets is tested using method and procedure for testing co-integration suggested by Johansen (1991, 1995), and Johansen and Juselius (1990). Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary, or I(0), linear combination exists, the non-stationary (with a unit root), time series are said to be co-integrated. The stationary linear combination is called the co-integrating equation and may be interpreted as a long-run equilibrium relationship between the variables.

The co-integrated price series do not move independent of each other in the long run. There is systematic co-movement among the series. But, if in the short-run, there is any deviation from this long run equilibrium path, then, some error correction process would bring the system back on to the path defined by long run equilibrium relationship. This error correction process for co-integrated series is represented by a Vector Error Correction Model (VECM). The VECM can be obtained from standard VAR after few reparameterisation and term manipulations. Consider a VAR of lag order p:

$$y_t = A_1 y_{t-1} + \cdots\cdots\cdots + A_p y_{t-p} + \varepsilon_t$$

where y_t is a (k×1) vector of non-stationary I(1) variables, y_{t-1} ... y_{t-p} are lagged terms of y_t; $A_1 \ldots A_p$ are (k×k) matrices of unknown parameters, and ε_t is a (k×1) vector of white-noise error terms. We can rewrite the VAR(p) after few reparameterisation and term manipulations as a VECM(p) with an error correction tem, Πy_{t-1} as follows:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t$$

where,

$$\Pi = -(I - \sum_{i=1}^{p} A_i) \quad ; \quad \Gamma_i = -(I - \sum_{j=1}^{p} A_j)$$

The Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r<k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. r is the number of co-integrating relations (the co-integrating rank) and each column of β is the co-integrating vector. The elements of α are known as the adjustment parameters or speed of adjustment in the VECM. Johansen's method is used to estimate the Π matrix in an unrestricted form, and then test whether we can reject the restrictions implied by the reduced rank of Π.

To test for the number of co-integrating vectors, Johansen suggests the following likelihood ratio trace test statistic.

Trace statistic: $\lambda_{trace}(r) = -T \sum_{i=r+1}^{k} \ln(1-\hat{\lambda}_i)$

where, T is the number of usable observations and $\hat{\lambda}_i$ are the estimated ordered characteristic roots of Π. The null hypothesis of at most r co-integrating vectors against an alternative hypothesis of more than r co-integrating vectors is tested by this trace test statistic.

The number of co-integrating equations and estimated α and β are very sensitive to specification of deterministic (or linear) trends in y_t therefore, two versions of VECM(p) are estimated. The two versions are different only in the way the Πy_{t-1} is specified as follows:

Unrestricted model: y_t have linear trends but the co-integrating equations have only intercepts: $\Pi y_{t-1} = \alpha(\beta' y_{t-1} + \rho_0) + \alpha_{\perp}\gamma_0$,

Restricted model: y_t have no deterministic trends and the co-integrating equations have intercepts: $\Pi y_{t-1} = \alpha(\beta' y_{t-1} + \rho_0)$,

where, $\alpha_{\perp}$ is the non-unique $(k \times (k-r))$ matrix such that $\alpha' \alpha_{\perp} = 0$ and $rank([\alpha \,|\, \alpha_{\perp}]) = k$.

To test the restrictions implied by restricted model, the following LR test statistic is suggested by Johansen which is distributed as χ^2 with (k-r) degrees of freedom.

LR statistic: $-T \sum_{i=r+1}^{k} [\ln(1-\lambda_i^*) - \ln(1-\lambda_i)]$

where, λ_i^* and λ_i are estimated ordered characteristic roots of Π in restricted and unrestricted models, respectively. If the calculated value of statistic exceeds the critical value then, the restricted model would be rejected in favour of unrestricted model.

In order to determine appropriate lag length Akaike information criterion (AIC) and Schwarz information criterion (SIC) were used.. The AIC is a measure of the goodness of fit of an estimated statistical model and the SIC is a criterion for selecting among formal econometric model.

Before, checking for co-integration among different markets, the stationarity properties of the data series needs to be checked to ensure that all of the price series are nonstationary and integrated of same order. For this purpose, the Augmented Dickey-Fuller (ADF) test has been used. A brief overview of the test is as follows:

To test if a sequence y_t contains a unit root, three different regression equations are considered.

(1) $$\Delta y_t = \alpha + \gamma y_{t-1} + \theta t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t$$

(2) $$\Delta y_t = \alpha + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t$$

(3) $$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t$$

where the vector y_t represents the milk price series for five markets, α is the drift term, γ is the deterministic trend, t is the time index, $\Delta y_t = y_t - y_{t-1}$, and p is the lag order set as the highest significant lag from either the autocorrelation function (ACF) or partial autocorrelation function (PACF) of the first differenced series so that the regression residuals behave as white noise series. The first equation includes both a drift term and a deterministic trend; the second excludes the deterministic trend; and the third does not contain an intercept or a trend term. In all three equations, the parameter of interest is γ. If $\gamma=0$, the y_t sequence has a unit root. The estimated t-statistic is compared with the appropriate critical value in the Dickey-Fuller tables to determine if the null hypothesis of unit root is valid. If the first difference of data series is stationary then that series is regarded as integrated of order one i.e. I(1). Therefore, this same procedure of checking unit root is repeated for first difference of the price series to ensure that these are integrated of order one.

Results

The ADF test shows that the milk price series for the selected wholesale milk markets viz., Chennai, Delhi, Kanpur, Kolkata and Mumbai are integrated of order one. The results of ADF test, performed in levels and the first differences of price series for all the selected markets are presented in Table 1. It is obvious that the absolute values obtained in ADF test are significantly less than the critical value at 5 percent level of significance for any level of the price series. This means that the level of wholesale price series for the selected milk markets is non-stationary because the null hypothesis of the unit root can not be rejected. However, the null hypothesis of unit root can be rejected at 5% significance level for all the price series using first differences. This implies that the wholesale price series becomes stationary when the first differences were taken. Therefore, it can be safely concluded that the price series for all the selected milk markets are integrated of order one [I(1)] and they may explain a long-run equilibrium relationship among the markets. But in short-run, markets often deviate from this long run-equilibrium path due to various exogenous shocks and internal dynamism and reinstate the original long-run equilibrium path only when some error correction process begins.

This error correction process is represented by the VECM. To determine the lag order (p) for the VECM different versions of standard VAR, each having different lag lengths, were estimated. The lag length of the VAR with minimum AIC and SIC was selected as proper lag length for VECM. The result suggests two months to be the appropriate lag length of the VECM, i.e. p=2.

Since, the rank of $\prod$ is sensitive to the inclusion of exogenous variables and deterministic factors both unrestricted and restricted models were estimated. The results of these VECM are presented in table 2. The null hypothesis of no cointegrating equation for both the models gets rejected as the calculated trace statistics ($\boldsymbol{\lambda}_{\textbf{trace}}$) for no co-integrating equations were found to be larger than the critical value of 76.07 at 5% significance level. But the null hypothesis of at most one co-integrating equation cannot be rejected because the values of their calculated trace statistics is less than the critical value of 53.12 at 5% significance level for both the models. It is obvious that rank of $\prod$ for both the models is one, that is, both models has one co-integrating equation. It signifies that the wholesale milk markets of Chennai, Delhi, Kanpur, Kolkata and Mumbai are integrated with a single co-integrating relation.

The computed value (0.146) of LR test statistic to discriminate the restricted and unrestricted models is much smaller than the critical value (9.49) at 5% significance level with four degrees of freedom and, therefore, the restricted model cannot be rejected. This test help us to conclude that the price series do not exhibit linear time trend and hence it is appropriate to specify the intercept term in the co-integrating vector.

The presence of one co-integrating equation implies that the markets are integrated and there exists long-run relationship among prices of these markets. The co-integrating equation with long run elasticities, normalized by elasticity of Delhi can be written as follows (table 3):

Delhi = 13.937 + 0.467 Kanpur + 0.159 Chennai - 1.488 Kolkata - 0.123 Mumbai

The above relation suggests that the Delhi prices are positively related to Kanpur, and Chennai prices while they are negatively related to Kolkata and Mumbai prices. Any deviation from the long-run relationship presented above would be corrected by error correction process and the speed of adjustments is tabulated in table 3.

The speed of adjustment for Delhi, Kanpur and Chennai are statistically insignificantly different from zero at 5% significance level, while they are statistically significantly different from zero for Kolkata and Mumbai markets. This shows that the prices in Delhi, Kanpur and Chennai markets are weakly exogenous and thus there is likelihood that milk prices in these markets may not change in response to deviations from the long run equilibrium. In other words, the prices in Delhi, Kanpur and Chennai will be less affected by the changes in prices in Kolkata and Mumbai milk markets. Whereas prices in Kolkata and Mumbai milk markets will be highly affected by the price changes in Delhi, Kanpur and Chennai milk markets. The calculated speed of adjustments suggests that if there is positive deviation from the long-run relationship of prices, then the system would respond with a decrease in the prices for Kolkata and Mumbai markets. For instance, if the price in Chennai decreases then, the system would force the prices in Kolkata and Mumbai to fall. Further, if the speeds of adjustment of Mumbai (-0.052) and Kolkata (-0.37) are compared, the Mumbai market would take relatively longer time to adjust its price as compared to Kolkata market because it has relatively high speed of adjustment. It implies that, the long-run equilibrium in Indian milk market, if disturbed by any exogenous shock, would primarily be reinstated by the steps undertaken in Mumbai, and Kolkata markets to correct the error.

The weakly exogenous milk markets of Delhi, Chennai, and Kanpur, however, are extremely important for the producers as these markets are more stable, less risky and less prone to external shocks in the short-run. The milk markets of Delhi, Chennai, and Kanpur also provide hedge against the high price risk of more volatile milk markets of Mumbai and Kolkata. Thus, price risk management is feasible.

Policy Implications

The wholesale milk markets in India are correlated with varying degrees of integration. The wholesale milk markets of Delhi, Kanpur and Chennai hold weakly exogenous relationship. This has a strong policy implication. These markets offer more stable and relatively less risky milk markets to the milk producers and also help in mitigating risks of other volatile milk markets by providing hedge against the price risk. These markets, therefore, are extremely important for the Indian milk producers as these markets provide them cushion against external shocks and adversaries of price volatility. However, a word of caution is essential. Though these markets seem to be integrating in long run, under present circumstances they are sending less price signals to other markets. It implicates that they will not be able to influence each others prices and to some extent behave independently in short run. This may obtuse the progress and pace of many national level milk market policies. Therefore, in short-run a macro policy may not yield desirable and uniform results in the country.

The milk markets of Kolkata and Mumbai are critical to sustaining long-run equilibrium or to correct disequilibrium due to any exogenous shocks. These two markets has strong bearings on the milk prices of other three markets viz, Delhi, Kanpur and Chennai. The speeds of error correction for Kolkata and Mumbai markets are also relatively faster than that of other markets. Thus the milk markets of Kolkata and Mumbai would be able to reinstate the long-run equilibrium more quickly if appropriate error correction measures are taken therein.

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Table1: Augmented Dickey Fuller (ADF) Test for Testing Unit Root

Market	ADF Performed at	No. of Lags#	$H_0:\gamma=0$ in eq. 1	$H_0:\gamma=0$ & $\theta=0$ in eq. 1	$H_0:\gamma=0$ in eq. 2	$H_0:\gamma=0$ & $\alpha=0$ in eq. 2	$H_0:\gamma=0$ in eq. 3	Is stationary
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mumbai	Level	2	-1.74	1.54	-1.39	0.98	-0.21	NO
	1st Diff	8	-3.75	---	---	---	---	YES
Delhi	Level	11	-0.89	1.06	-0.92	0.53	-0.47	NO
	1st Diff	11	-4.61	---	---	---	---	YES
Kanpur	Level	0	-1.92	2.34	-1.99	1.99	-0.13	NO
	1st Diff	3	-5.81	---	---	---	---	YES
Chennai	Level	0	-2.37	4.13	-1.14	0.72	-0.37	NO
	1st Diff	12	-2.80	4.25	-2.66	3.88	-2.53	YES
Kolkata	Level	12	-2.34	2.96	-2.41	3.03	-0.520	NO
	1st Diff	12	-5.44	---	---	---	---	YES
Critical values at 5 %			-3.41	6.25	-2.86	4.59	-1.95	

Table 2: Trace test for rank of Π matrix

Model Type	Ordered root	Estimated λ	λ_{trace}	Critical value at		Hypothesized No of CE(s)
				5%	1%	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Restricted Model	λ_1	0.241993	84.97	76.07	84.45	None **
	λ_2	0.155438	43.41	53.12	60.16	At most 1
	λ_3	0.067239	18.07	34.91	41.07	At most 2
	λ_4	0.027899	7.63	19.96	24.6	At most 3
	λ_5	0.022312	3.39	9.24	12.97	At most 4
Unrestricted Model	λ_1	0.241965	84.82	68.52	76.07	None **
	λ_2	0.155302	43.27	47.21	54.46	At most 1
	λ_3	0.067098	17.95	29.68	35.65	At most 2
	λ_4	0.027862	7.53	15.41	20.04	At most 3
	λ_5	0.021706	3.29	3.76	6.65	At most 4
*(**) denotes rejection of the hypothesis at 5%(1%) significance level						

Table 3: Long-run elasticities and speed of adjustment

Name	Delhi	Kolkata	Mumbai	Kanpur	Chennai	Constant
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Co-Integrating Vector	1.00	1.49 (-1.75)*	0.12 (-0.26)	-0.47 (-1.31)	-0.16 (-0.49)	-13.94 (-1.62)
Speed of Adjustment	-0.044 (-1.32)	-0.367 (-5.39)	-0.052 (-2.90)	0.017 (-0.73)	0.010 (-0.61)	---
*-Figures in parentheses represent t-values						