



Integration of food markets in India: A case of milk markets

SHIV KUMAR¹, PRATAP S BIRTHAL² and KHYALI RAM CHAUDHARY³

National Centre for Agricultural Economics and Policy Research New Delhi 110 012 India

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ABSTRACT

Dairy policy in India has undergone a sea change in recent years, creating an ample space for public and private investment in dairy business. This is likely to have influenced inter-regional trade in dairy products and prices there of in different markets. This paper examines integration of milk markets, and concludes that milk markets have moved towards a long-run integration after a course of corrections and adjustments. Some markets are more stable due to existence of strong basics of production and marketing in the regions where they are located. However, the less stable markets are also important to sustain long-run equilibrium or to correct disequilibrium due to short-run exogenous shocks.

Key words: Co-integration, India, Milk markets

Integration of food markets is crucial to ensure consistent food supplies to consumers, to enhance livelihood of farmers and to stimulate agricultural growth. Well integrated markets allow free flow of information from one market to another, curb price volatility and provide incentives to farmers to improve production efficiency, adopt best production practices and optimize their production portfolio based on comparative advantage. On the other hand, lack of integration among markets encourages arbitrage and unwarranted trade practices, in case of both excess demand and supply situations. It assumes greater significance in a large country like India, which has spatially diversified patterns of food production and consumption, which offer ample scope for inter-regional trade. Integration of food markets also enhances regional food security through inter-regional trade.

Agri-food marketing policy in India has undergone a sea change in recent years. India has witnessed a revolutionary change in information and communication technologies and improvements in infrastructure. These measures are expected to lead to a convergence among agricultural markets.

Empirical evidence on integration of agricultural markets in India is scanty and scattered. Kumar and Sharma (2003) and Jha *et al.* (2005) while studying rice and wheat markets, offered two important conclusions — markets tend to integrate in the long run, but not in the short run, and markets are integrated within a region, but lack integration across regions. Its main reasons are weak infrastructure and communication networks, and excessive regulations and controls on markets in terms of procurement and distribution

of agricultural commodities (Jha *et al.* 2005). Jayasuriya *et al.* (2007) however concluded that agricultural markets in India are heading towards spatial integration.

Milk marketing requirements are altogether different than for staple food commodities. These need to be transported immediately to the consumption centres or transported into less perishable forms to avoid pre and post-processing losses. Transfer to distant markets requires refrigerated transport leading to high transportation and marketing costs. With this backdrop, in this paper we monitored whether milk prices in selected markets are co-integrated, analyzed short-run and long-run equilibrium relationships of milk prices in different markets, and a overview of the India's dairy sector.

An overview of dairy sector: Nearly two-thirds of the farm households are associated with dairy production. In 2005–06, India produced 97 million tons of milk worth 18% of the agricultural gross domestic product. Over the past few decades, milk production has grown faster than many other agricultural commodities. During 1980–81 to 2005–06, milk production grew at an annual rate of 4.5% as compared to a growth rate of 2.9% in the agricultural gross domestic product (Birthal and Taneja 2006), providing a cushion to agricultural growth and livelihood of the farmers against income shocks of crop failure.

Sustained income growth and a fast-growing urban population have been fueling rapid growth in demand for milk and milk products. Between 1983 and 1999 per capita milk consumption increased by 71%, from 43 kg to 74 kg per annum (Kumar and Birthal 2004). By 2020 demand for milk is expected to increase to around 140 million tons (Delgado *et al.* 2001).

Present address: ¹Senior Scientist (e mail: shivkumardull@gmail.com), ²Principal Scientist, ³Technical Officer.

There are significant regional differences in the consumption of milk largely due to its scarcity in some regions and surpluses in others. For example, the per capita milk consumption as well as production is lowest in the eastern region and highest in the northern region (Kumar and Birthal 2004). Such regional imbalances in demand and supply indicate a considerable scope for inter-regional trade in milk and milk products and growth of dairy sector.

Until recently, dairy cooperatives provided much needed market support to dairy farmers. The cooperatives were protected from external and internal competition. External trade in dairy products was regulated through licensing and tariffs. Internally, the entry of the private processors in the dairy industry was restricted through regulations. However, some notable changes have taken place in the dairy policy since the initiation of economic reforms programme in 1991. Dairy markets were opened up to external and internal competition. Quantitative restrictions on imports of dairy products were removed and import tariffs reduced. The private sector is now freely allowed to invest in dairy processing and compete with the dairy cooperatives. Besides, the government has reduced custom duties on machinery and equipment, excise duties and corporate taxes, provided tax holidays for new firms, priority sector lending to food processors, de-reservation of dairy products from the list of small-scale industries etc. to strengthen backward and forward market linkages in the dairy industry. With appropriate policies in place the organized sector, cooperatives and private processors could procure 17% of the total milk produced in 2005–06, up from 10% in 1994–95. During this period, the share of private sector in the organized milk market went up from 40 to 55% (Candler and Kumar 1998, Birthal 2008). In anticipation of further increase in the share of private sector, milk markets are conjectured to move towards integration.

Data and methodology: To test integration of milk markets, we have used monthly wholesale prices of milk for the period April 1994 to December 2006 for major market centres located in different directions. These centres are Chennai in the South, Delhi and Kanpur in the north, Kolkata in the east, and Mumbai in the west. The information on prices was collected from various issues of the Agricultural Prices in India (GOI). These prices were converted into real prices by deflating with monthly wholesale price index of all commodities at 1993–94 prices.

Behaviour of real prices of milk at the selected market centres is given in Fig. 1. At all the centers, behaviour of real prices of milk was quite erratic until 1999. Between 1994 and 1999 milk prices showed a similar trend in Mumbai and Kanpur - first declined and then increased, while in Chennai there was almost an opposite trend. In Delhi, milk prices were somewhat stable initially, but increased with fluctuations afterwards. Milk prices in Kolkata depicted a considerable volatility during this period. After 1999 milk

prices at all the centres, except Kolkata had a similar declining trend, indicating a tendency of market integration in the dairy sector. This also reduced price volatility Kolkata market. This can be attributed to policy of liberalization of dairy markets. This was also tested econometrically (Vector Error Correction Model, Johansen 1991, 1995).

We have applied VECM, as many economic time series are non-stationary and do not have a constant mean or variance over time (Myers 1994). A linear combination of two or more non-stationary series, however, may be stationary, called as the co-integrating equation or long-run equilibrium relationship between the variables (Banerjee *et al.* 1993). The co-integrated series do not move independent of each other and there is systematic co-movement of the series in the long run. However, in the short-run, if there is any deviation from the long run equilibrium path, then some error correction process would bring the system back onto the path defined by this equilibrium.

The VECM can be derived from standard vector auto regression (VAR). Consider a VAR of lag length (p):

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

where, y_t is a ($k \times 1$) vector of non-stationary variables, y_{t-1} ; y_{t-p} are lagged terms of y_t ; $A_1 \dots A_p$ are ($k \times k$) matrices of unknown parameters, and ε_t is a ($k \times 1$) vector of white-noise error terms. We can rewrite the VAR (p) after re-parameterizations and term manipulations as a VECM (p) with an error correction term, 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,

$$\pi = - \left(I - \sum_{i=1}^p A_i \right) \Gamma_1 = - \left(I - \sum_{j=1}^p A_j \right)$$

The number of co-integrating relations is determined by the rank of Π matrix. Moreover, if matrix Π has a reduced rank, $r < k$, then there exists ($k \times r$) matrices α and β , each with rank r such that Π can be decomposed into their product i.e. $\Pi = \alpha \beta'$. $\beta' y_t$ is the stationary deviation from long-run equilibrium path, and each column of β is the co-integrating vector. The elements of α are known as the adjustment parameters or speed of adjustment. To determine the number of co-integrating vectors, the following likelihood ratio trace test statistic is used, which has the null hypothesis of at most r co-integrating vectors against an alternative hypothesis of more than r co-integrating vectors.

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

where, T is the number of usable observations and $\hat{\lambda}_i$ is the calculated ordered characteristic root of Π .

However, the rank of Π is very sensitive to the specification of deterministic (or linear) trends in y_t , therefore, two versions of VECM (p) are estimated. First version is a restricted model where the intercept term is incorporated in the co-integrating vector; and the second version is an unrestricted model where the intercept term is included as a trend drift in the equation.

To test the restrictions implied by the restricted model, the following likelihood ratio (LR) test statistic is suggested in Enders (1995) which is distributed as χ^2 with $(k-r)$ degrees of freedom.

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

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.

Before testing for co-integration, stationarity properties of price series need to be checked to ensure that all of these are nonstationary and integrated of the same order. For this purpose, we use Augmented Dickey-Fuller (ADF) test. A sequential procedure (Doldado *et al.* 1990) to test for the presence of a unit root has been followed as the form of the data-generating process is unknown (Enders 1995). To test if a sequence y_t contains a unit root, three different cases are considered. In the first case, the ADF regression equation includes both a drift term and a deterministic trend; in the second case, the deterministic trend is excluded; and in the third case, neither intercept nor a trend term is included.

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

where the vector y_t represents the price series, t is the time index, $\Pi y_t = y_t - y_{t-1}$, Π is the drift term, Π is the deterministic trend, and p is the lag order set as the highest significant lag from either the auto-correlation function (ACF) or partial auto-correlation function (PACF) of the first differenced

series so that the error term, ε_t behaves as white noise series. In all three cases, the parameter of interest is α . If $\alpha=0$, the y_t sequence has a unit root. The estimated test statistic is compared against the appropriate critical value in the Dickey-Fuller tables to determine if the null hypothesis of unit root is valid. If the null hypothesis of the unit root cannot be rejected, then the series is non-stationary. Further, if the series becomes stationary after taking first difference then it is integrated of order one i.e. $I(1)$.

RESULTS AND DISCUSSION

We use logarithmically transformed monthly wholesale prices of milk, in real terms for estimation of the model described in the previous section. Results of ADF test are given in Table 1. The price series in all markets is found non-stationary, as the unit root test statistic is less than the critical value at 5% level of significance and therefore the null hypothesis of unit root cannot be rejected. However, at first difference, the null hypothesis of unit root can be rejected at 5% significance level for all price series. Thus, it can be safely concluded that the milk price series in the selected markets, viz. Chennai, Delhi, Kanpur, Kolkata and Mumbai are integrated of order one $I(1)$, and may explain long-run equilibrium relationship among the markets. In the short-run, markets however can deviate from the long run-equilibrium path due to various exogenous shocks, and the original long-run equilibrium path is reinstated only when some error correction process begins.

This error correction process is explained by the VECM. To determine lag length, p for VECM, different versions of standard VAR- each having a different lag length were estimated. The lag length of the VAR with minimum Akaike Information Criterion and Schwarz Information Criterion values was selected as the appropriate lag length for VECM. Accordingly, we identify two months as the appropriate lag length, i.e. $p=2$.

Table 1. Unit root tests for milk market prices

Market	ADF test at	Lag length	Case I		Case II		Case III	Series stationary
			$H_0: Y=0$	$H_0: Y=0 \text{ \& } \Pi=0$	$H_0: Y=0$	$H_0: Y=0 \text{ \& } \Pi=0$	$H_0: Y=0$	
Chennai	Level	0	-2.37	4.13	-1.14	0.72	-0.37	No
	First difference	12	-2.80	4.25	-2.66	3.88	-2.53	Yes
Delhi	Level	11	-0.89	1.06	-0.92	0.53	-0.47	No
	First difference	11	-4.61					Yes
Kanpur	Level	0	-1.92	2.34	-1.99	1.99	-0.13	No
	First difference	3	-5.81					Yes
Kolkata	Level	12	-2.34	2.96	-2.41	3.03	-0.520	No
	First difference	12	-5.44					Yes
Mumbai	Level	2	-1.74	1.54	-1.39	0.98	-0.21	No
	First difference	8	-3.75					Yes
Critical values at 5%			-3.41	6.25	-2.86	4.59	-1.95	

Note: Case I includes both a drift term and a deterministic trend; case II includes only a drift term, and case III has neither intercept nor a trend term.

Since the number of co-integrating relationships, speeds of adjustment, and long-run elasticities are sensitive to the exogenous variables and deterministic factors, two models-unrestricted and restricted were estimated (Table 2). The calculated trace statistic (λ_{trace}) is larger than the critical value at 5% significance level, therefore the null hypothesis of no co-integrating equation for both the restricted and unrestricted model is rejected. However, the null hypothesis of at most one co-integrating equation cannot be rejected as the calculated trace statistic is significantly lower than the critical value. Thus, the rank of λ for both restricted and unrestricted models is one, i.e. each model has one co-integrating equation. This signifies that the wholesale milk markets of Chennai, Delhi, Kanpur, Kolkata and Mumbai are integrated with a single co-integrating relation.

Further, the computed value of LR test statistic- that tests the appropriateness of the restricted or unrestricted model- is much smaller (0.146) than the critical value (9.49) at 5% significance level with four degrees of freedom, and therefore the restricted model is selected, and implies that milk price series do not exhibit a linear time trend and it is appropriate to specify the intercept term in the co-integrating vector.

The presence of one co-integrating equation implies that wholesale milk markets are co-integrated and there exists a long-run relationship among milk prices in these markets. Using information presented in table 3, the co-integrating equation with long run elasticities, normalized by the elasticity in Delhi market can be written as:

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

The above equation suggests that milk prices in Delhi are positively related to the milk prices in Chennai and Kanpur,

while these are negatively related to the prices in Kolkata and Mumbai markets. In other words, in the long run 1% increase in wholesale milk price in Kolkata market for example, will lead to decline of about 1.5% in Delhi market. Any short-run deviation from this long-run relationship will be corrected by error correction process with speed of adjustment (Table 3).

The speed of adjustment in Chennai, Delhi and Kanpur milk markets is not significantly different from zero (at 5% significance level). This suggests that Chennai, Delhi and Kanpur milk markets are weakly exogenous and there is likelihood that milk prices in these markets will not change much in response to short-run deviations from the long run equilibrium. Putting it differently, in short-run milk prices in Chennai, Delhi and Kanpur are less affected by the changes in prices in Kolkata and Mumbai milk markets. On the other hand, the speed of adjustment in Kolkata and Mumbai markets is significantly different from zero, indicating that prices in these markets are sensitive to price changes in Chennai, Delhi and Kanpur markets. This implies that the long-run equilibrium in Indian milk market, if disturbed by any exogenous shock would primarily be reinstated by corrective measures in Mumbai and Kolkata markets. This unique behavior of milk market integration in long run is explained by interplay production and policy factors such as increase in herd size, adoption of high-yielding exotic breeds, seasonality in milk production, improvements in dairying processing technology and infrastructure which have established synergy among themselves, resulting in spurt in milk production and distribution under organized marketing structure. When the policy changes, it takes into account emerging situation and provides momentum for speedy

Table 2. Trace test for rank of λ matrix

Model	Ordered root	Estimated λ	λ trace	Critical values at		Hypothesized No of co-integrating equation (s)
				5%	1%	
Restricted	λ_1	0.24199	84.97	76.07	84.45	None *
	λ_2	0.15544	43.41	53.12	60.16	At most 1
	λ_3	0.06724	18.07	34.91	41.07	At most 2
	λ_4	0.0279	7.63	19.96	24.6	At most 3
	λ_5	0.02231	3.39	9.24	12.97	At most 4
Unrestricted	λ_1	0.24197	84.82	68.52	76.07	None *
	λ_2	0.1553	43.27	47.21	54.46	At most 1
	λ_3	0.0671	17.95	29.68	35.65	At most 2
	λ_4	0.02786	7.53	15.41	20.04	At most 3
	λ_5	0.02171	3.29	3.76	6.65	At most 4

* Indicates rejection of the hypothesis at 5% significance level.

Table 3. Long-run elasticities and speed of adjustment

	Delhi	Chennai	Kanpur	Kolkata	Mumbai	Constant term
Co-integrating vector	1.00	-0.16 (-0.49)	-0.47 (-1.31)	1.49 (-1.75)	0.12 (-0.26)	-13.94 (-1.62)
Speed of adjustment	-0.044 (-1.32)	0.010 (-0.61)	0.017 (-0.73)	-0.367 (-5.39)	-0.052 (-2.90)	—

action. This phenomenal change in milk markets can be attributed to the changes in dairy policy, and its tuning to the emerging trends in world dairy markets.

The estimated speed of adjustment and together with its significance for different markets suggests that if there is a short-run positive deviation from the long-run relationship, then the system would respond with a decrease in milk prices in Kolkata and Mumbai markets. For example, if the milk price in Chennai decreases creating a short-run positive deviation, the system would force the prices in Kolkata and Mumbai to fall. Further, a comparison of the speed of adjustment in Mumbai (−0.052) and Kolkata (−0.37) markets brings out that the milk prices in Mumbai would take relatively longer time to correct the short-run deviation than milk prices in Kolkata market.

However, weak exogeneity in Chennai, Delhi and Kanpur markets indicates that these markets are more stable and less prone to external shocks in the short-run. Organized procurement and distribution of milk by private dairy firms and dairy cooperatives has brought dynamism in dairy sector in the regions where these markets are located, and thus a consistent and reliable local milk supply mitigates effects of demand-pull factors. For example, the northern states of Punjab, Haryana and Uttar Pradesh together account for about one-third of the total milk produced and 54% of the private dairy processing capacity in the country (GOI 2006). Similarly, the state of Tamil Nadu, which feeds Chennai market shares 18% of the total dairy processing capacity in the country as against its share of 6% in the total milk production.

Owing to liberalization of dairy markets, increased competition among market players, improvements in road, transportation and communication infrastructure, and increased investment in dairy processing, the milk markets in India have moved towards a long-run integration after a course of corrections and adjustments.

The results reveal that the markets where basics of dairy production and marketing are strong are not affected much by the short-run exogenous shocks. In such regions, stability in prices provides an incentive to producers to improve scale of production and use quality inputs and improved technologies. Contrary to it, milk markets are more prone to short-run exogenous shocks where dairy sector is not well entrenched. Nevertheless, these markets are important to sustaining long-run equilibrium or to correct disequilibrium. The speed of error correction in these markets is relatively faster, implying that the long-run equilibrium will be reinstated if appropriate error correction measures are taken therein.

Dairying is an important income source for the farmers. Integration of milk markets is therefore important for dairy farmers to provide them fair returns to investment. However, a word of caution is essential. Though, the markets are

integrated in the long run, but may behave differently in the short run. It is therefore essential to ensure convergence of macro and micro policies creating an enabling environment for private investment in value chain for dairy products.

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