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Price dynamics and market integration of natural rubber under major trade regimes of India and abroad

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ABSTRACT

Rubber is a perennial crop with an economical life span of 10-20 years. Price fluctuations has got multifaceted effect on the area, production and productivity of the crop. Unexpected and wide fluctuations in prices may discourage farmers from taking up of improved production and plant protection methods which may result in low production and instability in farm income. Cuddy Della Valle Instability Index showed that rubber prices were having considerable instability in both domestic and international markets. GARCH (1, 1) model was applied to analyse the extent of volatility in prices of natural rubber for RSS 4 grade. Results indicated that the markets experienced high level of volatility during the study period (2005–06 to 2011–12). Uniformity in prices and thereby efficiency in marketing system can be brought about by integration of the markets. Johansen's co-integration analysis was used to test the market integration between domestic and international reference markets of rubber and the results revealed that there exists long run equilibrium.

Key words: Co-integration, Seasonality, Natural rubber, Price dynamics

Rubber is a major plantation crop contributing considerable degrees to the agricultural economy of the country. Since it is a perennial crop with an economic life span of 10-20 years, price fluctuations has got multifaceted effect on the area, productivity and hence the production. One of the major variables that affect the replanting decision by farmers is the price of rubber (Edirisinghe and Perera 2005). Plantation expansion plans of the major natural rubber producing countries are getting accelerated on account of the rising trend in rubber prices (Mathews 2011).

High volatility exists in natural rubber price, which can be attributed to factors like international trade policies, natural disasters, political changes, demand for raw rubber, cost of production of synthetic rubber, etc (Abeysekera 2011). This uncertainty in rubber prices makes it difficult for producers to allocate resources efficiently, limits their access to credit for productivity enhancing inputs, and leads to adopt low-yield, low risk production technologies, thereby lowering average incomes. Success of price stabilisation policies is dependent upon the efficient assessment of price volatility and price movements. Therefore it is important to have a clear picture regarding the behaviour of prices over the time period.

With the establishment of WTO, the extent of integration of domestic market prices and world market prices have increased and volatility of the prices of agricultural commodities in domestic markets have been affected. Markets that are not integrated may deliver vague idea regarding the prices that might mislead production decisions and cause to inefficiencies in markets. This slow transmission of price information would adversely affect small holders. The demand as well as supply variations in a market will have an equal impact on prices of both markets if the markets are integrated and having free trade. Underdeveloped markets will have high marketing margins due to transportation costs, poor infrastructure and communication facilities. High transfer costs and marketing margins hinder the transmission of price signals, as they may prohibit arbitrage (Sexton *et al.* 1991, Badiane and Shively 1998). In this backdrop, the present study was conducted to study the price dynamics of natural rubber during the last decade and to analyse the integration of major natural rubber markets in India with international markets.

MATERIALS AND METHODS

The present study of analysing the price dynamics of natural rubber in India was based on the secondary data published by Rubber Board, Kottayam. Daily price data from the period of 2005 to 2012 for domestic and international

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markets were collected. The entire study period was divided into two parts for identifying whether the trend was same or fluctuating as the time progressed. The main items of observations were the daily and monthly prices of RSS 4 (Ribbed Smoked Sheet 4) and Latex 60 from Kottayam, Bangkok and Kuala Lumpur markets, since these are major reference markets for natural rubber. RSS 4 and Latex 60 grades of natural rubber were selected for the analysis because these two grades together form the major bulk of marketed natural rubber. The daily prices of RSS 4 and Latex 60 were available only from Bangkok and Kuala Lumpur markets respectively. Based on the availability of daily prices for specific grades from the Rubber Board, data from Kottayam and Bangkok markets were used for RSS 4 and Kottayam and Kuala Lumpur markets for Latex 60.

The magnitude of instability in the prices of rubber was measured in relative terms by Cuddy Della Valle Index which is used as a measure of variability in time-series data. Simple coefficient of variation overestimates the level of instability in the time series data characterised by the long term trends, whereas Cuddy Della Valle Index corrects this.

$$II = CV * (1-R^2)^{0.5}$$

where, II= Instability index (per cent), CV = Coefficient of variation (per cent) and R^2 = Coefficient of determination from a time trend regression adjusted by the number of degrees of freedom.

The instability in prices of RSS 4 and Latex 60 grades of natural rubber in Kottayam-Bangkok markets and Kottayam-Kuala Lumpur markets were analysed for the period of 2005-2006 to 2011-2012 and presented. Deflated daily prices using price index was used to find out the instability index. The entire study period was divided into two parts to check whether instability was increasing or decreasing over the period.

Generalised Autoregressive Conditional Heteroscedasticity (GARCH) was used to measure the extent of volatility in agricultural commodity prices. This approach distinguishes not only between predictable and unpredictable components of prices but also allows the variance of unpredictable element to be time varying (Bollerslev 1986). The analysis used GARCH (1, 1) model as defined below.

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma t_{-1}^2$$

Here conditional variance of u at time t depends not only on the squared error term in the previous time period but also on its conditional variance in the previous time period.

The sum of $(\alpha_1+\beta_1)$ gives the degree of persistence of volatility in the price series. The closer the sum to one, greater is the tendency of price volatility to persist for longer time in the variable under consideration. If the sum exceeds one, it indicates an explosive time series with a tendency to meander away from the mean value.

Market integration has usually been conceived in terms of co- movements or long run relationship between the spatial prices (Fackler 1996). Before testing for co-integration, the time series was checked for its stationarity using Augmented Dicky Fuller (ADF) test. This test is conducted on the variables in level (original price series) and first differences (Dicky and Fuller 1979).

$$\Delta Y_t = \Sigma \prod_I \Delta Y_{t-i} + \alpha\beta Y_{t-k} + \varepsilon_t$$

where, Y_t = price time series, ΔY_t = first order difference and Matrix $\prod = \alpha\beta$ is (n x n) order with rank 'r' $(0 \leq r \leq n)$, the number of independent co-integration relations. The model was estimated by regressing ΔY_t matrix against the lagged differences ('k' lags) of ΔY_t and ΔY_{t-k} and to determine the number of co-integration vectors, the rank of $\prod = \alpha\beta$' has to be found.

In the co-integration regression model, the residual shows the deviation from equilibrium and this equilibrium in long run tends to be zero. This equilibrium error has to be made stationary for getting co-integration between two integrated variables. The stationarity of the error can be verified with the usual ADF test. The test implies that errors adjust to the long run equilibrium.

RESULTS AND DISCUSSION

Price instability (Cuddy Della Valle Index)

Several factors have influenced the price of rubber in the past quarter of the century. Growth in population and the development of world economy have enhanced the demand for goods and services, including rubber products. But the supply of rubber has not kept pace with the rise in demand. Role of hedge funds, futures market activities, exchange rate variations in currencies, rise in oil prices and stock position are some of the factors that have influenced the natural rubber market. These have brought about fluctuations in natural rubber prices, which have ultimately affected the growth prospects of the rubber producing sector and the rubber manufacturing sector.

An analysis in the fluctuations of prices of crops is very important for understanding the nature of supply. Fluctuation in crop prices will affect the demand conditions. High growth in production accompanied by the low level of instability in prices is desired for the sustainable development of natural rubber sector.

Instability analysis of daily domestic and international price of natural rubber (RSS 4 grade) for the periods 2005-2008 and 2009-2012 using Cuddy Della Valle Index has been shown as Table 1. The index revealed that 11% and 14% instability respectively was found in the prices of Kottayam and Bangkok markets for the period of 2005-2008. It was noted that during the second phase of the study the instability indices were comparatively high, i e 13% and 20% for the domestic (Kottayam) and international (Bangkok) markets.

Table 1 Instability indices (%) in daily domestic and international prices of natural rubber (RSS4)

Price	2005–2008			2009–2012		
Particulars	1-R^2	CV	CDI	1-R^2	CV	CDI
Kottayam	0.47	16.54	11.34	0.30	25.18	13.79
Bangkok	0.67	18.01	14.75	0.55	27.41	20.33

Source: Price details from Rubber Board

Table 2 Instability indices (%) in daily domestic and international prices of natural rubber (Latex 60)

Price	2005–2008			2009–2012		
Particulars	1-R^2	CV	CDI	1-R^2	CV	CDI
Kottayam	0.69	18.07	15	0.39	22.57	14.15
Kuala Lumpur	0.79	19.21	17.08	0.37	26.49	16.33

Source: Price details from Rubber Board

Table 2 gives an idea about the level of instability in prices of natural rubber (Latex 60). There was a significant level of instability in the prices of international market, i e Kuala Lumpur, compared to that of Kottayam market in Kerala. It was observed that the instability has reduced while moving from first phase to the second phase of study. The instability index was reduced from 15% to 14% for the domestic market (Kottayam) and the international market (Kuala Lumpur) also showed similar trend.

It was observed that price of Latex 60 grade was having higher instability compared to that of RSS 4 except for Bangkok market (2009-12 period). It was found that the instability in prices of RSS 4 was widened for both domestic and international markets. Instability in domestic market was comparatively lower in both the time periods. Because of the comparative inefficiency of the Kottayam market, prices were partially insulated. The effect of the price risk mitigation measure in the form of Price Stabilisation Fund Scheme, which was launched in April 2003 against the backdrop of decline in international and domestic price of rubber, also helped domestic Kottayam market to maintain low instability in prices. Price instability of natural rubber during the liberalisation periods had fallen more than its level recorded during pre-liberalisation period has been reported also (Mohankumar 2011). International demand and supply fluctuations has caused the significant instability in prices of RSS 4 for Bangkok market which is the reference market for international rubber trade. Instability in international market was having considerable impact on the domestic market since the price movements were in same direction.

Price volatility (GARCH model)

GARCH model was fitted to compute the extent of volatility in domestic and international market prices of rubber for the periods 2005-2008 and 2009-2012. Daily prices, the best indicator of volatility were collected for the representative domestic and international markets of natural rubber transformed into natural logarithms. The entire study period was divided into two for the comparison purpose. The missing observations were adjusted with the previous closing prices of daily trading.

GARCH model (1, 1) was used for analysis of time series data. The results of the GARCH analysis clearly indicated that the volatility in the current day depends on volatility in the preceding day and the conditional variance as evident from the significant ARCH and GARCH terms.

The $\alpha_i+\beta_i$ coefficients for Bangkok and Kottayam markets were 1.04 and 0.90 respectively (Table 3) for the period 2005-08. It can be inferred that the price volatility

Table 3 Estimates of fitted GARCH model in natural rubber market prices of Kottayam and Bangkok markets (RSS 4)

Period	Bangkok			Kottayam		
	Estimates of ARCH term (α_i)	Estimates of GARCH terms (α_i)	$\alpha_i+\beta_i$	Estimates of ARCH term(α_i)	Estimates of GARCH terms (β_i)	$\alpha_i+\beta_i$
2005-2008	0.283739*	0.756912*	1.04	0.184145*	0.729285*	0.90
2009-2012	0.345918*	0.723343*	1.06	0.622581*	0.337767*	0.96

*Significant at 1 percent level of probability (z statistic)

Table 4 Estimates of fitted GARCH model in natural rubber market prices of Kottayam and Kuala Lumpur markets (Latex 60)

Period	Kuala Lumpur			Kottayam		
	Estimates of ARCH term (α_i)	Estimates of GARCH terms (α_i)	$\alpha_i+\beta_i$	Estimates of ARCH term(α_i)	Estimates of GARCH terms (β_i)	$\alpha_i+\beta_i$
2005-2008	0.064402*	0.877743*	0.94	0.063735*	0.879787*	0.94
2009-2012	0.216547*	0.737800*	0.95	0.075712*	0.865776*	0.94

*Significant at 1 percent level of probability (z statistic)

was getting widened over the period of time, since during the second phase of study the $\alpha_i+\beta_i$ coefficients for Bangkok and Kottayam markets were 1.06 and 0.96 respectively. The international market prices were showing very high volatility of 1.04 and 1.06 over the period. In domestic Kottayam market also prices were highly volatile but slightly lower compared to that of Bangkok market. This could be attributed to the effect of Price Stabilisation Fund Scheme launched in domestic markets during 2003.

The $(\alpha_i+\beta_i)$ coefficients for Kuala Lumpur and Kottayam markets were 0.94 for the period 2005-08. Both domestic and international markets were showing similar volatility trend during this period. During 2009-12 period, volatility was slightly increased in international market, whereas remained same for the domestic market.

Comparison of both periods under study indicated only a miniscule change in the GARCH model $\alpha_i+\beta_i$ coefficients. The extent of volatility ranges from 0.94 to 1.06. The higher volatility of international market was caused by the fluctuating global demand and supply conditions which were mainly affected by crude oil and petroleum prices. This was also due to variations on different factors like demand for raw rubber, production fluctuations in other countries, cost of production of synthetic rubber etc. World prices of rubber are not only subject to changes in demand, but also to speculation regarding future markets (Chang *et al*. 2009).

Market integration (Johansen's Co-integration Test)

Integration of rubber markets is essential for its price stability. To test the integration of domestic and international rubber markets, the co-integration analysis was applied. Stationarity of the price data was examined using ADF test. The estimated ADF statistic for unit root test of the time series data on the prices of natural rubber for the period 2005–2008 and 2009–2012 are presented in Table 5 and 6. The results indicated the presence of non-stationarity in time series data of prices of Kottayam and Bangkok markets at their levels. However, all the non-stationary variables were found to be stationary at their first differences, and therefore, re-integrated of order one I (1). This conformation that each level series was I (1) allowed application of the Johansen's cointegration test. The estimates of the cointegration analysis are presented in Table 5 and 6.

Table 5 Estimated ADF statistic for unit root test in rubber prices (RSS 4)

Period	Kottayam		Bangkok	
	Level	First difference	Level	First difference
2005-2008	–1.82	–19.79*	–2.04	–14.84*
2009-2012	–1.49	–16.28*	–1.61	–17.11*

* indicates significance at 1 per cent of MacKinnon (1996) one-sided p-values

Table 6 Estimated ADF statistic for unit root test in rubber prices (Latex 60)

Period	Kottayam		Kulala Lumpur	
	Level	First difference	Level	First difference
2005-2008	–2.08	–7.62*	–2.82	–30.56*
2009-2012	–1.81	–23.30*	–1.23	–12.93*

* indicates significance at 1%of MacKinnon (1996) one-sided p-values

To proceed with the cointegration analysis, it was necessary to decide well before the optimum lag length since Johansen's cointegration is much sensitive to the number of lags. It confirms the influence of lagged days on the current day price. For the present study the optimum lag length was estimated using the AIC criterion. Lag length of 8 was selected for the test.

Correlation analysis was performed to identify integration between domestic and international markets. Correlation analysis revealed a significant co-movement between Kottayam and the international reference markets which indicated a strong interaction between the price movements in both the markets.

Johansen's cointegration test revealed the Eigen value and the trace statistic for each set of variables. The purpose of the test was to identify whether the two markets were integrated, thereby price transmission (information flow) takes place, helping in the process of price discovery. The cointegration analysis showed that test rejects the null hypothesis of no cointegration relationship between domestic

Table 7 Estimates of Johansen's cointegration test for Kottayam and Bangkok market prices of natural rubber (RSS 4)

Period	Correlation	Eigen value	Trace statistic	Null hypothesis	Log likelihood ratio
2005-2008	0.90^	0.009694	15.50000	r=0*	4 732.787
		0.007492	3.740000	r≤1	
2009-2012	0.97^	0.016455	16.84643	r=0*	5 106.887
		0.009164	6.011887	r≤1	

*Denote the rejection of null hypothesis at 5% level of significance, ^ indicates the significance of correlation coefficients at 1per cent level of probability.

Table 8 Estimates of Johansen's cointegration test for Kottayam and Kuala Lumpur market prices of natural rubber (Latex 60)

Period	Correlation	Eigen value	Trace statistic	Null hypothesis	Log likelihood ratio
2005-2008	0.67^	0.035253	26.63000	r=0*	3 194.950
		0.006557	4.124561	r≤1	
2009-2012	0.93^	0.018773	15.69209	r=0*	4 453.671
		0.005214	3.392768	r≤1	

*Denote the rejection of null hypothesis at 5% level of significance, ^ indicates the significance of correlation coefficients at 1% level of probability.

and international reference markets (r=0) indicating the presence of one cointegration equation between two markets.

The eigen values and trace statistics are provided in Table 7 and 8. The hypothesis of no cointegrating vector (r=0) can be rejected for all cases as the trace statistics were higher than the critical values at 5% level.

Johansen's test has revealed the long run equilibrium between the market prices of natural rubber for domestic and international markets, justifying the use of a vector error correction model (VECM) for showing the dynamics. The vector error correction coefficients were – 0.016565 and – 0.003747 for Bangkok and Kottayam markets respectively, for the period 2005–2008 (Table 9). Both the error correction coefficients suggested that sustainable long run equilibrium was achieved by bridging the gap between international and domestic markets prices.

Vector error correction coefficients indicate how quickly the dependent variables such as domestic and international market prices absorb and adjust themselves for previous period disequilibrium errors. In other words, the coefficient measures the ability of the prices to incorporate shocks or news in the prices. In this case, Kottayam and Bangkok market absorbed only 1.00 and 0.37% respectively to bring about the equilibrium in prices. The information flow was more in Kottayam market compared to Bangkok. For the period 2009–12 the rate of adjustment were 0.05 and 1.44% respectively.

Similar analysis was done for the Kottayam- Kuala Lumpur markets. The error correction coefficients in Kuala Lumpur and Kottayam markets were estimated to be 0.51 and 0.006 respectively (Table 10). This indicated that 51% of disequilibrium was corrected each day by changes in the international reference prices. Similarly only 0.60% of disequilibrium was corrected each day by changes in the Kottayam market prices. It also implied that information flows from international to domestic market. During the period 2009–12, error correction coefficients were 0.005 and 0.044, respectively, i e only 0.50% disequilibrium was corrected each day by changes in international reference prices of Kuala Lumpur. Whereas 4.40% of the disequilibrium was corrected each day by changes in the Kottayam market price, i e the information flow in the Kottayam market was high.

It is concluded that rubber prices were showing considerable instability in both domestic and international price behaviour. It was observed that the price volatility was getting widened over time and found to be higher in international markets. It is also inferred that the international and domestic markets are integrated. These results help to explore further on the market research studies of natural rubber which is a major raw material for industries like automobile, gloves etc. Such studies are equally important for efficient resource allocation also.

Table 9 Estimates of vector error correction model in natural rubber market prices of Kottayam and Bangkok markets

Period	Cointegration equation		Error correction estimates	
	Constant	Coefficient	Bangkok	Kottayam
2005–2008	–1.113605	–0.723320	–0.016565	–0.003747
		(0.21382)	(0.00668)	(0.00597)
2009–2012	0.943778	–1.222870	–0.005146	0.014496
		(0.09163)	(0.00588)	(0.00568)

Table 10 Estimates of vector error correction model in natural rubber market prices of Kottayam and Kuala Lumpur markets (Latex 60)

Period	Cointegration equation		Error correction estimates	
	Constant	Coefficient	Kuala Lumpur	Kottayam
2005–2008	0.158256	– 1.041458	0.509340	– 0.006010
		(0.06486)	(0.05248)	(0.00268)
2009–2012	– 0.852425	– 0.791324	0.005754	– 0.043644
		(0.08016)	(0.00554)	(0.01402)

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