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Modelling of price transmission: Evidences from Indian silk market

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Abstract
The study was conducted to investigate the degree and nature of integration among price series of Indian and Chinese raw silk and Indian reeling cocoons. The weekly average prices of reeling cocoon (Indian) and raw silk (Indian and Chinese) from 2nd January 2011 to 26th September 2020, which formed 508 sample records, were the data used for the study. The stationarity of data was checked with the help of Augmented Dickey-Fuller (ADF) (tau) test and Phillips- Perron test (PP test). Unit root test indicated that all the price series were non-stationary at level (original form of data), but were stationary after first difference. The cointegration of prices was examined by Johansen's cointegration procedure while price fluctuations were estimated by Error Correction Mechanism (ECM). The results obtained in Johansen's cointegration and error correction models suggest that both short run as well as long run and equilibrium relationships exist between Chinese and Indian silk prices. The results also show short run as well as long run and equilibrium relationship between Indian silk prices and Indian reeling cocoons prices but there is no direct relation between Chinese silk prices and Indian cocoon prices.

Keywords: raw silk, price transmission, stationarity, augmented dickey-fuller test, johansen's cointegration, error correction mechanism

Introduction
Silk, which is known as "Queen of Textiles", is the most elegant textile in the world. On the other hand, the silk industry provides livelihood opportunity for millions owing to its high employment generating potential, low capital requirement and remunerative nature of its production. Though silk is produced by more than 60 countries in the world, China and India are the leading producers of silk in the world. China and India together account for about 95% of the global raw silk production of 109,381MT during 2019. With the annual raw silk production of 68,600 MT during 2019, China is the world leader in the raw silk followed by India with the production of 35,820 MT (ISC, ND).

Silk industry plays a crucial role in shaping the rural economy of India by providing employment to more than nine million persons. India has the unique distinction of being the only country in the world which cultures all the five known commercial varieties of silk namely, mulberry, tasar, oak tasar, eri and muga. In the total annual production of 35,820 MT in 2019-20, mulberry raw silk output aggregated to about 25,239 MT. The remaining 10,581 MT was non-mulberry silks (tasar, eri and muga). Mulberry sericulture is mainly practiced in four states namely, Karnataka, Andhra Pradesh, West Bengal and Tamil Nadu, which jointly account for about 93.20% of the total mulberry silk production in the country (CSB 2019) [8].

India is the largest consumer of silk in the world. As the domestic consumption of silk is more than the production, India imported raw silk to fill the demand-supply gap. India imported 3,315 MT of raw silk primarily from China during 2019-20 (CSB 2019) [8]. As India imports a considerable quantity of silk, the international prices of silk are expected to influence the Indian silk prices, which in turn affects the prices of cocoon, as cocoon is the raw material for the production of silk.

A key economic principle is that markets permit price signals to be transmitted both spatially and vertically (Conforti, 2004) [9]. The price transmission analysis measures how changes in one market are transmitted to another, thus it reflecting the extent of market integration as well as the extent to which markets functions efficiently. If markets are perfectly integrated, price signals are transmitted from a selected location to other locations leading to a price adjustment in response to the existence of a supply or demand excess in other locations. Several factors such as trade flows, transactions costs, trade policies, availability of price information across markets and market infrastructure determine the degree of price transmission of a particular commodity in a country (Goundan and Tankari, 2018) [14].

Commodity dependence causes terms of trade imbalances and fiscal and monetary policy stresses for developing countries and adversely affects the domestic consumers and producers, as their economies are susceptible to the global commodity price shocks and volatility (UNCTAD. 2017) [31]. India's dependence on imported silk to bridge the demand supply gap subjects the Indian sericulture industry to the price fluctuations in the international markets. It is also equally important to understand how and to what extent the global prices of silk are transmitted to the farmers or producers of cocoon, as many studies indicated the farmers' response to the price changes (Kumaresan *et al.*, 2008) [18].

Though few studies are available on domestic cocoon and raw silk market integrations, there is hardly any study that has specifically examined the market interdependence of Indian raw silk with the international market in the recent years. In this context, the present study analyses causal relationships and dynamic interactions among Chinese raw silk prices with that of Indian raw silk prices and further the relationship between raw silk and reeling cocoon prices by employing a series of econometric tests.

Materials and Methods

Nature and Source of Data

The weekly average prices of Indian and Chinese mulberry raw silks and Indian mulberry cocoon were used for the study. The study data comprised 508 sample records of weekly average prices recorded for a period between 2nd January 2011 and 26th September 2020. There is no international commodity price for silk as there are very few countries involved the production and trade of raw silk. The Chinese price is the de facto international price as it is the largest trader of raw silk in the world (Currie, 2001) [10]. Therefore, Chinese silk prices were considered as international silk prices to compare with Indian silk prices in the study. The weekly Chinese silk prices were computed from the daily silk prices collected from the website, http://www.sunsirs.com/uk/prodetail-322.html.

Karnataka is the largest silk producing state in the country. Therefore, the filature silk prices collected from Karnataka State Silk Exchange were considered the Indian raw silk prices. The statistics pertaining to the cocoon prices were collected from Government Cocoon Market, Ramamanagaram, which is the largest cocoon market in India. The prices of bivoltine variety of cocoon were considered for the present study.

Analytical framework

The analysis of the market integration and price transmission mechanism has received considerable attention in recent years and various approaches can be found in the literature (Vavra and Goodwin, 2005) [33]. The literatures indicate that the research studies used different approaches such as correlation coefficients, regression models, time-series analysis techniques (dynamic regression, Granger Causality impulse response functions of vector autoregressive models (VAR), cointegration techniques) and nonlinear approaches such as nonlinear error correction model, nonlinear cointegration regression, functional coefficient regression, Markov modeling, Threshold cointegration approach etc, to analyze the price transmission (Goundan and Tankari, 2018) [14]. The common feature of these approaches is that they are generally based on time series analysis.

Before the introduction of cointegration techniques, the economists relied on linear regressions to find the relationship between several time series processes. However, Granger and Newbold (1974) [15] argued against the linear regression for analyzing time series due to the possibility of producing spurious correlation. The regression analysis in measuring price integration is usually customized using the time series variables in their first difference order, but this causes 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 spurious results, thus enhancing the accuracy of research findings.

In the present study, Augmented Dickey-Fuller (ADF) and traditional Phillips-Perron test (PP test) were employed to examine the presence of non-stationarity in the data series. The Jensen's cointegration analysis was used to investigate the dynamic interactions between price series. Besides, Engel-Granger error correction model was fitted to examine the causal structures among the study variables.

Cointegration and Error Correction Model

Markets are said to be integrated when the price changes in one market are fully transmitted to other markets. Markets that are not integrated may convey inaccurate price information that might distort market decisions and contribute to inefficient product movement.

The concept of cointegration and the methods for estimating the cointegrated relation provides a framework for estimating and testing the long run equilibrium relationships among the non-stationary integrated variables (Engel and Granger, 1987) [12]. Let P_{1t} and P_{2t} are the two price variables having different levels of the supply chain. If they are integrated of the same order, say I(d) and at least one linear combination of these market prices is stationary, they are said to be cointegrated. It can be expressed as

$$P_{1t} = \beta_0 + \beta \, P_{2t} + u_t \qquad \dots \dots (1)$$

Where β is the co-integrating coefficient and the Equation (1) is referred to be as the co-integrating regression model. Before going to cointegration estimation procedure, it is necessary to check for the stationarity of variables.

Stationarity and nonstationarity

Time series data consist of observations, which are considered as a realization of random variables that can be described by some stochastic process. The concept of stationarity is related to the properties of these stochastic processes. Data are assumed to be stationary, if the means, variances and covariance of the series are independent of time, rather than the entire distribution. Nonstationarity in a time series occurs when there is no constant mean μ, no constant variance σ_t^2 or both of these properties. It can originate from various sources but the most important one is the unit root.

Test for stationarity

Augmented Dickey- Fuller test (ADF) and Phillip-Perron test (PP) were employed to test the null hypothesis of non-stationarity against an alternative of stationarity of the price data under consideration. Though PP test is non-parametric but is relatively more powerful in testing stationarity compared to the parametric ADF test.

A test of stationarity is commonly known as unit root test. A series P_t is said to be integrated of order one I(1) or contains a unit root, if P_t is non-stationary. But it will become stationary after taking the first difference of the series (ΔP_t). Dickey-Fuller devised a procedure to formally test for non-stationarity. This is based on the following simple AR(1) model. The more convenient version of the test is given by the following equation

$$\Delta P_t = \gamma P_{t-1} + \varepsilon_t \qquad (2)$$

Where $\gamma = \Phi-1$, Null hypothesis of H_0: $\gamma = 0$ is treated against the alternative hypothesis H_1: $\gamma < 0$. Acceptance of null hypothesis is the indication of pure random walk model.

Augmented Dickey Fuller test (ADF test)

Dickey and Fuller made an assumption on residual to be a white noise. But in their usual DF test, this assumption is violated. To correct this, they augmented the DF test by adding the extra lagged terms of the dependent variable, which will eliminate the problem of serial correlation, thus makes the residual a white noise. The optimal lag length on the dependent variable is decided based on the Akaike Information Criterion (AIC) or Schwartz Bayesian Criterion (SBC).The ADF equation can be written as

$$\Delta P = a_0 + \gamma P_{t-1} + \sum_{i=1}^{p} a_1 \Delta P_{t-1} + \varepsilon_t \qquad \ldots\ldots (3)$$

This test assumes that there is at most one unit root and the residual to be Gaussian white noise. The test procedure for unit roots is similar to statistical tests for hypothesis, that is:

- Set the null and alternative hypothesis as H_0: $\gamma = 0$ H_1: $\gamma < 0$
- Determine the test statistic using $F_\gamma = \frac{\gamma}{SE(\hat{\gamma})}$ Where SE $(\hat{\gamma})$ is the standard error of γ.
- Compare the calculated test statistic F_γ with the critical value from Dickey-Fuller table to reject or not to reject the null hypothesis.
- The ADF test is a lower-tailed test. So if F_γ is less than the critical value, the null hypothesis of unit root is rejected and the conclusion is that the variable of the series does not contain a unit root and is non stationary.

Phillips- Perron test (PP test)

PP test is a modification of the ADF test statistic, which takes into account the less restrictive nature of the error process. It is represented by an AR(1) process. PP test makes a correction to the t statistics of the coefficient from the AR(1) regression to account for the serial correlation in the error term.

The Mackinnon (1991) critical values are applicable for both the tests. First the order of integration of the price series is examined, which is pre-requisite for testing the cointegration among the considered price series.

$$\Delta P_{t-1} = a_0 + \beta P_{t-1} + \varepsilon_t \qquad (4)$$

Cointegration tests

Testing for cointegration implies testing for the long-run relationship between variables. There are number of cointegration tests such as the Engle-Granger method developed by Engel and Granger (1987) [27], which is commonly known as the two-step estimation procedure, and the Johansen's procedure developed by Johansen (1988) that is known as a full information maximum likelihood method.

Johansen's procedure

Johansen's cointegration test relies on maximum likelihood method. This procedure is based on the relationship between the rank of a matrix and its characteristic roots. Johansen derived the maximum likelihood estimation using sequential tests for determining the number of co-integrating vectors. He suggested two test statistics to test the null hypothesis that there are at most 'r' co-integrating vectors. This can equivalently be stated as the rank of the coefficient matrix (∏), is at most 'r' for r=0, 1, 2, 3…n-1. The two test statistics are based on the trace and maximum eigen values, respectively.

$$\Delta P_t = \alpha + \beta_t + (p-1)P_{t-1} + \theta_1 \Delta P_{t-1} + \ldots\ldots\ldots + \theta_{k-1}\Delta P_{t-k+1} + W_t \ldots (5)$$

$$\lambda_{trace} = -T\sum_{i=r+1}^{n} \ln(1-\lambda_i) \qquad \ldots\ldots (6)$$

$$\lambda_{max} = T\ln(1-\lambda_{r-1}) \qquad \ldots\ldots (7)$$

In testing for efficiency of two spatially separated markets (which is the necessary condition for market integration), the null hypothesis should be tested for r=0 and r=1. If r=0 cannot be rejected, it can be concluded that there is no cointegration. On the other hand, if r=0 is rejected and r=1 cannot be rejected, it can be concluded that there is a co-integrating relationship. Cointegration implies existence of a co-integrating vector β. The hypothesis in market efficiency can be tested by imposing restrictions on the co-integrating vector β. Then the standard likelihood ratio test can be applied in this case. Specifically, the test statistics can be expressed by the canonical correlations as stated by Johansen (1988).

$$\mathrm{LR} = T\sum_{t=1}^{r} \ln(1-\lambda_t^*) - \ln(1-\lambda_i^*) \qquad \ldots\ldots (8)$$

Where $\lambda_1^*, \ldots\ldots\ldots\ldots\ldots\ldots\ldots, \lambda_r^*$ are the largest squared canonical correlations under the null hypothesis, the restricted model, the test statistics follows an asymptotic Chi-square distribution with the degree of freedom equaling the number of restrictions imposed. The next step is to estimate the error correction coefficients using Engel-Granger Error Correction (ECM) model.

Engel Granger error correction model

From the results of either Engle-Granger test or Johansen cointegration test, if the price series under consideration are found to be co-integrated, the residuals from the equilibrium regression can be used to estimate the error correction mechanism (ECM). It is performed with an intention to analyze the long term and short term effects of the variables as well as to find the speed of adjustment of disequilibrium to the original equilibrium condition. This coefficient is the lagged residual terms of the long run relationship. Its functional form is represented as

$$\Delta p_{1t} = C + \partial u_{t-1} + \beta \Delta p_{2t} + e_t \qquad \ldots\ldots (9)$$

Where e_t is identically and independently distributed (IID) and $\partial = (\alpha - 1)$ is the coefficient of the term and u_{t-1} is the error correction coefficient, which is also called as the adjustment coefficient. Error correction coefficient tells us how much of the adjustment to equilibrium takes place in each period, or how much of the equilibrium error is corrected. This error correction coefficient is expected to be negative and statistically significant. If the error term is negative, then only we can say that the two variables can converge to equilibrium. Convergence is a prerequisite for the presence of cointegration. If there is no convergence, the two variables cannot maintain a long run equilibrium relationship.

The Jensen cointegration and error correction models were endeavored using the Eviews-8 statistical package. The models were built by using weekly average price data of Indian silk, Chinese silk and Indian cocoon from 2nd January 2011 to 26th September 2020.

Results and Discussion

Gujarati and Sangetha (2007) [16] noted that before pursuing the formal examination of unit root test, it is always advisable to plot the time series under study because such plots give an initial hint about the probable nature of the time series. Accordingly, trivariate line charts for Indian and Chinese silk prices and Indian cocoon prices for the study period were plotted to understand the nature of the time series (Fig.1). Chinese silk prices were generally higher than Indian silk prices for entire study period, as there are differences in the quality of silk produced in India and China. The Chinese silk prices flew at the top of the chart across the time and the Indian silk prices followed the prices of the Chinese silk with same level of infancy, expansion and other fluctuations. The reeling cocoon prices stood at lower parts of the chart due to higher prices of silk compared to reeling cocoon price across the study period.

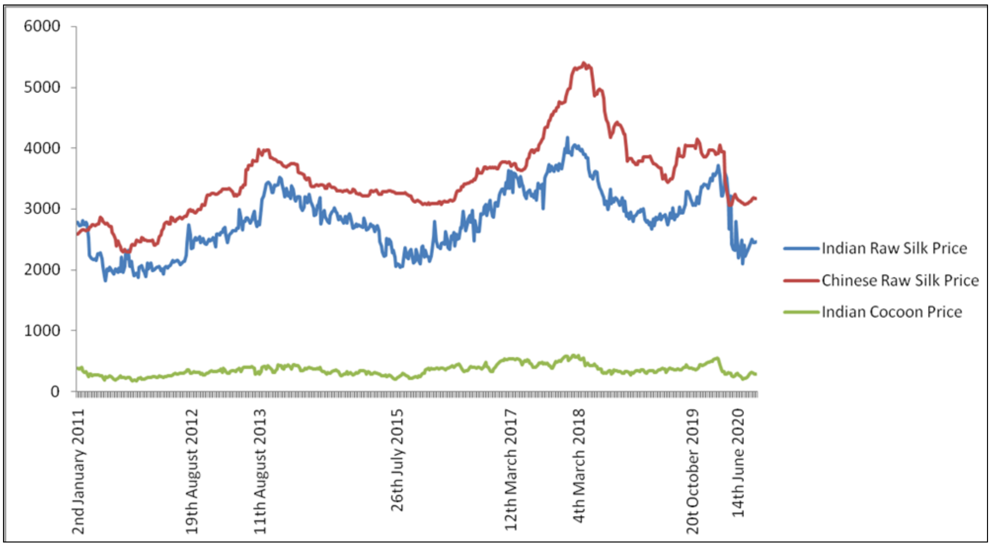

Fig 1: Trivariate plot for Indian silk price, Chinese silk price and Indian cocoon prices

I. Examination of Unit root test

The first and foremost step for any time series analysis is checking the viability of the data by employing stationary test to assess the constant mean and variance across the time period for all the price series considered under study. For testing the unit root, the null hypothesis as non-stationarity against the alternative hypothesis as stationarity was formulated. Both ADF and PP tests were conducted for all the price series at their level and at first differenced conditions. The tests were conducted by considering all the assumptions i.e. with intercept, with intercept but trend and without intercept and trend.

The results of ADF and PP tests for all the three price variables for both level series and differenced series are summarized in Table 1. The t statistics for all the three series with constant, with constant and linear trend and without constant and linear trend were showing non-significant for both the tests at 5 % level that indicates acceptance of the null hypothesis. Hence, we could conclude that all the three series were facing unit root problem indicating that the price series with level (raw series) were non-stationary in nature unless they were subjected to any sort of differencing.

Table 1: Augmented Dickey-Fuller and Phillip-Peron Stationarity tests for level series and differenced Series

Level Series												
Model	Indian Silk				Chinese Silk				Indian Cocoon			
	ADF test		Phillip Peron test		ADF test		Phillip Peron test		ADF test		Phillip Peron test	
	t-stat.	Prob.*	Adj. t-Stat.	Prob.*	t-stat.	Prob.*	Adj. t-Stat.	Prob.*	t-stat.	Prob.*	Adj. t-Stat.	Prob.*
Constant	-2.054	0.261	-2.320	0.165	-1.672	0.444	-1.743	0.408	-3.098	0.027	-3.040	0.032
Constant, Linear trend	-2.234	0.468	-2.620	0.271	-0.947	0.948	-1.264	0.895	-3.373	0.056	-3.351	0.059
None	-0.501	0.498	-0.504	0.497	0.044	0.696	-0.005	0.680	-0.922	0.316	-0.818	0.361
Differenced Series												
Model	Indian Silk				Chinese Silk				Indian Cocoon			
	ADF test		Phillip Peron test		ADF test		Phillip Peron test		ADF test		Phillip Peron test	
	t-stat.	Prob.*	Adj. t-Stat.	Prob.*	t-stat.	Prob.*	Adj. t-Stat.	Prob.*	t-stat.	Prob.*	Adj. t-Stat.	Prob.*
Constant	-30.693	0.000	-32.055	0.000	-12.374	0.000	-18.386	0.000	-21.747	0.000	-22.286	0.000
Constant, Linear trend	-30.668	0.000	-32.038	0.000	-17.689	0.000	-18.313	0.000	-21.726	0.000	-22.271	0.000
None	-30.723	0.000	-32.086	0.000	-12.382	0.000	-18.399	0.000	-21.768	0.000	-22.311	0.000

In order to convert all the three time series from non-stationary to stationary series, the data were subjected to first differencing technique. When data series were differenced once, t-statistics for all three series were greater than the critical value for both ADF and PP tests. Therefore, all these results allowed us to reject the null hypothesis of non-stationarity and accept the alternative hypothesis for all the three price series. The unit root test revealed that when all the series were in the level form, the null hypothesis of the unit root could not be rejected but in case of first difference form, null could be rejected, which indicates that the data series became stationary at one differencing and corroborated that all the time series variables were integrated at order one.

II. Cointegration test

After ensuring from unit root test that all the variables under study were stationary at same level I (1), Johansen cointegration test was carried out to check long run relationship among the price variables. The results of the test are given in Table 2, which presents the trace statistics, maximum eigen statistics and probability value listed for all possible hypotheses. The test statistics (trace=21.9579 and maximum eigen statistics=19.5452) was significant at 5% level for none, which guided us to reject the null hypothesis that there was no cointegrated vector for none among these series. On the other hand, as the test statistics was not significant at 5% level for the hypothesis at most one cointegrating equation (trace=2.4126 and maximum eigen statistics=2.4126), the null hypothesis was accepted. This indicates that there was a chance of single cointegrating vectors among these price series of Chinese and Indian silk and they had long run association between them. In other words, both Chinese and Indian silk prices moved together in long run in conformity with the concept of market integration irrespective of other determinants of prices. Even there were several shocks in domestic and international markets, Indian silk prices had a long-run relationship with Chinese silk prices. Arunkumar *et al.*, (1994) [3] reported that the Bangalore silk exchange prices were interrelated with the prices of Yohama silk exchange in Japan but not with the Kobe silk exchange.

Table 2: Johansen cointegration test between Chinese and Indian silk prices

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None	0.03811	21.9579	15.4947	0.0046
At most 1	0.00478	02.4126	03.8414	0.1204
Unrestricted Cointegration Rank Test (Maximum Eigen value)				
Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.0381	19.5452	14.2646	0.0067
At most 1	0.0047	02.4126	03.8414	0.1204
Cointegrating Equation				
China Silk Price		Indian Silk Price		
1.0000		1.3614 (0.1348)		

Note: Figure in parenthesis indicates standard error

The long run estimates of Chinese and Indian silk prices are also presented in Table 2. The coefficient (1.3614) is statistically significant and possesses positive sign. This implies that 1 % increase in Chinese silk price would lead to 1.36% increase in Indian silk price on an average in the long run. Thus both the Chinese and Indian silk prices were perfectly cointegrated for the study period considered. Though there was spatial price transmission in silk from Chinese market to Indian market, the effect of price transmission was considerable.

Table 3 presents the trace statistics, maximum eigen statistics and probability value listed for all possible hypotheses in order to test the long run relations between Indian silk and cocoon prices. The test statistics (trace=39.8361 and maximum eigen statistics=35.6950) was significant at 5% level for none, which let us reject the null hypothesis of no cointegrated vector for none among these series. Whereas the test statistics (trace=4.1411 and maximum eigen statistics= 4.1411) was not significant at 5% level at most one cointegrating equation. Therefore, null hypothesis of existence of single cointegrating vectors among these two series was accepted. This implies that the Indian cocoon and raw silk price series converges towards equilibrium in the long-run even though they might deviate in the short-run. As the demand for cocoon is derived from the demand for raw silk, a close relationship is expected among the prices of cocoon and raw silk. The study conducted by Arunkumar *et al.*, (1994) [3] also reiterated a high degree of interrelationship between raw silk and mulberry cocoon prices.

Table 3: Johansen cointegration test between Indian silk and cocoon prices

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None	0.0685	39.8361	15.4947	0.0000
At most 1	0.0081	04.1411	03.8414	0.0718
Unrestricted Cointegration Rank Test (Maximum Eigen value)				
Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.0685	35.6950	14.2646	0.0000
At most 1	0.0081	04.1411	03.8414	0.0718
Cointegration Equation				
Indian Silk Price		Indian Cocoon price		
1.0000		8.2384 (0.5624)		

Note: Figure in parenthesis indicates standard error

The long run estimates of Indian silk prices and Indian cocoon prices are given in Table 3. The positive coefficient indicates that 1% increase in Indian silk price in Indian major market would lead to 8.23% increase in cocoon prices on an average in the long run.

Table 4: Johansen cointegration test between China silk price and Indian cocoon price

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigen value**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None	0.0487	28.3897	15.4947	0.0004
At most 1	0.0064	03.2560	03.8414	0.0412
Unrestricted Cointegration Rank Test (Maximum Eigen value)				
Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.0487	25.1336	14.2646	0.0007
At most 1	0.0064	03.2560	03.8414	0.0412

The Johansen cointegration test conducted to analyze the long run relations between Chinese silk and Indian cocoon prices (Table 4) indicated that the test statistics was significant at 5% level for both none and at most one cointegrating equation. The results let us to reject the null hypothesis, which meant that there was no long run association between China silk price and Indian cocoon price for study period.

III. Error Correction Model (ECM)

The results of Johansen cointegration test indicated the cointegration between Chinese and Indian silk prices and also between Indian silk and cocoon prices. However, these results by their own do not provide sufficient information regarding the cause and effect relationship among the variables, except that they assure at least a unidirectional causality. Therefore, an ECM was endeavored using the Eviews-8 statistical package to find out the direction of price causality and the speed of adjustment of disequilibrium to the original equilibrium condition.

The regression of non-stationary time series on another non-stationary time series may cause a spurious regression or non-sense regression. A spurious regression model is not desirable as it causes violation of assumptions of regression model. In this study, the price of Chinese silk price was considered as the dependent variable and Indian silk prices acted as explanatory variable. These variables had unit root problem at 5% level before differencing and showed non-stationarity of time series. The model (Model 1) specified was

Chinese silk price $=B_1+B_2$*Indian silk price $+\varepsilon_i$ … (10)

The result of regression analysis of the above model is shown in Table 5. A R^2 value greater than Durbin Watson statistics is a major symptom of spurious regression. In the estimated Model 1, the R^2 value (0.749) was greater than Durbin Watson statistics (0.21). In addition to that, Adjusted-R^2valuewas also greater than 0.50, and AIC (14.41), SIC (14.42), and HQ (14.41) criteria were far away from zero. All these criteria indicated that the fitness of the model had to improve lot. Though a model is found to be spurious, the acceptance and rejection of the model depends upon the stationarity of the residuals obtained after estimation of the parameters. Therefore, Augmented-Dicky fuller test was undertaken in the next step to test the stat the stationarity of the residuals.

Table 5: Estimated Regression model for Chinese and Indian silk prices

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	468.9740	79.4108	5.9056	0.0000
Indian silk price	1.0781	0.0277	38.8592	0.0000
R^2	0.7490	Mean dependent variable		3503.4800
Adjusted R^2	0.7485	S.D. dependent variable		648.3059
S.E. of regression	325.1131	Akaike info criterion		14.4101
Sum squared residuals	534834	Schwarz criterion		14.4268
Log likelihood	-3658.17	Hannan-Quinn criteria		14.4168
F-statistic	1510.03	Durbin-Watson stat		0.2189
Prob(F-statistic)	0.0000			

The test statistics (-4.708) of Augmented Dickey-Fuller test was found to be significant at 5% level, which means rejection of null hypothesis and acceptance of the alternative hypothesis that the residuals were stationary in nature (Table6). Any model should satisfy two conditions to become non-spurious. First, the variables included in the model must stationary in nature and secondly, the residuals of the model should be stationary. If any of the above conditions are satisfied, the model becomes a non-spurious model.

Table 6: Augmented Dickey-Fuller test to test the stationarity of the residuals of the regression model between Chinese and Indian silk prices

Augmented Dickey-Fuller test statistic	t-Statistic	Prob.*
Test critical values:	-4.7085	0.0001
1% level	-3.4430	
5% level	-2.8670	
10% level	-2.5697	

The error correction models can be chosen only in the situation where the variables in the models are co-integrated. The stationary nature of residuals of the Model 1 indicates that the variables in the model (Chinese and Indian silk prices) were cointegrated and had equilibrium relationship between them. As the variables were cointegrated, we could go for ECM (Model 2) as mentioned bellow

D(Chinese silk price) $= B_1+B_2$*D(Indian silk price)$+B_3$*$(U_{t-1})+V$ ……(11)

Where Chinese and Indian silk prices are first difference series, B_1 is the intercept, B_2 is the short run coefficient, $B_3$is equilibrium and long run coefficient, $U_{t-1}$is one period lag of residuals and V is the white noise error term. One period lag of residuals (U_{t-1}) for the Model 2 is also known as equilibrium error term of one period lag. U_{t-1} guides the variables (Chinese silk and Indian silk prices) of the system to restore back to the equilibrium. In other words, it corrects the disequilibrium. The sign of error correction (B_3) should be negative after estimation. The coefficients B_3 tells us at what rate it corrects the previous period disequilibrium of the system. When B_3 is significant and contains a negative sign, it validates a long run equilibrium relationship among variables (Chinese silk and Indian silk prices) stated in the model.

It can be inferred from Table 7 that the estimated regression Model 2 was not spurious, as the model had a R^2 value (0.11) less than Durbin Watson statistics (1.51). The short run coefficient (0.023) in the Model 2 was found to be significant at 5% level which indicates existence of short run relationship between the price series of Indian and Chinese silks. The negative and statistically significant coefficient of error term (-0.017) indicates the validity of long run relationship between Chinese and Indian silk prices. The regression coefficient of error term of-0.017 implies that the system corrected its previous period disequilibrium at a speed of 1.70% in a week.

Table 7: Error Correction Model between China Silk price and Indian silk price

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	1.1737	2.4974	0.4699	0.6386
D(Indian silk price)	0.0231	0.0193	1.1953	0.0325
U_{t-1}	-0.0178	0.0079	-2.2638	0.0240
R^2	0.1100	Mean dependent variable		1.16045
Adjusted R^2	0.0707	S.D. dependent variables		56.4327
S.E. of regression	6.2327	Akaike info criterion		10.9027
Sum squared residuals	159371.	Schwarz criterion		10.9278
Log likelihood	-2760.85	Hannan-Quinn criteria		10.9125
F-statistic	2.8027	Durbin-Watson stat		1.5195
Prob (F-statistic)	0.0615			

The relationship of Indian silk prices with that of Indian cocoon prices was also examined by considering Indian silk price as dependent variable and Indian cocoons price as explanatory variable. The specified model (Model 3) was in the following form

Indian silk price =B_1 +B_2*Indian cocoons price +ε_i … (12)

The results of regressions between Indian silk and cocoons prices are shown in Table 8. The estimated Model 3 was found to be spurious as the R^2value (0.688) was greater than the Durbin Watson statistics (0.30). Adjusted-R^2value (0.687) was also greater than 0.50 and AIC (14.18), SIC (14.20), and HQ (14.19) criteria were far away from zero. Hence, an ECM was endeavored to improve the fitness of the model.

Table 8: Regression between Indian silk price and Indian cocoons price

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	1129.525	52.0628	21.6954	0.0000
Indian Cocoon Price	04.8297	0.1445	33.4092	0.0000
R^2	0.6880	Mean dependent variable		2814.59
Adjusted R^2	0.6874	S.D. dependent variable		520.41
S.E. of regression	290.94	Akaike information criterion		14.1880
Sum squared residuals	428315	Schwarz criterion		14.2047
Log likelihood	-3601.76	Hannan-Quinn criteria.		14.1945
F-statistic	1116.17	Durbin-Watson stat		0.3072
Prob(F-statistic)	0.0000			

Augmented-Dicky fuller test was conducted to test the stationarity of the residuals obtained after estimation of the parameters in the model. Table 9 indicates that the test statistics (-5.208) was found to be significant at 5% level indicating rejection of null hypothesis. As the residuals were showing stationary in nature, we could accept the model and proceed for ECM between selected variables to test whether short run relation or long run relationship was existing between the variables.

Table 9: Augmented Dickey-Fuller Test to check the stationarity of residuals of the regression model between Indian silk prices and Indian cocoon prices

Augmented Dickey-Fuller test statistic	t-Statistic	Prob.*
Test critical values:	-5.208097	0.0000
1% level	-3.443046	
5% level	-2.867032	
10% level	-2.569757	

As the Augmented-Dicky fuller test indicated that both Indian silk and cocoon prices were cointegrated, we developed an ECM (Model 4) as mentioned bellow

D(Indian silk price) = B_1+ B_2*D(Indian cocoon price) + B_3*(U_{t-1}) + V ……(13)

Where Indian silk price and Indian cocoon price are first difference series, B_1 is the intercept, B_2 is the short run coefficient, $B_3$is equilibrium and long run coefficient, U_{t-1} is one period lag of residuals and V is the white noise error term. The results of ECM between Indian silk and cocoon prices shown in Table 10 indicates that Model 4 was not spurious, as R^2 value (0.12) was less than Durbin Watson statistics (2.53). The short run coefficient (1.072) was significant at 5% level indicating short run relationship between two price series. The coefficient of error term (-0.1376) was negative and significant. This implies the validity of long run relationship between Indian silk and cocoons prices. The coefficient of error term also indicates that the system corrected its previous period disequilibrium at the rate of 13.76% per week. Arunkumar *et al.*, (1994) [3] reported that the cocoon prices immediately responded to the changes in filature silk prices.

Table 10: Error Correction Model between Indian silk and cocoon prices

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-0.448531	5.521502	-0.081233	0.9353
D(Indian Cocoons price)	1.072637	0.223836	4.792070	0.0000
U_{t-1}	-0.137694	0.019021	-7.239057	0.0000
R^2	0.125057	Mean dependent variable		-0.654499
Adjusted R^2	0.121585	S.D. dependent variable		132.6476
S.E. of regression	24.3224	Akaike information criterion		12.48953
Sum squared residuals	7789852.	Schwarz criterion		12.51455
Log likelihood	-3163.097	Hannan-Quinn criteria.		12.49935
F-statistic	36.01863	Durbin-Watson stat		2.531811
Prob(F-statistic)	0.000000			

Conclusion

The purpose of this paper is to investigate the degree and nature of integration of the prices of the raw silk and reeling cocoons. The results of the Johansen's cointegration suggest that there was long run relationship existing between Chinese and Indian silk prices. The results also suggest that 1% increase in Chinese silk price would lead to 1.36% increase in Indian silk price on an average in the long run. The error correction models established short run as well as long run and equilibrium bidirectional relationships existing between Chinese and Indian silk prices. The regression coefficient of error term in ECM model implies that the system corrected its previous period disequilibrium at a speed of 1.70% in a week. The study concludes that there is considerable effect of price transmission from Chinese market to Indian market. As China is the largest producer of raw silk in the world, it has leadership role in the prices of raw silk in international market.

The study also revealed prevalence of short run as well as long run and equilibrium bidirectional relationship existing between Indian silk and Indian reeling cocoons prices. Further, the results showed that if 1% increases in Indian silk price in Indian major market would result in 8.23% increase in Indian cocoon prices on an average in the long run. The estimated parameter of error term indicates that the system corrected its previous period disequilibrium at the rate of 13.76% per week.

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