Market Integration and Price Leadership among Major Mulberry Cocoon Markets in South India

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Authors' contributions

This work was carried out in collaboration among all authors. Author GRH designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors PK, MUT and YS reviwed, corrected and added certain required points to the study. All authors read and approved the final manuscript.

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ABSTRACT

Market integration is a good proxy for measuring market efficiency and the emerging price signals from the markets can be utilized to benefit both farmers and reelers alike. The present study empirically examines the dynamic interrelationships among the prices of major cocoons markets viz. Ramanagaram (Karnataka), Sidlaghatta (Karnataka), Hindupur (Andra Pradesh) and Dharmapuri (Tamil Nadu) in terms of market integration. The monthly average prices of cross breed mulberry cocoons for a period between April 2002 and March 2021 were considered for the present study. The Augmented Dickey-Fuller (ADF) (tau) testindicated that all the price series were non-stationary at level, but were stationary after first difference. The Johansen's multivariate cointegration procedure revealed existence of cointegration among the prices of cocoon markets. The Vector Error Correction Models (VECM) revealed a long run price causality running from Ramanagaram and Sidlaghatta markets to all other markets considered under study. The Granger causality test indicated a unidirectional causality running from Ramanagaram and Sidlaghatta markets to all markets and not *vice versa*. The prices prevailed in Ramanagaram and Sidlaghatta markets controlled and decided the current prices of cross breed cocoons both in long run and short run in all other markets considered for the study.

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1. INTRODUCTION

Sericulture is an agro-based industry with enormous employment and income generation potential, which makes it among one of the most appropriate tools for socio-economic development of largely agrarian economy like India. India is the second largest producer of silk in the world after China with an annual silk output of 35,820 MT during 2019-20. India has the distinction of being the only country producing all five kinds commercially exploited natural silks namely, mulberry, eri, muga, oak tasar and tropical tasar. However, mulberry silk is dominant one and contributes for about 70% of the country's raw silk production. Mulberry silk is primarily produced in the states of Karnataka, Andhra Pradesh, Tamil Nadu and West Bengal, which collectively account for 95% of the total mulberry silk production in the country.

The rate of growth in sericulture depends on the way farmers respond to dynamic market conditions, as they are the final decision makers concerning the allocation of land and other resources and supply of farm produces. Remunerative and stable cocoon prices play a crucial role in increasing its production. On the other hand, wide price fluctuations disincentivize the farmers from making large-scale investments to improve productivity.

High degree of market integration is crucial for higher competeveness among the markets which leads to improved market efficiency. On the other hand, the markets that are not integrated presents inaccurate picture about price information leading to misallocation of resources, which in turn causes price fluctuations pronounced more particularly in one market or the other. Thus the condition of less or no market integration may distort production decisions, contribute to inefficiencies in markets and harm the ultimate consumers [1].

The existing literature on market integration in mulberry cocoon is quite scanty. Nagaraj et al., [2], Devaiah et al., [3], Prabhakara [4] and Bharathi [5] analyzed market integration and price transmission in spatially separated cocoon markets in Karnataka. Naik and Babu [6], Arunkumar et al., [7] and Parameshwarappa [8] examined if the prices of Indian silk integrated with the international prices. Prabhakara [4] and

Arunkumar et al., ([7] analyzed vertical price transmission between silk prices at Bangalore Silk Exchange and cocoon markets in Karnataka. Most of these studies used correlation coefficients to measure the market integration, which suffer from the limitation that they use raw price series, which more likely to include the influences of factors such as climatic factors, inflation, policy change or any other shocks that affect the markets [9]. This is likely to conceal the true degree of integration.

With the advances in time-series and econometric techniques, the recent studies have started using the cointegration methodology. Chaithra [10] and Halagundegowda et al., [11] used Vector Error Correction Model (VECM) for analyzing the degree and nature of integration among price series of mulberry cocoons. The former study analyzed cointegration of specially separated cocoon markets in Ramanagaram, Shidlaghatta and Vijayapura in Karnataka, whereas the later one investigated the vertical integration among price series of Indian and Chinese raw silk and Indian reeling cocoons.

A review made on the previous studies conducted on integration of mulberry cocoon and silk markets in India indicates that eitherthey were confined to a limited geographical regionor vertical integration of cocoon and raw silk markets or have used less advancedmethods like correlation coefficients.There is hardly any study to analyze the integration of cocoon markets across the states and the extent of influence of the most influential market on the other markets across the country.

In South India, mulberry cocoons are primarily traded in regulated cocoon markets organized by the State Governments. There are 55 cocoon markets functioning in Karnataka, 8 markets in Andhra Pradesh and 23 markets in Tamil Nadu. Government Cocoon Market (GCM), Ramanagaram in Karnataka is the largest cocoon market in the country and is considered as a leader in setting the prices for mulberry cocoons. Therefore, specifically, the study intends to objectively explore the power of Ramanagaram cocoon market to influence the mulberry cocoon prices in other states. Knowledge of the most influential markets would help the policymakers to pay more attention to those markets considering their potential to

influence the national price. The study also empirically examines the degree of exchange of market information in terms of market integration among the major cocoons markets in the key mulberry silk producing states.

2. MATERIALS AND METHODS

2.1 Nature and Source of Data

The monthly average prices of cross breed mulberry cocoons were considered for the present study. The study data comprised 228 sample records of monthly average prices pertaining to a period between April 2002 and March 2021. The cocoon price statistics were collected from two major Government Cocoon Markets (GCM) in Karnataka namely Ramamanagaram and Sidlaghatta, one market each in Andhra Pradesh (Hindupur) and Tamil Nadu (Dharmapuri). However, the price of cross breed cocoons in Dharmapuri market was available only for a period between April 2011 and March 2021. Therefore, to compensate overall series data, we used price data of Coimbatore market (which was leading cocoon market in Tamil Nadu during that period) from April 2002 to March 2011. The markets were selected on the basis of the quantum of cocoon transacted in the respective states. The statistical software, Eviews-8 was used for cointegration analysis and also to construct VECMs.

2.2 Analytical Framework

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. Non-stationarity 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.

2.3 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 [12],

$$\Delta P = a_0 + \gamma P_{t-1} + \sum_{i=1}^{p} a_1 \Delta P_{t-1} + \mathcal{E}_t \qquad (1)$$

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: γ = 0 H_1: γ < 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.

2.4 Johansen's Cointegration 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 [13].

$$\Delta P_t = \alpha + \beta_t + (p-1)P_{t-1} + \theta_1 \Delta P_{t-1} + \dots + \theta_{k-1} \Delta P_{t-k+1} + W_t \qquad (2)$$

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \qquad (3)$$

$$\lambda_{max} = T \ln(1 - \lambda_{r-1}) \qquad (4)$$

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).

$$LR = T \sum_{t=1}^{r} \ln(1 - \lambda_t^*) - \ln(1 - \lambda_i^*) \qquad (5)$$

Where $\lambda_1^*, \dots \lambda_r^*$ 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.

2.5 Vector ErrorCorrection Models (VECM)

The vector autoregressive (VAR) model is a general framework used to describe the dynamic interrelationship among stationary variables. So the first step in time series analysis should be to determine whether the levels of the data are stationary. If not, take the first differences of the series and try again. Usually, if the levels (or log-levels) of your time series are not stationary, the first differences will be. If the time series are not stationary, the VAR framework needs to be modified to allow consistent estimation of the relationships among the series. The vector error correction (VEC) model is just a special case of the VAR for variables that are stationary in their differences (i.e., I (1)). The VEC can also take into account any cointegrating relationships among the variables. Consider two time-series variables, y_t and x_t. Generalizing the discussion about dynamic relationships to these two interrelated variables yields a system of equations [13]:

$$\psi_\tau = \beta_{10} + \beta_{11}\psi_{\tau-1} + \beta_{12}\xi_{\tau-1} + v^y{}_t \qquad (6)$$

$$\xi_\tau = \beta_{20} + \beta_{21}\psi_{\tau-1} + \beta_{22}\xi_{\tau-1} + \varpi^\xi{}_\tau \qquad (7)$$

The equations describe a system in which each variable is a function of its own lag and the lag of the other variable in the system. In this case, the system contains two variables y and x. Together

the equations constitute a system known as a vector auto regression (VAR). In this example, since the maximum lag is of order one, we have a VAR (1).

If y and x are stationary, the system can be estimated using least squares applied to each equation. If y and x are not stationary in their levels, but stationary in differences (i.e., I (1), then take the differences and estimate using least squares:

$$\Delta\psi_\tau = \beta_{11}\Delta\psi_{\tau-1} + \beta_{12}\Delta\xi_{\tau-1} + \varpi^{\Delta y}{}_t \qquad (8)$$

$$\Delta\xi_\tau = \beta_{21}\Delta\psi_{\tau-1} + \beta_{22}\Delta\xi_{\tau-1} + \varpi^{\Delta x}{}_t \qquad (9)$$

If y and x are I(1) and cointegrated, then the system of equations is modified to allow for the cointegrating relationship between the I(1) variables. Introducing the cointegrating relationship leads to a model known as the Vector Error Correction (VEC) model.

2.6 Granger Causality Test

Causality test is considered as a potential technique to investigate price leadership in the market [14]. If two variables are integrated of order one, i.e., I(1),Granger causality test proposed by Granger [15] is the most accepted way to know the causal relation between them [16]. Therefore, Granger causality test was used in the present study, which is based on premise that the prices in market X causes the price in market Y if and only if the past values of market X provide additional information for the forecast of market Y.

A time series X is said to Grangercause Y, if it can be shown, usually through a series of t-tests and F-tests on lagged values of X (and with lagged values of Y also included), that those X values provide statistically significant information about future values of Y. We say that a variable X that evolves over time Granger-causes another evolving variable Y if predictions of the value of Y based on its own past values and on the past values of X are better than predictions of Y based only on Y's own past values.

If a time series is a stationary process, the test is performed using the level values of two (or more) variables. If the variables are non-stationary, then the test is done using first (or higher) differences. The number of lags to be included is

usually chosen using an information criterion, such as the Akaike information criterion (AIC) or Schwarz information criterion (SIC). Any particular lagged value of one of the variables is retained in the regression, if it is significant according to a t-test and the other lagged values of the variable jointly add explanatory power to the model according to an F-test. Then the null hypothesis of no Granger causality is not rejected if and only if no lagged values of an explanatory variable have been retained in the regression [15].

For a bivariate system of stationary time series $\{x_t\}$ and $\{y_t\}$, the variable x is said to Granger cause y if we can better forecast y using lagged values of x, even after lagged y variables are taken into account. Following Alexander (2001), consider a VAR (p) model for x and y which can be represented as:

$$Y_t=a_0+a_1Y_{t-1}+\dots+a_pY_{t-p}+b_1X_{t-1}+\dots+b_pX_{t-p}+U_t$$
(10)

$$X_t=c_0+c_1X_{t-1}+\dots+c_pX_{t-p}+d_1Y_{t-1}+\dots+d_pY_{t-p}+U_t$$
(11)

3. RESULTS AND DISCUSSION

The graphical analysis on the pattern of price movement is generally used as a primer to perform the formal tests of price integration. A plot of distinct cross breed cocoon price series of GCM, Ramangaram, Sidlaghatta, Hindupur and Dharmapuri for the entire study period is depicted in Fig. 1. The graph shows that all market prices were moving togetherin the long run albeit certain amount of disequilibrium or fluctuations in the shorter run. All market prices flew at the middle of the chart across the time with the Ramanagaram market prices guiding the flow and the remaining market prices mimicking the flow with same level of infancy, expansion and other fluctuations. The Sidlaghatta market prices showed the same trend and pattern of other markets at initial part, further it poses some outward shifts and swings at later part of the flow, which might be due to demand and supply inequillibruim. The Hindupur market prices fluctuated between Ramanagaram and Dharmapuri market prices, taking intermediate position in between these markets. Further, Dharmapuri market prices swung at lower part of all market prices.

3.1 Stationary 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 for the study.The results of the unit root test for all the series at both levels (original raw series) and the first differenced form are shown in Table 1. The null hypothesis set for ADF test was that there is unit root or nonstationarity in the respective series. The t-statistic of original series of all the fourmarket prices for ADF test was lower than the critical values. So this result did not allow us to reject the null hypothesis of non stationarity in any of the price series.
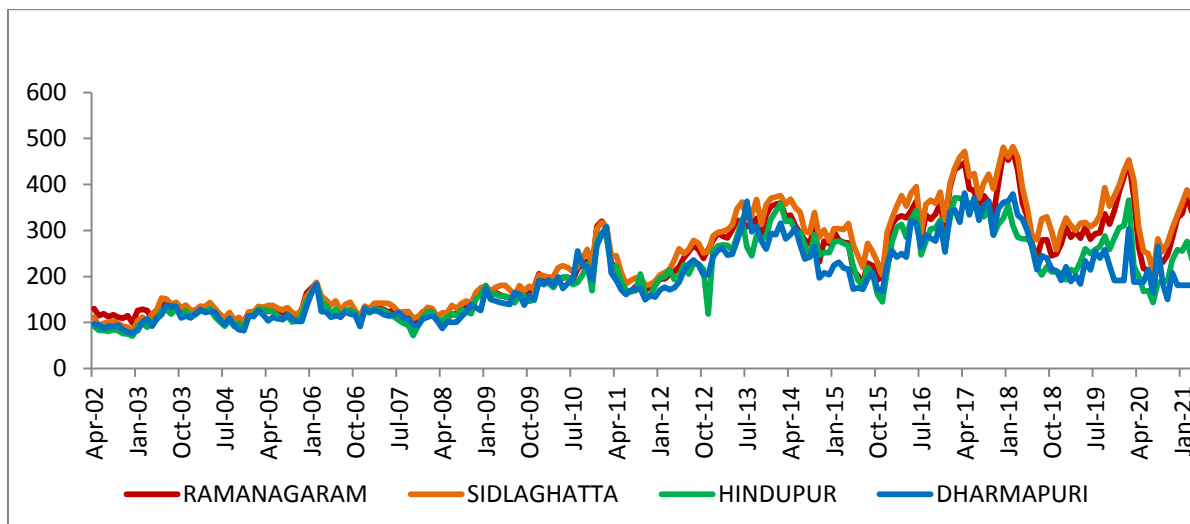

Fig. 1. Evolution of bivoltine cocoon prices in GCM Ramangaram, Sidlaghatta, Hindupura and Dharmapuri from April 2002 to March 2021

When the data series were differenced once, the t-statistics for all four market series became greater than the critical value for ADF test. Therefore, the results let us to reject the null hypothesis of non-stationarity and accept the alternative hypothesis. In a nutshell, the facts revealed by the unit root test was 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 hypothesis could be rejected. This indicates that all the series were integrated of order one. This is a necessary but not sufficient condition for cointegration.

3.2 Cointegration Analysis

After ensuring from unit root test that all the variables considered for the study were stationary at same level I (1),Johansen cointegration testwas carried out to check long run relationship among the price variables and theresults of Johansen's maximum likelihood tests(maximum eigen value and trace test) are reportedin Table 2. In both cases, the null hypothesis of no cointegration could be rejected, if the test statistic is greater than the critical value. It is clear that there were at most two long run cointegrating relationship existing among four market price series. This implies that the four price series converged towards equilibrium in the longrun even though they might deviate in the short run.

The empirical results implied that the price series were cointegrated and there was a stable equilibrium relationship between them. The results are in confirmation with the findings of the studies conducted by Nagaraj et al.*,* [2], Devaiah et al., [3], Prabhakara [4], Bharathi [17] and Chaithra [10], in which reported that the selected cocoon markets in Karnataka were spatially integrated. However, this situation prevailed in the markets while prices were tied together in the long run, but it might drift apart in the short run because of scarceness of availability of information and lack of quicker dissemination of available information. Further, the test statistics was significant at 5% level for two hypotheses for none to at most one cointegrating equation. Acceptance of the null hypothesis for at most two cointegrating equations clearly indicates that there is an existence of cointegration among the cocoon market prices and possible to construct two cointegrating equationsout of four market prices for the study period.

3.3 Vector Error Correction Model

There are four stages to develop the VECM. The first stage is confirmation of stationarity of the data, followed by finding lag length, then checking cointegration of variables and finally, construction of the model. Augmented Dickey-Fuller test was used to confirm stationarity of variables by checking the presence of unit root and the cointegration analysis was carried out by using Johansen test of cointegration. The results of both the tests are presented and discussed in previous sections.

Table 3 provides the criteria for deciding the lag length of the dependent variable for constructing the VECMs. The quantified value for Akaike information criteria, Schwarz information criteria and Hannan-Quinn information criteria are enlisted in the table for various lag lengths of the variable. Here, lower the values of AIC, SIC and HQ indicate better model fit and *vice versa*. Further, in present study,AIC, SIC and HQ tests posed the lowest value for the lag 2. Hence, lag 2 was selected for constructing the VEC Model.

Restricted VAR model indicates the speed of adjustment from the short run equilibrium to the long run equilibrium state. A VECM is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with nonstationary series that are known to be cointegrated. If the variables are not cointegrated, the model can be an unrestricted VAR model but not VECM.

The VECM helps to assess the causality in all possible combinations among four price variables. Here the relation can be quantified in terms of long run causality. It can be inferred from Table 4 that the model fitness criteria show that the F statistics is significant for all models at 5% level of significance and R^2 value are sufficient for all model to indicate goodness of fit.

The coefficients C (1) and C (2) indicate the error correction term, which means the speed of adjustment towards equilibrium. The coefficient C(1) for Hindupur(-0.836) and Dharmapuri(-0.902) had negative sign and was statistically significant at 5% level. A negative and statistically significant C (1) coefficient confirms that there was a long run causality running from Ramanagaram and Sidlaghatta markets towards Hindupur and Dharmapuri markets. The coefficient C(2) for Sidlaghatta (-0.895), Hindupur(-0.940) and Dharmapuri (-0.843)was negative and statistically significant at 5% level. This indicates that there was a long run causality

Table 1. Augmented dickey-fuller test results for level series and differenced series

Model	Ramanagaram		Sidlaghatta		Hindupur		Dharmapuri	
	t-test	Prob	t-test	Prob	t-test	Prob	t-test	Prob
I. Level Series								
Constant	-2.059	0.261	-1.929	0.318	-2.822	0.067	-2.258	0.186
Constant, Linear trend	-3.212	0.186	-3.951	0.116	-4.313	0.089	-2.792	0.201
None	-0.346	0.559	-0.188	0.617	-0.736	0.396	-0.576	0.466
II. Differenced Series								
Constant	-14.503	0.000	-15.796	0.000	-17.414	0.000	-21.141	0.000
Constant, Linear trend	-14.469	0.000	-15.760	0.000	-17.381	0.000	-21.117	0.000
None	-14.516	0.000	-15.797	0.000	-17.441	0.000	-21.183	0.000

Table 2. Joint Johansen cointegration test results for the cocoon prices

HypothesizedNumber of CE(s)		TraceStatistics	Max Eigen
r=0 (None)	Test Stat	104.011	67.294
	Critical Value	47.856	27.584
	Prob.	0.000	0.000
r<=1	Test Stat	36.717	27.753
(at most one)	Critical Value	29.797	21.131
	Prob.	0.006	0.005
r<=2	Test Stat	8.963	5.888
(at most two)	Critical Value	15.494	14.264
	Prob.	0.368	0.627

Table 3. Lag selection based on AIC, SIC and HQ criteria

Lag	AIC	SIC	HQ
0	38.566	38.627	38.591
1	34.474	34.780	34.597
2	34.314*	34.264*	34.336*
3	34.417	35.012	34.538
4	34.583	35.422	34.603
5	34.606	35.389	34.624

*Note: * indicates the lag order selected by criteria*

Table 4. Least square estimates of VECM

Error Correction	Ramanagaram	Sidlaghatta	Hindupur	Dharmapuri
C(1) CointEq1	-0.126	-0.138	-0.836*	-0.902*
	(-0.943)	(-0.882)	(-4.421)	(-5.096)
C(2) CointEq2	-0.131	-0.895*	-0.940*	-0.843*
	(-0.921)	(-4.688)	(-5.972)	(-4.681)
C(3) Ramanagaram$_{t-1}$	1.013*	1.046*	0.773*	0.667*
	(5.841)	(6.086)	(4.309)	(3.456)
C(4) Ramanagaram$_{t-2}$	0.966*	0.815*	0.604*	0.589*
	(5.542)	(4.723)	(3.353)	(3.086)
C(5) Sidlaghatta$_{t-1}$	-0.844*	-0.873*	-0.351*	-0.206*
	(-5.022)	(-5.243)	(-2.022)	(-2.121)
C(6) Sidlaghatta$_{t-2}$	-0.675*	-0.627*	-0.405*	-0.445*
	(-4.209)	(-3.944)	(-2.446)	(-2.531)
C(7) Hindupur$_{t-1}$	-0.003	-0.123	-0.235*	-0.167
	(-0.032)	(-1.149)	(-2.105)	(-1.412)
C(8) Hindupur$_{t-2}$	0.052	-0.021	-0.405*	-0.073
	(0.535)	(-0.219)	(-3.037)	(-0.683)
C(9) Dharmapuri$_{t-1}$	-0.127	-0.133	-0.176	-0.459*
	(-1.325)	(-1.106)	(-1.393)	(-4.643)
C(10) Dharmapuri$_{t-2}$	-0.100	-0.145	-0.156	-0.176*
	(-1.409)	(-1.097)	(-1.021)	(-2.827)
C(11) Constant	0.982	1.359	0.605	0.540
	(0.598)	(0.836)	(0.357)	(0.300)
Model Fitness				
R-squared	0.533	0.527	0.543	0.505
F-statistic	6.503	6.307	6.902	5.537
Prob.	0.011	0.016	0.010	0.019

*Note: *- Significant at 5% level; Figures in parentheses indicate t-statistics*

running from Ramanagaram market towards all other markets (Sidlaghatta, Hindupur and Dharmapuri).The results are in confirmation with the studies conducted by Nagaraj et al., [2] and Devaiah et al., [3] that indicated a long run causality running from the Ramanagaram market towards other markets in Karnataka.

The coefficients C(3), C(4), C(5) and C(6) are found to be significant at 5% level for Ramanagaram market, which depicts that the prices of cross breed cocoons in Ramanagaram markets were decided by the past prices of their own market and prices of Sidlaghatta market. The same coefficients are also found to be significant at 5% level for Sidlaghatta market as well, which means that the prices of cross breed cocoons in Sidlaghatta markets were decided by the past prices of their own market and prices of Ramanagaram market. Both Ramangaram and Sidlaghatta markets are major markets for transaction of cross breed cocoons in Karnataka. These two markets put together accounted for about 48.8% of total cross breed cocoon transacted in Karnataka during 2019-20. Hence, the prices of both markets are integrated in long

run to decide their future prices mainly relying on themselves each other.

The coefficients C (3), C(4), C(5), C(6), C(7) and C(8) are found to be significant at 5% level for Hindupur and Dharmapuri markets also. This indicates that the prices of cross breed cocoons in Hindupur and Dharmapuri markets were decided by the past prices of their own market and prices of Ramangaram as well as Sidlaghatta market. Both Ramanagaram and Sidlaghatta markets act as leader marketsfor cross breed cocoons to decide the prices in all other cocoon markets in south India.

3.4 Granger Causality Test

In order to evaluate the nature of relationship between prices of different markets, Grangers causality test was employed. The purpose of this test is to evaluate the relations in pair wise by considering two variables at a time in order to assess the relations in terms of unidirectional relation or bidirectional relations. The short run relations among the major cocoon markets are depicted in Table 5

Table 5. Market pair wise results of the Granger causality test

Market Pair	F-Statistic	Prob.	Decision of null hypothesis	Result
Ramanagaram- Sidlaghatta	10.391	0.000	Reject	Causality
Sidlaghatta- Ramanagaram	4.861	0.008	Reject	Causality
Ramanagaram- Hindupur	15.917	0.000	Reject	Causality
Hindupur- Ramanagaram	1.821	0.164	Accept	No Causality
Ramanagaram- Dharmapuri	7.050	0.001	Reject	Causality
Dharmapuri- Ramanagaram	1.028	0.115	Accept	No Causality
Sidlaghatta- Hindupur	9.880	0.000	Reject	Causality
Hindupur- Sidlaghatta	0.784	0.457	Accept	No Causality
Sidlaghatta- Dharmapuri	4.943	0.007	Reject	Causality
Dharmapuri- Sidlaghatta	1.580	0.208	Accept	No Causality
Hindupur- Dharmapuri	2.582	0.077	Accept	No Causality
Dharmapuri- Hindupur	1.786	0.169	Accept	No Causality

The F-statistics is found to be significant at 5% level for the Granger causality between markets mainly from Ramanagaram and Sidlaghatta markets with all other markets such as Hindupur and Dharmapuri, which confirms the short run unidirectional price transmission from both Ramanagaram and Sidlaghatta markets towards other markets. On the other hand, there was a bidirectional relation between Ramanagaram and Sidlaghatta markets, which means that inter transmission of prices happened between these two major markets in short run. Chaithra [10] reported speed of adjustment of price signals among in Ramanagaram, Sidlaghatta and Vijayapura in Karnataka cointegrated with unidirectional feedback mechanism.

Further, the F-statistics is not significant for Hindupur-Ramanagaram, Hindupur-Sidlaghatta and Hindupur-Dharmapuri, which shows that there was no short run causality from Hindupur market towards other markets. Non-significant F-statistics for Dharmapuri-Ramanagaram, Dharmapuri- Sidlaghatta and Dharmapuri-Hindupur indicates no short run causality from Dharmapuri market towards all other markets.

5. CONCLUSIONS

The purpose of this paper is to investigate the degree and direction of integration of the prices of the cocoon markets. The results of VECM guide that there was a long run causality running from the prices of the Ramanagaram and Sidlaghatta markets to the prices of all other markets considered for the study. Further, the prices of all markets were determined by the prices of their previous period (lags) and the prices prevailing in Ramanagaram and Sidlaghatta markets.

The results obtained from Granger causality test depict that there was a directional causality between Ramanagaram and Sidlaghatta markets and a unidirectional causality running from Ramanagaram and Sidlaghatta markets to all other markets. Thus it can be concluded that both in long run and short run, the prices prevailing in Ramanagaram and Sidlaghatta markets controlled and decided the prices of cross breed cocoons in all markets of south India.

The price transmission happens mainly from Ramanagaram and Sidlaghatta markets to remaining markets. The number of reeling units, which purchase cocoons for the production of raw silk, is concentrated more in Ramanagaram and Sidlaghatta areas compared to any other area in Karnataka or in other South Indian states. Besides, the cross breed cocoon producing farmers are highly congregated in and around Ramanagaram and Sidlaghatta areas in Mysore, Mandya, Ramanagaram, Chikkaballapur and Kolar districts. Besides, the farmers from other neighboring states also bring cocoon to Ramanagaram and Sidlaghatta markets for fetching better price. Thus both Ramanagaram and Sidlaghatta markets are ideally located logistically to emerge as major markets and act as leaders of all markets with respect to price transmission of cross breed cocoons. Daily publication and transmission of cocoon prices through newspapers, television, radio, websites of Central Silk Board and State Sericulture Departments, SMSs, and WhatsApp messages help in free flow of information about the cocoon prices in major cocoon markets among farmers and reelers and result in better integration of markets.For future research in the same field, it is suggested to include the transmission cost and

other factors that influence the degree of market integration in the framework of analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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