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Price Transmission along the Cotton Value Chain[§]

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Abstract

The study has examined integration and price transmission in the cotton-based textile value chain, using Johansen multivariate co-integration and error correction model. Although price adjustment mechanism is slow, the findings have provided a clear indication of the price transmission along the chain, and also the existence of a long-run equilibrium. The raw cotton price has been found exogenous, but has significant influence on the prices of cotton yarn and cloth. The textile value chain has been found effectively integrated; hence the policies should take into account the effect of impact on the entire value chain as to enable the cotton producers capture benefits of value addition.

Key words: Price transmission, cotton, value chain, impulse response, India

JEL Classification: C 13, C 32, M 31, Q 13, Q 17

Introduction

Cotton is an important commercial crop in India grown on about12 million hectares with an output of 353 lakh bales[1] during 2011-12 (GoI, 2012). Cotton constitutes a major raw material for the textile industry meeting about 60 per cent of its total fibre demand. One of the important features of the textile value chain is that both cotton and its value-added products (cotton yarn, clothings, readymade garments, etc.) have domestic as well as export demand. Therefore, the impact of any intervention in any of the chain links will be transmitted to the other links in the chain. Many studies relating to price transmission along the value chain for agricultural commodities have focussed on the price transmission from producers to consumers (Goodwin and Holt, 1999; Jean-Paul and Mehta, 2004), but hardly any study has analysed the vertical price transmission.

In this study, vertical integration or price transmission has been examined along the cotton value chain (raw cotton, cotton yarn and cotton cloth) and an attempt has been made to find whether it is the supply side factors or the demand side factors that drive prices along the value chain.

Data and Methodology

Data

The monthly price indices of the commodities in the value chain were used to make a meaningful comparison, because of the differences in measurement

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[1]One bale contains 170 kg of cotton lint

units[2] of value-added products and in the quality of the product at different stages of value chain. The time span for the study was April 1982 to March 2012. The data on price indices of raw cotton, cotton yarn and the cotton cloth were collected from the Office of Economic Advisor, Ministry of Commerce, Government of India, New Delhi. The data on production of raw cotton, yarn and cloth were obtained from the Ministry of Textiles and the Office of Textile Commissioner, Government of India.

The different stages of cotton value chain include: production of raw cotton, spinning into yarn, weaving into cloth, further processing into fabrics and garments and other finished products. Since the unit of measurement differs in the cotton value chain and the final retail prices of textile products are fixed on negotiable basis, the present study focused on the cotton textiles (raw cotton, i.e. lint, cotton yarn, and cloth) to understand better the price dynamics along the value chain.

Methodology

A number of studies have examined the market integration under the hypothesis of Law of One Price (LOP) (Ardeni, 1989; Baffes, 1991) or market integration (Ravallion, 1986; Sexton *et al.*, 1991; Gardner and Brooks, 1994; Baulch, 1997). Another important issue that needs exposition is the relationship between prices at different stages of the value chain (Asche *et al.,* 2007). In the investigations on price relationship, the economic theory does not provide any guidance with respect to exogenous variables (Goodwin and Schroeder, 1990).

Co-integration Analysis

The relationship between prices in different markets has been studied using simple correlation (Lele, 1967; Southworth *et al.,* 1979; Stigler and Sherwin, 1985) or a regression model given in Equation (1) (Mundlak and Larson, 1992; Gardner and Brooks, 1994):

$$P_t^1 = \mu + \beta_1 P_1^2 + \varepsilon_t \qquad \ldots(1)$$

where, P_t^1 and P_t^2 denote the prices from the two origins of a commodity under consideration; μ and β_1 are the parameters to be estimated and ε_t denotes an identically and independently distributed error-term (0, σ^2).

In this case, the presence of non-stationarity in the price series and differences in quality may give misleading results regarding the degree to which the price signals are being transmitted between the markets. If the price series is non-stationary, the appropriate tool to study the market integration is the co-integration test.

Engle and Granger (1987) developed a test which is generally used to test co-integration in combination with the error correction model to draw meaningful inferences. This approach is applicable for a pair-wise comparison or bivariate relation and does not hold in a multivariate system. Moreover, Engle's approach requires an assumption regarding the exogenity of the variables and is limited by the fact that it cannot test the hypothesis on the estimated parameters (Banerjee *et al.,* 1993). Since the cotton value chain involves differentiated and value-added products, a single equation specification cannot capture all the relevant information. Hence, we used the Johansen multivariate approach (Johansen, 1991) that can deal with more than two variables at a time and also provides scope to test a wider range of hypotheses. Let X_t be an $n \times 1$ vector, such that X_t follows unrestricted VAR in the levels of the variable, then the Johansen test is represented as per Equation (2):

$$X_t = \Pi_1 X_{t-1} + \ldots + \Pi_k \Delta X_{t-k} + \mu + \varepsilon_t \qquad \ldots(2)$$

where, each of the Π_i is n × n matrix of parameters, μ is a constant term, and ε_t are identically and independently distributed residuals with zero mean and covariance matrix, Ω. The VAR system in Equation (2) can be represented in the error correction form as in Equation (3):

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots\ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \varepsilon_t \qquad \ldots(3)$$

where, Γ_i = -I + Π_1 + ... + Π_i, and i= 1, 2 …, k-1. Hence, Π is the long-run level solution to Equation (3). The rank of Π, i.e. r, determines the number of linear combinations of X_t that are stationary. If $r = n$, the variables in levels are stationary; if $r = 0$, then none

[2] Raw cotton and cotton yarn are measured in kilograms, and cloth is measured in sq. metres. Raw cotton is classified into short staple, medium staple, medium long, long and extra-long staple based on the quality characteristics, and cotton yarn is classified into different counts from 6s to 120s (coarser to finer cotton yarn).

of the linear combinations of the variables is stationary. When $0 < r < n$, then there exists r co-integrating vectors or linear combinations of X_t. In such cases, the matrix Π can be factored into '$\alpha\beta$', where both α and β are $n \times r$ matrices and β contains the co-integrating vectors and α factor loadings or the adjustment parameters.

Johansen suggested two tests to identify the number of co-integrating vectors in the system, viz. the maximal eigenvalue test (λ_{max}) and the trace test (λ_{trace}). The trace statistic provides whether r co-integrating vectors are present in the system against the alternative hypothesis that the system is already stationary (i.e., n cointegrating vectors are present in the system). Equivalently, the max eigen value statistic provides whether the rank is r against the alternative hypothesis that the rank is $(r+1)$. When testing hypothesis with respect to price differences between markets, it is the restrictions on the parameters in the co-integrating vector β that one tests for. Information on the leading prices is tested using the exogenity test on α coefficient, where α measures the impact of change in the price difference respectively on different markets. Thus, in the case of two markets, if $\alpha_1 \neq 0$, the change in price difference will at least partly be corrected by the change in the price in first market. While if $\alpha_2 \neq 0$, the correction will occur in the second market due to the change in price difference. If $\alpha_1 = 0$, there will be no change in market one and all corrections will have to be made by the changes in market two and vice versa if $\alpha_2 = 0$. Hence, if $\alpha_1 = 0$, the price at market one will be the leading price and market two will be the price leader if α_2=0. If $\alpha_1 \neq \alpha_2 \neq$ 0, there will be no leading price and both the alphas cannot be simultaneously zero, as there will be no long-run relationship.

Cotton Value Chain: An Overview

The cotton production system in India has undergone a significant transformation with the introduction of Bt cotton in 2002-03. Along with productivity there has also been a significant increase in cotton area. The improved production capacity in the processing sector could not keep pace with the increased supply of cotton (Figure 1), hence surplus was available for exports as well. This has turned India from a net importer of cotton to the largest exporter of cotton.

The decadal changes in production, mill consumption and trade of cotton and its value-added products are depicted in Table 1 for the 30-year period 1980-2010. The production of spun yarn has increased from 2,485 million kg to 6,263 million kg, of which around 60 per cent is contributed by cotton yarn, and the output of cloth has reached a level of 61,761 million square metres with half of it coming from cotton cloth (Official Indian Textile Statistics, 2012). The growth

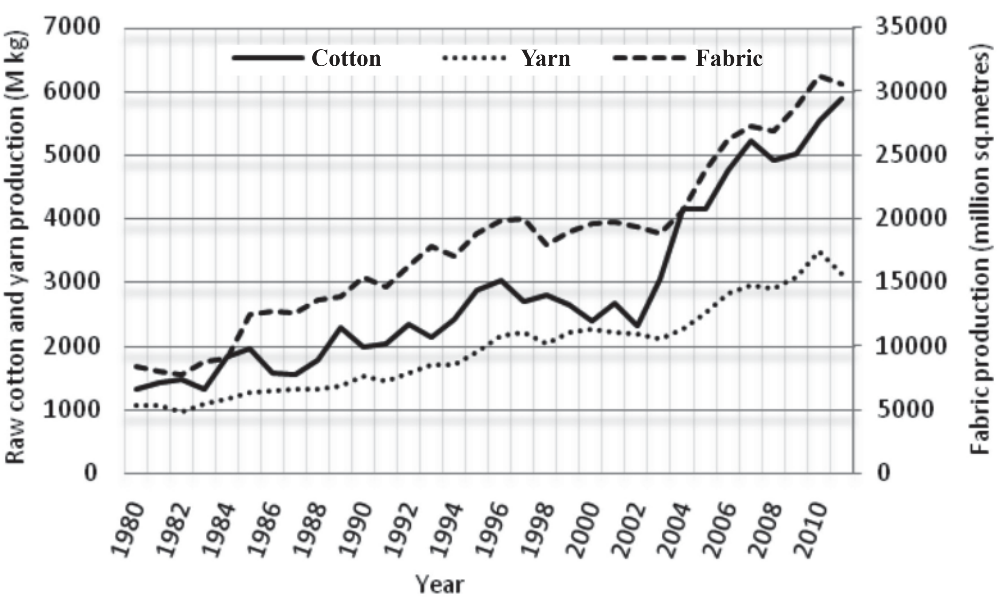


Figure 1. Trends in production of cotton, yarn and fabric, 1980-2010

Table 1. Production, mill consumption and trade of cotton-based textile products

Items	1980-81	1990-91	2000-01	2010-11
Cotton production (lakh bales)	78	117	140	325
Production of spun yarn (M kg)	1298	1824	2485	6263
Cotton yarn (M kg)	1067	1510	1894	3490
Cloth production (million sq. metres)	10988	20354	31460	61761
Production of man-made fibres (M kg)	115.2	336.9	498.4	1285
Mill consumption of all fibres (M kg)	1489	2116	2846	5771
Cotton (M kg)	1313	1822	2308	4374
Man-made fibres (M kg)	176	294	538	1397
Export of all textile items (in crore ₹) (Constant Price)	3777	20321	57908	63362
Export of cotton textiles (in crore ₹) (Constant Price)	3616	14359	17901	27870

Source: Official Textile Statistics, Office of Textile Commissioner, Ministry of Textiles, New Delhi

in production was fuelled by the two major factors, one improvement in the productive capacity in processing and another increase in production of raw cotton. The mill consumption of fibres has doubled to 5,771 million kg in 2010-11 from 2,846 million kg in 2000-01. The textile exports have grown at an annual growth rate of 10 per cent since the 1990s. Though there is a continuous increase in the exports of textiles, their share in total exports (all commodities) has come down to around 12 per cent in 2010-11 from around 29 per cent in 1992-93. The textile import has a meagre share in the overall imports of India accounting for around one per cent. The share of cotton-based imports is less than 10 per cent of the total textile imports. There has been a drastic increase in the share of man-made fibre based exports, from 7 per cent in 1992-93 to around 18 per cent in 2009-10, implying an increasing competition between the natural fibre and the man-made fibre.

Price Linkages in Cotton Value Chain

The relationship between the prices of cotton and its value-added products was studied in two steps. First, the relationship across all the products in the value chain was examined through correlation analysis and co-integration test in a multivariate framework. Then, the link among different commodities in the value chain was analysed pair-wise.

The correlation coefficient (Table 2) indicates that there is a strong association between the commodity price and its immediate value-added product. The correlation is higher between raw cotton and yarn as well as between yarn and cloth. The correlation gets weaker on going beyond the immediate value-added product, as in the case of raw cotton and cotton cloth.

Table 2. Correlation between price indices of cotton value chain

Particulars	Raw cotton	Cotton yarn	Cotton cloth
Raw cotton	1.000		
Cotton yarn	0.797**	1.000	
Cotton cloth	0.495**	0.728**	1.000

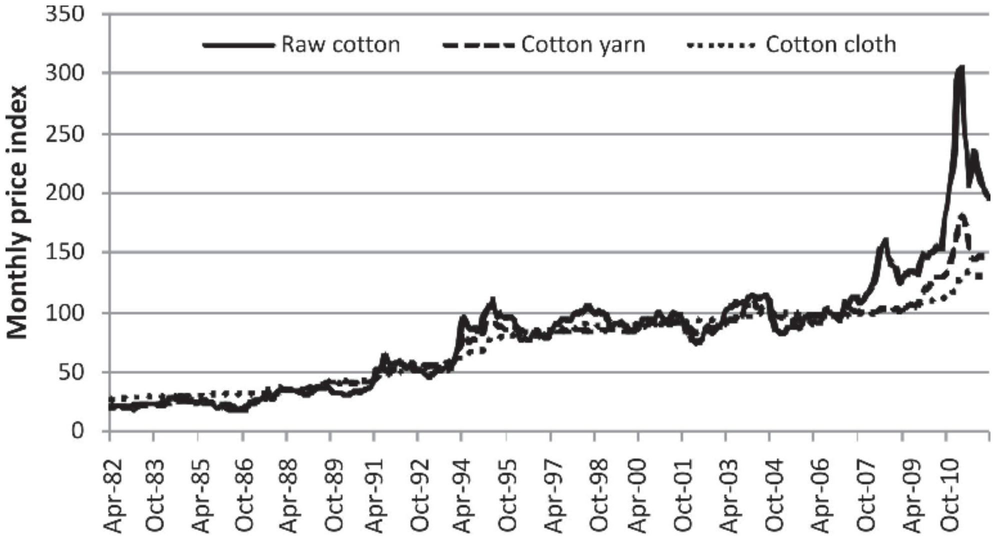
Note: ** denotes significance at 1 per cent level

Vertical Co-integration

The price indices of the three commodities in the cotton value chain are presented in Figure 2.

The stationarity of the price indices were tested before establishing the causal relationship between different commodities in the chain. The Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1979) was employed and the presence of unit root was checked under different scenarios of the equation such as with intercept, with intercept & trend, and none (Table 3). Phillips and Perron (PP) test, which provides an alternate method for correcting serial correlation and heteroscedasticity, was used to validate the results.

The results of the unit root test did not reject the null hypothesis of presence of unit root when the commodities were considered at level. The first differenced series were found to be stationary, i.e., these



Source: Office of Economic Advisor, Ministry of Commerce, Government of India, New Delhi

Figure 2. Trends in the prices of cotton and its value-added products, 1982-2010

Table 3. Unit root test for cotton value chain using Augmented Dickey Fuller (ADF) test and Phillip Perron (PP) test

Item	Model	ADF test		PP test	
		Level	First difference	Level	First difference
Raw cotton	Intercept	-1.588	-9.538**	-1.295	-9.487**
	Trend and intercept	-2.541	-9.555**	-2.338	-9.506**
	None	0.619	-9.529**	0.598	-9.482**
Cotton yarn	Intercept	-0.888	-9.657**	-0.348	-9.592**
	Trend and intercept	-2.275	-9.679**	-1.976	-9.619**
	None	1.196	-9.570**	1.153	-9.493**
Cotton cloth	Intercept	0.815	-5.983**	0.949	-6.073**
	Trend and intercept	-1.546	-6.389**	-1.488	-6.481**
	None	1.868	-5.611**	1.969	-5.798**

Note : ** denotes significance at 1 per cent level

are integrated of order one. Having ensured non-stationarity of the price series, the vertical relationship between prices was estimated using the co-integration test.

The relationship between the non-stationary price series in the cotton value chain was examined using the Johansen multivariate co-integration method. The Vector Autoregressive (VAR) model was used for cotton value chain and the lag length was identified based on the Schwartz information criteria (SIC) from the estimated stable VAR model. The lag length of one was identified to be optimal. Using the lag length, the Johansen co-integration test was undertaken and the co-integrating equation was identified using the max eigen value test and the trace statistic. The co-integration test revealed only two co-integrating equations for the cotton value chain, indicating that there is one stochastic trend present in the system (Table 4).

Having established the existence of co-integration in the cotton value chain, the Granger causality[3] test was used to identify the causal variable in the cotton

[3] If the past values of a variable say x, contain useful information (in addition to the past values of y) to predict the future y, then we say x granger causes y.

Table 4. Multivariate Johansen co-integration test for cotton value chain

H_o: rank=P	Max test	Critical values at 5%	Trace test	Critical values at 5%
P=0	37.49	21.13	54.706	29.79
P≤1	16.22	14.26	17.206	15.49
P≤2	0.986	3.84	0.986	3.84

Note: Trace test indicates 2 co-integrating equations at 5 per cent level of significance; Max Eigen value test indicates 2 co-integrating equations at 5 per cent level of significance

value chain. The Granger causality test showed that raw cotton price Granger causes cotton yarn and cotton cloth price, while cotton yarn price Granger causes cotton cloth price. The raw cotton prices thus seemed to be exogenous[4] and were determined outside the system, which was validated using the Wald test for weak exogenity (Table 5). The null hypothesis of Wald test is that the correlation parameter ρ=0, i.e. the error-terms in the structural and reduced form equations for the endogenous variables are not correlated. The calculated test statistic was less than the critical value, and thus the null hypothesis of presence of weak exogenity was accepted. The exogenity test helps to identify whether the flow of price information is unidirectional or bidirectional. The Wald test for the cotton value chain signified the dominant role played by the raw cotton prices in the cotton value chain.

Table 5. Wald test for block exogenity test

Variable	Test statistic	P-value
Raw cotton	6.527	0.3543
Cotton yarn	45.180	< 0.0001
Cotton cloth	93.012	< 0.0001

In order to establish one to one relationship between the commodities in the cotton value chain, a bivariate Johansen co-integration test was performed for all the possible combinations (Table 6). The bivariate co-integration between different commodities in the cotton value chain revealed that there was a one co-integrating equation among all the combinations.

The exogenity test indicated that raw cotton price was exogenous in its bivariate co-integration with cotton yarn and cloth, indicating that raw cotton price influences the prices of both cotton yarn and cloth. In the case of bivariate relationship between cotton yarn and cloth, the price of former was exogenous. The results indicated that price of yarn was influenced by the prices of raw cotton and in turn influenced the prices of cotton cloth. The prices of raw cotton were absolutely exogenous and were determined outside the system perhaps by quality, price intervention (minimum support price), and to some extent by export demand. The cotton cloth prices are influenced by the demand for the diversified processed products ahead and the prices of raw cotton and cotton yarn also exert influence on the price of cloth.

Error Correction Model

The presence of co-integration indicates the existence of long-run equilibrium among the co-integrated variables. The short-run dynamics of the co-integrated equation was modelled through the error correction model (Table 7).

The β-coefficients represent the long-run relationship between the variables and the short-run price dynamics is explained by the α-coefficient. The negative sign of the α_1 coefficient suggests that the prices adjust themselves in the short-run and move towards equilibrium. The coefficient of atleast one error correction term was significant for all three combinations, confirming the presence of co-integration. The coefficient of the error correction term was negative and significant in the case of yarn and cloth in all possible pair-wise combinations. This implies that the prices of yarn and cloth are stable in the long-run and any deviation in these due to external shocks that occur in the short-run, are well adjusted. In most models, the coefficient of α_2 is not significantly different from zero, indicating the presence of leading price in the system. In the short-run, yarn prices adjust by 4 per cent if there arises an external shock that affects

[4] Sims (1972) points out that a necessary condition for x to be exogenous of y is that y fails to granger cause x.

Table 6. Bivariate Johansen test for co-integration and exogenity test

Variable	H_o:rank=P	Max test	Trace test	Exogenity test	
				Price 1	Price 2
Raw cotton - Cotton yarn	P=0	18.33*	19.494*	4.926	39.917
	P≤1	1.037	1.037	(0.085)	(< 0.0001)
Raw cotton - Cotton cloth	P=0	27.169*	27.916*	4.96	57.52
	P≤1	0.747	0.747	(0.083)	(< 0.0001)
Cotton yarn - Cotton cloth	P=0	30.275*	31.577*	1.876	76.85
	P≤1	1.301	1.301	(0.391)	(< 0.0001)

Note: Critical values for max eigen value test are 14.26 and 3.84, respectively for none and one co-integrating equation at 5 per cent level of significance and critical values for trace test are 15.49 and 3.84, respectively for none and one co-integrating equation at 5 per cent level of significance. The values within the parentheses indicate the p-value.

Table 7. The long-run and short-run coefficients from error correction model

Model	Long-run coefficients (β)	Short-run coefficients (α)		Co-integration rank
		α_1	α_2	
Cotton yarn/ Raw cotton	-0.993* (0.0052)	-0.041* (0.0132)	0.022 (0.0234)	1
Cotton cloth/ raw cotton	-0.508* (0.0975)	-0.037* (0.0068)	0.034 (0.0285)	1
Cotton cloth / Cotton yarn	-0.735* (0.0995)	-0.055* (0.0094)	-0.005 (0.0237)	1

Note: The values within the parentheses indicate the standard error

the long-run equilibrium. A clear unidirectional lead lag relationship can be established that flows from raw cotton to yarn and then to cloth.

The analysis further reveals that the adjustment that occurs in the yarn prices is influenced by the changes in raw cotton prices as well as from its lagged prices. The adjustments in the prices of cloth are influenced by the changes in its lagged prices and other exogenous factors (as reflected by a significant constant term in Appendix 1). The response of price series with respect to the shocks from the other variables is captured through the impulse response function and is presented in Figure 3.

The estimation of impulse response function was inconsistent at long horizon when estimated from the unrestricted VAR, if there was unit root or co-integration. So the stable impulse response function was derived from the error correction model. All the three variables yielded a positive response (increase) to its own shock (unexpected increase). The cotton yarn prices responded positively to any shock that occurred in the raw cotton prices and the response was not so prominent for any shock from the cloth prices. The variance decomposition indicated that the variation in prices of raw cotton was explained by its own change, while in the case of cotton yarn, 45 per cent of the variation could be explained by the variation in the raw cotton price and the rest by its own variation. In the case of cloth, more than 80 per cent of the variation could be explained by itself.

Conclusions

The vertical market integration has revealed that the textile value chain is well connected and the variations in one sector influence the other sector as well. The exogenity test for the entire cotton value chain has revealed that raw cotton prices are determined exogenously and it influences the prices of value-added products. There is a clear evidence of a unidirectional transmission of the price changes from raw cotton to yarn and then to cotton cloth. The variance decomposition has also suggested a strong influence of raw cotton prices in the value chain.

With globalization the export demand for cotton has increased, exerting an upward pressure on the prices. Cotton production in India is also supported

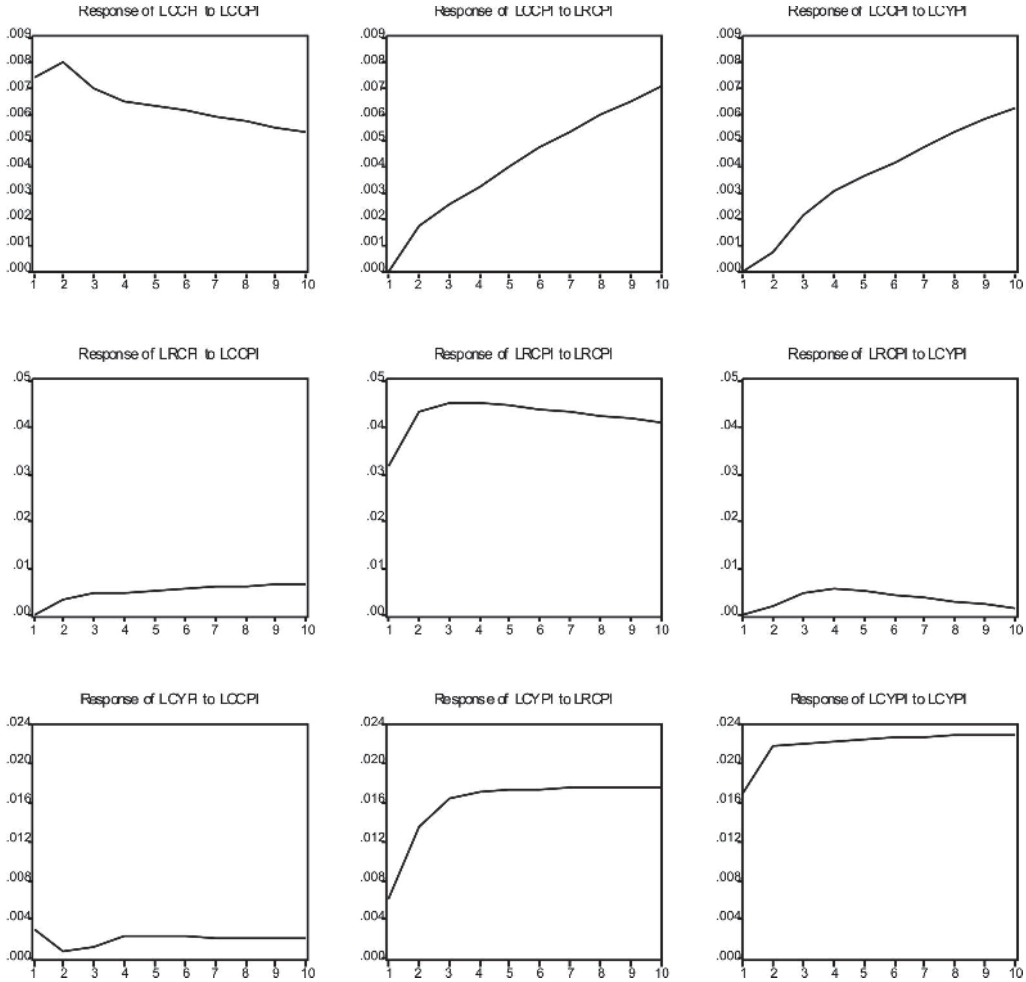


Figure 3. Impulse response function for the cotton value chain

Note: LCCI stands for logarithmic values of cotton cloth price index, LCYPI stands for logarithm of cotton yarn price index, and LRCI represents the lograthim of raw cotton price indices

through the minimum support prices that provide an adequate protection against price fluctuations. The price dynamics and the transmission mechanisms along the cotton value chain are of prime importance as the policy effects from one link to another are carried through the price movements. The study has brought out clearly that the raw cotton prices are weakly exogenous, and the prices of yarn and cloth are endogenous, indicating the importance of a pricing policy for raw cotton. Any change in the price of raw cotton in the long-run will impact prices of yarn and cloth, while the reverse may not happen. Thus, the prices in the cotton value chain seem to be supply-driven. The high price of cotton may cause its substitution by cheaper synthetic raw materials. The textile value chain in India is an important sector as it contributes to industrial output, export earnings and employment generation on one hand and supports the livelihood of millions of cotton farmers on the other. The value chain in the textile industry is effectively integrated and the policy decisions at one point will cause ripple effect on the other linkages. Hence, the policies should take into account the effect of impact on the entire value chain as to enable the cotton producers capture the benefits of value addition.

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Appendix I

The estimated parameters for the Error Correction Model for each of the bivariate cases are presented below.
(LCYPI – log of cotton yarn price index; LRCPI - log of raw cotton price index; LCCPI - log of cotton cloth price index)

Raw cotton and cotton yarn

(No intercept and trend in the co-integrating equation and VAR)

$$\Delta LCYPI = -0.0407^{*}(LCYPI_{(t-1)} - 0.993^{*} LRCPI_{(t-1)}) + \mathbf{0.247^{*} \Delta LCYPI_{(t-1)}} - 0.076^{*} \Delta LCYPI_{(t-2)} + \mathbf{0.168^{*} \Delta LRCPI_{(t-1)}} - 0.047^{*}\Delta LRCPI_{(t-2)}$$

$$\Delta LRCPI = 0.0225^{*}(LCYPI_{(t-1)} - 0.993^{*}LRCPI_{(t-1)}) + 0.135^{*} \Delta LCYPI_{(t-1)} + 0.104^{*}\Delta LCYPI_{(t-2)} + \mathbf{0.357^{*}\Delta LRCPI_{(t-1)}} - 0.0823^{*}\Delta LRCPI_{(t-2)}$$

Raw cotton and cotton cloth

(Linear deterministic trend)

$$\Delta LCCPI = -0.0366^{*}(LCCPI_{(t-1)} - 0.508^{*}LRCPI_{(t-1)} - 2.480) + 0.165^{*}\Delta LCCPI_{(t-1)} - 0.072^{*}\Delta LCCPI_{(t-2)} + \mathbf{0.0335^{*}\Delta LRCPI_{(t-1)}} - 0.0182^{*}\Delta LRCPI_{(t-2)} + 0.00241$$

$$\Delta LRCPI = 0.0348^{*}(LCCPI_{(t-1)} - 0.508^{*}LRCPI_{(t-1)} - 2.480) + 0.310^{*} \Delta LCCPI_{(t-1)} - 0.0743^{*}\Delta LCCPI_{(t-2)} + \mathbf{0.383^{*}\Delta LRCPI_{(t-1)}} - 0.0517^{*}\Delta LRCPI_{(t-2)} + 0.00120$$

Cotton cloth and cotton yarn

(Linear deterministic trend)

$$\Delta LCCPI = -0.0553^{*}(LCCPI_{(t-1)} - 0.735^{*}LCYPI_{(t-1)} - 1.375) + 0.0921^{*}\Delta LCCPI_{(t-1)} - 0.0804^{*}\Delta LCCPI_{(t-2)} + \mathbf{0.0335^{*}\Delta LCYPI_{(t-1)}} + 0.0224^{*}\Delta LCYPI_{(t-2)} + 0.00254$$

$$\Delta LCYPI = -0.00510^{*}(LCCPI_{(t-1)} - 0.735^{*}LCYPI_{(t-1)} - 1.375) - 0.415^{*} \Delta LCCPI_{(t-1)} + 0.294^{*} \Delta LCCPI_{(t-2)} + \mathbf{0.404^{*} \Delta LCYPI_{(t-1)}} - 0.0672^{*} \Delta LCYPI_{(t-2)} + 0.00228$$