The effects of MFA quota elimination on Indian fibre markets

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DOI: 10.1080/00036840600771205

Publication Frequency: 24 issues per year

Published in: Applied Economics

First Published on: 30 August 2007

Abstract

This article examines the effects of multi-fibre arrangement (MFA) quota elimination on Indian fibre market. The partial equilibrium Indian fibre model was developed using a theoretically consistent framework and incorporated regional supply response, substitutability between cotton and man-made fibres, and appropriate linkage between cotton and textile sectors. Baseline projections were developed for supply, demand and prices of cotton, man-made fibres and textiles under a set of exogenous assumptions. The effects of MFA textile quota eliminations were introduced into the model by conducting three scenarios, i.e. increasing textile exports by 10, 20 and 30% from the baseline level. The results suggest that on an average, cotton imports rise by 4–8% annually, while the man-made fibre exports from India decline with the opening of textile markets in the developed countries. The higher domestic cotton prices encourage acreage expansion in cotton in all the three regions in India, but not enough to meet rising mill demand under the scenarios of higher textile exports. The rise in cotton imports from India has little effect on world cotton prices.

1. Introduction

India has the largest cotton-producing area in the world, accounting for 25% of the world acreage. However, India's contribution to the world production is estimated to be around 14%, primarily because of low yield. In the last decade, cotton production in India has increased only 8%, whereas consumption has risen by more than 35%. The increase in cotton consumption is primarily driven by strong textile consumption and exports. The textile exports during this period increased on an average of 19% per annum. The disparity between the cotton production and consumption turned India from a net exporter into a net importer of cotton. Since 1999, India has accounted for 6% of the world cotton imports.

India's re-emergence as a major cotton importer has occurred mainly because of external and internal constraints. The external constraint was the multi-fibre arrangement (MFA), which provided a framework under which developed countries abided by a quota on the export of yarn, textiles and apparel from the developing countries. These bilateral quotas have restricted Indian exports of cotton textile products in which it has a strong comparative advantage. Established in 1974, MFA allowed for discrimination not only against specific fibres and products, but also among exporting countries. Under Uruguay Round/General Agreement on Tariff and Trade (UR/GATT), Agreement on Textile and Clothing (ATC) started phasing out MFA within 10 years period since 1995, and all bilateral quotas were eliminated on 1 January 2005.

Many studies project that India will be a major beneficiary of MFA textile quota eliminations, with textile exports expanding by as much as 25%. In addition, domestic textile consumption is also expected to increase rapidly in the future so far as the international monetary fund (IMF) and the World Bank project the Indian economy to grow at 6–8% annually in the medium-term. The projected strong growth in textile exports and domestic consumption would lead to the expansion of mill demand for cotton, necessitating an increase in cotton production at a much faster pace than the historical rate of less than 1% annually. Since cotton acreage is unlikely to expand in the future, production growth will have to come through yield improvements.

Very few studies have examined the future of the Indian fibre market under the scenario of MFA quota elimination and its effects on the world fibre market. However, these studies have either failed to take into account substitutability between cotton and man-made fibres, or appropriate linkage between cotton and textiles, thus producing incomplete assessment of the elimination of MFA quota on the Indian cotton market and the world fibre market. More specifically, it is critical to develop better understanding of the effects of MFA quota elimination on India's and world fibre markets.

The objective of this study is to develop an empirical framework that incorporates regional supply response, substitutability between cotton and man-made fibres, and appropriate linkage between cotton and textile sectors to measure the effects of MFA quota eliminations on the Indian and world fibre markets. This is achieved by developing a partial equilibrium structural econometric model of Indian fibre markets. Partial equilibrium structural policy simulation models have been extensively used in the past for policy analysis (Fuller *et al.*, 1999; Koo, 2002; Devadoss and Wahl, 2004).

The remainder of this article is organized as follows. The next section develops a conceptual framework of various components of the Indian cotton model that are critical to a conceptual analysis of the evaluation of the elimination of MFA quota. We then develop a partial equilibrium structural econometric model of Indian fibre markets to measure the effects of MFA quota eliminations on Indian cotton trade. This is followed by a description of the data. Policy simulations along with their implications are presented next. Finally, we make concluding remarks.

II. Conceptual Framework

This section starts with the graphical representation of the potential impacts of the MFA quota elimination on the Indian and world cotton markets. The graphical analysis presented in Fig. 1 shows the expected directional changes to the Indian and world cotton markets, in a price-quantity space, due to MFA quota elimination. As shown in Fig. 1, panels (a) and (b) represent Indian textile and cotton market respectively. Panel (d) represents the rest of the world (ROW) cotton market, whereas panel (c) shows the market clearing mechanism at the world level by equating excess supply with excess demand. Transportation cost effects are ignored for simplicity.

[\[Enlarge Image\]](#)

Fig. 1. Impacts of MFA quota elimination on world cotton and textile markets.

Indian cotton demand is derived from the textile market in panel (a). AGB^I and $HCDE^I$ are the export demand and total demand for Indian textiles, where total demand is a horizontal summation of export and domestic demand (HCF). As shown in the diagram, export demand for textiles is zero at or above the price P_T . In this range, total textile demand is same as the domestic consumption. However, as the price falls below P_T , export demand becomes positive and is added to the domestic demand; thus the total textile demand curve is kinked and is represented by $HCDE^I$.

The presence of MFA quotas limit textile exports to certain markets causing the textile export demand kinked at G to become AGB. This, in turn, results in kinked total textile demand, HCDE. Since the domestic cotton demand in panel (b) is derived from the total textile demand and the latter is kinked, this results in kinked cotton demand curve represented by IJK. Panel (c) displays the world market equilibrium with excess supply, ES, derived from the ROW in panel (d), and excess demand, ED, from the Indian cotton market in panel (b), yielding a world cotton price of P_w . At this world price, India's cotton imports are $(X_{IN}-X_{IN})$, and ROW cotton exports are $(X_{RW}-Y_{RW})$, and both are equal to X_w , the volume traded in world cotton market.

With the elimination of MFA, the textile export demand shifts to AGB^I in panel (a), an increase in export demand, resulting in an outward shift in the total textile demand from $HCDE$ to $HCDE^I$. The rise in textile demand, in turn, increases the mill demand for cotton in India with the cotton demand curve shifting from IJK to IJK^I in panel (b). The rise in cotton demand in India causes excess demand for cotton derived from panel (b) to shift from ED to ED^I (panel c). This results in an increase in the world cotton price from P_W to P_W^I , and an increase in the volume of world cotton trade to X_W^I . Price rise in ROW results in declining cotton consumption, increasing cotton production and therefore, widening exports to $(X_{RW}^I - Y_{RW}^I)$ (panel d). Higher prices results in an expansion of cotton production in India from X_{IN} to X_{IN}^I ; however, due to increase in textile consumption cotton demand increases more than its production, thus, cotton imports expands to $(Y_{IN}^I - X_{IN}^I)$ (panel b).

If the representation of the markets depicted in Fig. 1 is reasonably accurate then the expected effects of textile quota elimination would be to increase Indian textile exports, Indian cotton imports, world cotton price and increase cotton exports from the ROW. However, the conceptual analysis does not, and cannot, reveal the magnitude of these expected effects. For this purpose, a partial equilibrium structural econometric model of Indian fibre markets is developed to measure the effects of MFA quota eliminations on Indian cotton trade. Schematic representation of the Indian fibre model, which depicts the relationships among different components of the model, is presented in Fig. 2. The framework includes supply, demand and price linkages equations for cotton and man-made fibres.

[\[Enlarge Image\]](#)

Fig. 2. Schematic representation of the Indian fibre model

As shown in the diagram, acreage and yield levels contribute to cotton production, which builds up total domestic supply after incorporating beginning stocks and imports. Indian cotton supply responses are estimated in a regional framework consisting of four regions in order to account for heterogeneity in growing conditions arising out of climatic differences and

availability of water and other natural resources that influence the mix of crops in each of the regions.

This structural model of the Indian fibre model also takes into account inter-fibre competition among fibres such as cotton and wool, and man-made fibres at the mill level. This allows substitution between cotton and man-made fibres based on their relative prices. Mill utilization of each fibre is estimated in two steps: (1) total textile consumption and (2) its allocation among various fibres such as cotton, man-made fibres, and other fibres based on the relative prices. Thus, the second step yields domestic mill use demands of cotton, wool and man-made fibre in the Indian fibre model. Cotton ending stocks and cotton trade must also be taken into account in the cotton component in order to close the model. Total cotton supply and total cotton demand in equilibrium determine the domestic cotton price. Total cotton demand includes domestic mill utilization, ending stocks and exports.

Similarly, man-made fibre production is estimated as the product of capacity and utilization rate. Man-made fibre production and man-made fibre demand, domestic mill use and net trade combined, determine market clearing conditions for the man-made fibre sector. This enables to solve the man-made fibre price endogenously in the model to allow inter-fibre substitution at the mill level. Finally, world cotton price (A-index) enters into the model through cotton trade equations.

III. Model Specification

Fibre supply estimation

In this study, the Indian cotton-producing area is segregated into four regions in order to account for heterogeneity in growing conditions arising out of climatic differences, availability of water and other natural resources that influence the mix of crops in each of the regions. The four regions include north, central, south and the rest of India. The i th region acreage response is specified as:

$$AC_{i,t} = f(EPC_{i,t}, EPCM_{i,t}, AC_{i,t-1}) \quad (1)$$

where i = north, central, south and the others regions in India. $AC_{i,t}$ is the cotton acreage in i th region in time t in thousand hectares; $EPC_{i,t}$ represents expected cotton price in i th region in time t ; $EPCM_{i,t}$ are the expected prices of competing crops in the i th region in time t .

Competing crops for the northern region include wheat, rice and rapeseed; for the central region, include sugarcane, groundnut, rapeseed and wheat, while groundnut, corn, sugarcane and rice are the competing crops for the southern region. The area devoted to cotton is expected to be positively related to the price of cotton and negatively related to the prices of competing crops. Expected prices are calculated as the weighted average of the current year's minimum support price and last year's average market prices for the corresponding crops.

Cotton yield is specified as follows.

$$YC_{i,t} = f(EPC_{i,t}, YC_{i,t-1}, RF_i, FA_i, T_i) \quad (2)$$

where $YC_{i,t}$ represents cotton yield in the i th region in metric tons/hectare; $YC_{i,t-1}$ is cotton yield lagged one year in the i th region; RF_i represents rainfall in millimeter; and FA_i is the fertilizer application in kg/hectare. Once cotton area and yield have been estimated, cotton production can be calculated by multiplying area by yield and sum over all four regions:

$$CPR_t = \sum_{i=1}^4 AC_{i,t} \times YC_{i,t} \quad (3)$$

where CPR_t represents total cotton production in India in time period t .

Man-made fibre production capacity is specified as a function of polyester and crude oil prices, lagged 3-6 years, and man-made fibre production capacity, lagged 1 year.

$$MMPC_t = f(PP_{t-k}, PO_{t-k}, MMPC_{t-1}) \quad (4)$$

where $MMPC_t$ represents the man-made fibre productive capacity at time t ; PP_{t-k} is the lagged price of polyester; PO_{t-k} is the lagged price of petroleum crude oil; $MMPC_{t-1}$ represents the man-made fibre productive capacity at time $t-1$, and $k = 3, \dots, 6$.

Man-made fibre capacity utilization is specified as the function of polyester and crude oil prices, and utilization rate lagged 1 year:

$$MMCUT_t = f(PP_t, PO_t, MMCUT_{t-1}, T) \quad (5)$$

where $MMCUT_t$ is the man-made fibre capacity utilization in period t .

Fibre demand estimation

As discussed in the conceptual framework, fibre demand is derived using a two-step process. In the first step, consumers allocate expenditures to a broad group of commodities, i.e. per capita textile consumption in fibre equivalent in India is estimated and then allocated among various fibres in the second stage.

Textile consumption (per capita textile demand in fibre equivalent) is specified as the function of textile price index, food price index, per capita real income and time trend:

$$TXPC_t = f(PTX_t, PFD_t, I_t, T) \quad (6)$$

where $TXPC_t$ is the per capita textile demand in fibre equivalent in time t ; PTX_t is the textile price index; PFD_t is the food price index; I_t represents per capita income and T represents time trend. Because of economic expansion, consumers will have higher disposable income resulting in elevated purchasing power, and higher demand for various products, including textiles and clothing. Thus, textile consumption is hypothesized to be positively related to income. In addition, economic theory suggests that consumption of a good is inversely related to its own price and positively related to the prices of competing goods. Thus, textile consumption is expected to have an inverse relationship with the textile price index and a direct relationship with the food price index. Equation 6 is estimated by using the ordinary least square (OLS) method.

In the second stage, the share of each of the fibres in the textile consumption framework is estimated using linear approximation/almost ideal demand system (LA/AIDS), (Deaton and Muellbauer, 1980). The empirical LA/AIDS model for the cotton, man-made fibre and wool shares for Indian textiles is specified as follows:

$$SC_t = \alpha_1 + \gamma_{11} \log(PC_t) + \gamma_{12} \log(PMF_t) + \gamma_{13} \log(PW_t) + \beta_1 \log\left(\frac{Y}{P^*}\right) + u_{1t} \quad (7)$$

$$SMF_t = \alpha_2 + \gamma_{21} \log(PC_t) + \gamma_{22} \log(PMF_t) + \gamma_{23} \log(PW_t) + \beta_2 \log\left(\frac{Y}{P^*}\right) + u_{2t} \quad (8)$$

$$SW_t = \alpha_3 + \gamma_{31} \log(PC_t) + \gamma_{32} \log(PMF_t) + \gamma_{33} \log(PW_t) + \beta_3 \log\left(\frac{Y}{P^*}\right) + u_{3t} \quad (9)$$

where PC_t is the price of cotton; PMF_t is the price of man-made fibre; PW_t is the price of wool; Y is the total fibre expenditure; P^* is the stone price index; SC_t is the share of cotton fibre in the textile; SMF_t is the share of man-made fibre and SW_t represents the share of wool. Uncompensated and the compensated elasticities, as well as the expenditure elasticities in the LA/AIDS model will be computed from the estimated coefficients using the formula given by Green and Alston (1990).

Cotton ending stocks and trade equations

Cotton ending stocks can be specified as the function of domestic cotton price, cotton production and beginning stocks.

$$CES_t = f(PC_t, CES_{t-1}, CPR_t) \quad (10)$$

where CES_t is the cotton ending stocks. Both beginning stocks and cotton production variables are expected to have a direct relationship with ending stocks; at the same time, the cotton market price is expected to have an inverse relationship with ending stocks. Equation 10 is estimated using the OLS method.

Cotton export in India is specified to depend on relative prices between domestic and world markets, and cotton supply. The exchange rate is not modelled explicitly here, but it is captured in the model by expressing international price in domestic currency after adjusting for export tax:

$$CEX_t = f(PC_t, PA_t(1 - ET_t)XR_t, CSU_t) \quad (11)$$

where CEX_t is the export of cotton; PA_t is the international cotton price represented by A-index c.i.f. North Europe; CSU_t is the cotton supply; ET_t the export tax on cotton in percentage and XR_t is the exchange rate of US dollars into Indian currency. Cotton exports should increase with a rise in international cotton prices relative to domestic price and vice versa. In addition, a greater supply of cotton means that more cotton can be exported owing to high international price, thus a direct relationship is hypothesized between supply of cotton and export of cotton. The cotton export equation is estimated using the OLS method.

The cotton import equation is specified as the function of the relative domestic price of cotton with respect to the international price, adjusted for the import tariff and income.

$$CIM_t = f(PC_t, PA_t(1 + IT_t)XR_t, I_t) \quad (12)$$

where CIM_t is the import of cotton at time t ; IT_t is the import tariff rate in India in percentage and gross domestic product represents the proxy for income (I_t) in India. It is assumed that as I_t increases and the international prices of cotton relative to domestic price decreases, cotton import demand should increase; that is, more cotton fibre will be imported. The cotton import equation is estimated by the OLS method.

Market clearing condition

Baffes and Ajwad (2001) found that volume of trade relative to the size of domestic consumption is an important factor in determining the degree of linkage between the domestic and the world price. Since Indian cotton trade is very small relative to the domestic consumption, it seemed appropriate to solve domestic cotton price by adding an identity equation to solve the system of demand and supply equations. The equilibrium condition exists at the point where total cotton consumption is equal to total cotton supply in India. This can be specified as in the following equation:

$$CPR_t + CES_{t-1} + CIM_t = DC_t + CES_t + CEX_t \quad (13)$$

Similarly, the man-made fibre market clearing condition includes production, consumption and net trade. Since ending stocks data is not available, it is assumed that stock does not change from year to year.

$$MMPR_t = DMF_t + MMTR_t \quad (14)$$

where $MMPR_t$ represents man-made fibre production, which is obtained through multiplying man-made fibre capacity utilization with its capacity; DMF_t is the man-made fibre consumption, and $MMTR_t$ is the man-made fibre net trade (exports-imports).

All the above equations except those of LA/AIDS models are estimated using OLS. A battery of statistical methods is used to test whether the assumptions of normal, independent and identically distributed (NIID) error terms are violated and whether these violations cause a bias in their estimators. The assumption of homoskedastic conditional variance is tested using the White's test. For testing whether the errors are linear with respect to the conditioning variables, the respecification error test (RESET) developed by Ramsey is used. To test the assumption of a normal conditional distribution, the skewness-kurtosis (SK) test, the Shapiro-Wilk (SW) test, and a graph of the conditional distribution with a normal curve overlay are used. The LA/AIDS model for share of fibre is estimated first without any restrictions and later, imposing adding-up, homogeneity and symmetry restrictions combined. The error terms across the equations in LA/AIDS models are correlated by the fact that the dependent variables need to satisfy the budget constraint. Consequently, the OLS estimates of these equations would be inconsistent and biased. Therefore, seemingly unrelated regressions (SUR), which provide more efficient estimates are used instead. In the first stage, OLS is used to estimate the variance-covariance matrix among the residuals, while in the second stage, the estimated matrix is used in a generalized least squares estimation. Imposing of the adding-up restriction makes the variance-covariance matrix for the disturbances singular, thus, nonsingularity is maintained by deleting the equation of ROW from the fibre share empirical LA/AIDS model. The parameters associated with the omitted demand equation are recovered later on by making use of the restrictions. Correction for autocorrelation is done in the estimation of parameters, and a nonlinear algorithm is used for the estimation of the LA/AIDS model. All the equations are estimated using SAS (SAS Version 9.1, 2002-2003).

IV. Data

Data were collected from various sources. Macroeconomic variables for India such as gross domestic product (GDP), population, exchange rate, GDP deflator and the average spot price of crude oil were obtained from 'International Financial Statistics' published by the IMF. Cotton A-index price, US 1.5 denier polyester price, and US farm price sheer wool (greasy basis) were collected from Cotton and Wool Yearbook of Economic Research Service, United States Department of Agriculture (ERS, USDA). Prices of polyester staple fibre and cotton fibre, and cotton tariff/duty in India were obtained from Foreign Agricultural Service, USDA and the Textile Commissioner's Office, Government of India (GOI). Minimum support price for cotton and competing crops were obtained from the website of India's Ministry of Agriculture (available online at <http://agricoop.nic.in/statistics/>). The textile price index was gathered from the Handbook of Industrial Policy and Statistics 2001, India; at the same time, wholesale price index for food was obtained from the Handbook of Statistics on Indian Economy, 2001 on CD-

ROM. Both indices were originally available on 1970/1971 and 1981/1982 base years, which were converted to 1993/1994 base year for consistency. The textile price index for the year 1982-1984 was missing and had to be interpolated. The producer price for cotton and competing crops was obtained from the database of Food and Agricultural Organization (FAO). The consumer price index was gathered from the Ministry of Finance, GOI. Total fibre consumption, total cotton consumption and total man-made fibre consumption were obtained from the FAS/USDA, and the Textile Commissioner's Office, GOI. Wool and other fibre consumption were calculated by subtracting cotton and man-made from total fibre consumption. Similarly, man-made fibre capacity, utilization and man-made fibre production were also collected from the same sources.

Data for cotton supply and demand were obtained from the Foreign Agricultural Services of the United States Department of Agriculture (FAS/USDA). The database consists of cotton area, yield, production, imports, exports, ending stocks and total domestic consumption. The area, yield and production data for cotton at the state level were obtained from the FAS/USDA, Indiatat.com and the Ministry of Agriculture, India on-line. The yield data for competing crops at the state level were gathered from the Centre for Monitoring Indian Economy, and the Directory of Indian Agriculture, 1997. Fertilizer consumption was obtained from the Centre for Monitoring Indian Economy. The percentage of coverage under irrigation was collected from the Department of Agriculture and Cooperatives, India (available online at <http://agricoop.nic.in/statistics/>), while rainfall data was collected from Indiatat.com. Although the data were obtained from various sources, these were cross-checked for consistency.

V. Policy Simulations

The estimated model was used to develop baseline projections for Indian fibre demand, supply and prices for ten-year period under a set of assumptions for exogenous variables. Some of the exogenous variables include per capita GDP, exchange rate, consumer price index, crude oil price and population. Projections for macro economic variables such as real GDP, consumer price index (CPI), exchange rates and population were obtained from the 2004 World and US Agricultural Outlook published by the Food and Agricultural Policy Research Institute (FAPRI, 2004). The GDP is projected to grow at an annual rate of 5.5% between 2003 and 2015. During the next 10 years, the exchange rate is projected to appreciate in the initial years and depreciate towards the later period. The population growth is projected to decline from 1.50% in 2003 to 1.23 in 2014. Projections for international prices for crude oil, wheat, rice, corn and groundnut were also taken from the same source. Projections for competing crop prices were obtained by regressing domestic prices on their respective international prices. Projections for textile and food price indices were obtained by the regression of these indices on CPI.

Baseline projections

Baseline projections generally assume the continuation of the current policies including MFA quotas in textile and apparel exports. The baseline projections were developed by linking the India model to the world fibre model of Texas Tech University (Pan *et al.*, 2004). The baseline projections show that the total textile consumption is projected to rise by 30% from 4803 thousand metric tons (TMT) in 2004 to 6224.36 TMT in 2014, partly due to rising per capita consumption. Per capita textile consumption is projected to increase by about 14% in the next 10 years, primarily driven by strong income growth. Rising textile consumption will result in higher mill use of raw fibre, with cotton and man-made fibre mill use increasing by 13 and 72%, respectively.

During the baseline period, the domestic fibre prices are projected to rise steadily. As shown in Table 1, the cotton price is expected to rise from 52.50 rupees per kilogram in 2004/2005 to 64.65 rupees per kilogram in 2014/2015, whereas the polyester price increases from 77.78 rupees per kilogram to 88.25 rupees per kilogram during the same period. Cotton production, on the regional basis, is projected to increase by 8% (from 432 TMT to 467 TMT) in the northern region, by 24% (from 1739 TMT to 2158 TMT) in the central region, and by 16% (from 890 TMT to 1034 TMT) in the southern region during the same period (Table 2a). The total cotton production, on the other hand, is projected to rise by 19% from 3180 TMT in 2004/2005 to 3778 TMT in 2014/2015 (Table 2b). As expected, most of the production growth is projected to come from yield improvements rather than area expansion. Although total cotton area is projected to be flat in the next decade, shift in the cotton area among the regions is likely to happen based on relative profitability among crops. An increase in cotton area in the central region is projected to be offset by decline in area in the other two regions.

Table 1. Effects of MFA quota elimination on Indian fibre consumption and fibre prices

	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Average
Cotton consumption	Thousand metric tons											
Baseline	3397.16	3459.06	3453.83	3506.99	3544.42	3575.55	3609.59	3677.39	3729.88	3786.31	3849.48	3599.06
	Percentage change											
Scenario 1	0.15	1.79	1.41	1.43	1.36	1.20	1.18	1.15	1.15	0.97	1.09	1.17
Scenario 2	0.19	2.37	1.78	1.67	2.32	2.62	2.69	2.77	2.55	2.57	2.70	2.20
Scenario 3	0.36	3.35	2.62	2.49	2.41	2.60	2.70	3.53	3.76	3.20	3.43	2.77
MMF consumption	Thousand metric tons											
Baseline	1348.15	1511.23	1635.70	1759.64	1863.98	1952.73	2076.35	2148.92	2210.48	2259.29	2316.72	1916.65
	Percentage change											
Scenario 1	8.53	4.23	4.89	4.71	4.74	4.95	4.86	4.87	4.84	5.13	4.90	5.15
Scenario 2	17.34	11.22	11.98	11.79	10.25	9.51	9.16	8.95	9.26	9.20	8.94	10.69
Scenario 3	25.81	17.29	18.08	17.73	17.41	16.69	16.06	14.50	14.01	14.80	14.45	16.99
Indian cotton price	Rupees per kilogram											
Baseline	52.50	56.58	59.26	60.07	60.54	60.59	61.75	62.75	63.96	64.55	64.65	60.65
	Percentage change											
Scenario 1	7.99	5.07	5.52	5.55	5.17	5.44	5.53	5.76	4.81	5.71	6.85	5.76
Scenario 2	10.77	6.58	6.33	9.84	11.68	12.53	13.63	12.82	13.31	14.52	15.59	11.60
Scenario 3	15.13	10.04	9.93	9.95	11.74	12.48	17.41	19.13	16.30	18.32	21.70	14.74
Indian polyester price	Rupees per kilogram											
Baseline	77.78	80.34	84.48	83.89	81.41	77.34	77.20	81.13	85.46	87.93	88.25	82.29
	Percentage change											
Scenario 1	14.63	12.34	8.43	8.58	10.02	13.74	13.95	14.55	15.73	15.82	16.01	13.07
Scenario 2	18.98	16.53	11.96	17.28	21.74	29.72	31.25	30.36	24.57	22.64	23.11	22.56
Scenario 3	25.35	25.70	20.82	22.07	25.91	30.51	34.63	35.86	36.53	39.34	42.50	30.84

Notes: Scenario 1 indicates a 10% increase in textile exports, scenario 2 indicates a 20% increase in textile exports and scenario 3 indicates a 30% increase in textile exports.

Table 2. Effects of MFA quota elimination on fibre production

	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Average
Panel A												
Northern cotton production												
Baseline (1000MT)	432.35	452.91	465.17	471.20	472.13	470.79	468.67	467.49	466.87	466.83	466.67	463.73
	Percentage change											
Scenario 1	0.00	0.82	0.66	0.46	0.21	-0.04	-0.19	-0.27	-0.29	-0.38	-0.31	0.06

Scenario 2	0.00	1.10	0.85	0.48	0.47	0.38	0.20	0.04	-0.23	-0.38	-0.38	0.23
Scenario 3	0.00	1.54	1.25	0.75	0.24	-0.04	-0.26	-0.08	-0.05	-0.44	-0.50	0.22
Central cotton production												
Baseline (1000MT)	1739.08	1779.26	1817.94	1869.16	1908.35	1945.31	1981.04	2024.02	2067.99	2114.18	2158.25	1945.87
Percentage change												
Scenario 1	0.00	1.61	1.21	1.22	1.18	1.05	1.05	1.03	1.03	0.85	0.94	1.02
Scenario 2	0.00	2.17	1.58	1.41	2.03	2.35	2.41	2.53	2.33	2.31	2.42	1.96
Scenario 3	0.00	3.05	2.38	2.22	2.13	2.36	2.41	3.17	3.42	2.90	3.04	2.46
Southern cotton production												
Baseline (1000MT)	890.42	934.17	908.97	935.69	951.42	964.69	975.43	991.34	1006.15	1021.88	1034.36	964.96
Percentage change												
Scenario 1	0.00	2.49	1.71	1.86	1.83	1.66	1.69	1.69	1.73	1.42	1.65	1.61
Scenario 2	0.00	3.35	2.22	2.13	3.24	3.74	3.89	4.16	3.84	3.93	4.19	3.15
Scenario 3	0.00	4.71	3.39	3.34	3.28	3.76	3.88	5.32	5.73	4.81	5.29	3.96
Panel B												
Total cotton production												
Baseline (1000MT)	3180.48	3284.97	3310.70	3394.68	3450.53	3499.42	3543.77	3601.48	3659.62	3721.51	3777.90	3493.19
Percentage change												
Scenario 1	0.00	1.69	1.23	1.25	1.19	1.04	1.03	1.01	1.02	0.83	0.95	1.02
Scenario 2	0.00	2.28	1.59	1.43	2.08	2.39	2.45	2.57	2.34	2.35	2.48	2.00
Scenario 3	0.00	3.20	2.41	2.25	2.11	2.34	2.38	3.23	3.50	2.91	3.12	2.50
MMF production												
Baseline (1000MT)	1640.02	1747.94	1847.88	1963.02	2093.28	2174.96	2296.19	2361.13	2423.02	2481.92	2537.98	2142.49
Percentage change												
Scenario 1	2.56	2.25	1.93	1.57	1.16	0.83	0.50	1.49	0.12	0.43	0.65	1.23
Scenario 2	2.56	2.25	2.34	2.66	2.16	1.77	1.38	2.35	2.08	1.84	2.90	2.21
Scenario 3	3.80	3.75	4.40	4.60	3.53	4.98	4.33	4.16	4.17	4.28	4.44	4.22

Notes: Scenario 1 indicates a 10% increase in textile exports, scenario 2 indicates a 20% increase in textile exports and scenario 3 indicates a 30% increase in textile exports.

Average cotton yield, one of the lowest in the world, is projected to increase by around 18% in the next decade, primarily because of expected adoption of Bt (*Bacillus thuringiensis*) cotton at a larger scale. This is fairly conservative considering the findings of ICAC (2004), which concluded that Bt cotton adoption could increase yield as much as 50%.

Currently, India is a net importer of cotton and net exporter of man-made fibres. Strong domestic fibre demand in the future, fueled by rising textile exports, is likely to make India a growing net importer of cotton and a declining net exporter of man-made fibres. Cotton net imports are projected to rise by 27% from 115 TMT in 2004/2005 to 197 TMT in 2014/2015. Similarly, man-made fibres' net exports are projected to decline by 24% from 292 TMT to 221 TMT during the same period (Table 3).

Table 3. Effects of MFA quota elimination on fibre trade and world prices

	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Average
Cotton net imports												
Thousand metric tons												
Baseline	155.62	167.88	169.11	169.00	168.56	167.95	167.65	187.32	187.24	187.15	197.06	174.96
Percentage change												
Scenario 1	3.20	3.81	4.78	4.71	4.30	3.96	3.78	3.23	2.95	3.11	3.17	3.73
Scenario 2	3.96	4.24	5.02	5.98	6.19	5.98	6.06	4.98	5.05	5.28	5.20	5.27
Scenario 3	7.73	6.41	6.09	6.60	7.40	6.56	7.72	7.08	6.32	6.75	7.13	6.89
MMF net exports												
Thousand metric tons												
Baseline	291.88	236.71	212.19	203.38	229.31	222.22	219.84	212.21	212.54	222.62	221.26	225.83
Percentage change												
Scenario 1	-24.98	-10.39	-20.85	-25.63	-27.95	-35.37	-40.71	-32.71	-48.97	-47.31	-43.84	-32.61
Scenario 2	-65.69	-55.01	-71.97	-76.34	-63.61	-66.27	-72.08	-64.49	-72.57	-72.87	-60.40	-67.39
Scenario 3	-97.87	-82.66	-101.03	-108.97	-109.28	-97.90	-106.47	-100.61	-98.19	-103.51	-100.30	-100.62
A-index price												
Cents per pound												
Baseline	64.40	63.09	61.94	61.86	62.44	63.22	64.51	65.91	66.94	67.46	67.46	64.47
Percentage change												
Scenario 1	0.28	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.05
Scenario 2	0.52	0.08	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.03	0.09
Scenario 3	0.58	0.08	0.08	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.10

Notes: Scenario 1 indicates a 10% increase in textile exports, scenario 2 indicates a 20% increase in textile exports and scenario 3 indicates a 30% increase in textile exports.

Simulation results

After developing the baseline, alternate scenarios were performed for three different levels of textile exports at 10, 20 and 30% above the baseline level. Scenarios 1, 2 and 3 refer to 10, 20 and 30% increases in textile exports, respectively, due to MFA quota elimination. Simulation results, expressed as a percentage change from each year's baseline level, are summarized in Tables 1-3.

As shown in Table 1, the increase in textile exports due to quota eliminations raises the domestic mill use of raw fibres in India. Cotton and man-made fibre mill use are projected to increase each year by an average of 1.2 and 5.1%, respectively, over their respective bases in scenario 1 (10% increase in textile exports).

In the case of a 30% increase in textile exports (scenario 3), cotton and man-made fibre mill use are projected to rise each year by an average of 2.8 and 17%, respectively, relative to the baseline levels. Expansion in the mill demand for fibres should increase fibre prices, with cotton and polyester prices rising as much as 22 and 43%, respectively. In the case of scenario 1, cotton and man-fibre prices are projected to be higher each year by an average of 5.8 and 13.1%, respectively, over their respective bases. The effects on fibre prices are much higher (an average of 14.7% for cotton and 30.8% for man-made fibres each year relative to their baseline levels) for scenario 3, where textile exports increase by 30%.

An increase in fibre prices should induce higher production levels of cotton and man-made fibres. As shown in Table 2(a), cotton production is projected to increase the least, each year by an average of 0.06, 0.23 and 0.22 above the baseline level, in the northern region, while the cotton production is highest in the southern region, where it is projected to increase each year by an average of 1.6, 3.15 and 3.96 above the baseline level in scenarios 1, 2 and 3, respectively. However, the total cotton production is projected to increase each year by an average of 1, 2 and 2.5% above the baseline level in scenarios 1, 2 and 3, respectively. Almost all the production growth is projected to come from the cotton acreage expansion in response to higher prices, with little to no change in yield. The northern region accounts for most of the increase in cotton acreage followed by the southern and central regions.

In the case of man-made fibre, production is projected to be higher each year between 1 and 4% (Table 2b), depending on the level of textile exports. In scenario 1, the average annual production increase each year is estimated to be 1.2% as compared to 4.2% over their respective bases in scenario 3. Most of the increases in man-made fibre production in the initial years come from a higher utilization of existing capacity rather than building additional capacity. However, capacity is projected to rise towards the second half of the projection period, contributing to higher man-made fibre production.

Since the expansion in domestic cotton production is not enough to meet the rising mill demand, imports are projected to be higher than the baseline level. Cotton imports in scenario 1 are estimated to be approximately 3–5% higher than the baseline level with an average increase of 3.7% each year over its respective base (Table 3). Similarly, higher textile exports are likely to result in higher cotton imports. In scenario 3, cotton imports are projected to rise around 6–8% above the baseline level (Fig. 3). Unlike cotton, India is a net exporter of man-made fibres and with rising mill use, its exports are projected to be lower in the scenarios (Table 3). In scenario 1, man-made fibre net exports are projected to decline by as much as 50%, with an average decline of 33% each year relative to the baseline level. Similarly, in scenario two (20% increase in textile exports), man-made fibre net exports are projected to decline each year by an average of 67% compared to its baseline level during the period 2004/2005 to 2014/2015. As shown in Fig. 4, India is projected to transform from a net exporter to a small net importer of man-made fibres, with the 30% increase in textile exports.

[Enlarge Image]

Fig. 3. Indian cotton net trade projections (baseline vs. scenarios)

[Enlarge Image]

Fig. 4. Indian man-made fiber net trade projections (baseline vs. scenarios)

The world cotton price is estimated to increase by one-half of a percent in the first year of simulation for scenario 2 (Table 3). However, adjustment by the competitors, who boost production, takes away most of the price increase after the initial year. For the remaining period, the world price is projected to increase by less than 0.05%. The effects on world prices are similar for scenarios 1 and 3.

Overall, the simulation results suggest that elimination of MFA quotas are likely to lead to higher cotton imports by India. In addition, man-made fibre exports from India are projected to decline significantly with the opening of textile markets in the developed countries. Higher domestic cotton prices encourage acreage expansion in cotton in all three regions but not enough to meet rising mill demand under the scenarios of higher textile exports.

VI. Conclusion

The cotton supply response being price-inelastic in India and given that yield is expected to increase only marginally during the next decade, increase in cotton production is not expected to be sufficient to meet the rising demand. Thus, it is likely that India would continue to rely heavily on cotton imported from other countries. Results of the study also suggest that man-made fibre production in India would be increasing over the next decade. Currently, India is a net exporter of man-made fibres. Strong domestic fibre demand in the future, fueled by rising textile exports, is likely to make India a declining net exporter of man-made fibres.

From Indian perspective, the results provide important insight into course of action that could potentially prevent India from becoming a net importer of cotton. In India, production of cotton needs to grow at a much faster pace than the historical rate to be able to meet domestic demand in the future. Since production increase through area expansion is limited, policies should be directed to improving productivity and quality. In order to achieve this, management practices encouraging widespread adoption of high-yielding varieties of cotton and new technologies must be promoted. In addition, improvement in fibre quality is also essential to meet the demand of high-quality cotton by export-oriented textile mills.

Appendix

Empirical Results

Fibre supply model

The regional cotton acreage models were estimated using OLS for the period 1970 to 2003. The adjusted R^2 for the cotton acreage models for northern, central and southern regions are 0.73, 0.62 and 0.49, respectively. The estimated parameters along with the diagnostic statistics are presented in Table A1. Table A2 describes the definition of the variables used in the Indian fibre model. The cotton acreage was specified as the function of the expected prices of cotton, expected prices of competing crops and lagged acreage.

Table A1 Parameters estimates of Indian fibre model

Equations		Adj. R^2	D-W statistics	D-H statistics
Cotton acreage				
Northern	$= 587.06 + 0.88 * EPC - 6.97 * EPCM1 + 0.64 * LAC1 - 309.94 * D02$ (289.98) (0.46) (3.91) (0.14) (133.11)	0.73		1.92
Central	$= 4115.38 + 2.04 * EPC - 19.71 * EPCM2 + 27.34 * T + 4102.86 * LYC2$ (593.03) (0.92) (5.83) (15.38) (1911.69)	0.62	1.70	
Southern	$= 1431.15 + 1.71 * EPC - 7.94 * EPCM1 - 604.96 * D86$ (185.73) (0.53) (3.77) (1166.81)	0.49	2.10	
Cotton yield				
Northern	$= 0.098 + 0.006 * PERCVIRG - 0.0001 * LAC1 + 0.65 * LYC1$ (0.06) (0.003) (0.00) (0.16)	0.37		-2.34
Central	$= -0.08 + 0.0002 * EPC + 0.006 * T + 0.06 * D01$ (0.05) (0.0001) (0.001) (0.03)	0.72	1.38	
Southern	$= 0.02 + 0.004 * T + 0.49 * LYC3$ (0.11) (0.001) (0.14)	0.91		-1.28
Man-made fibre				
Production capacity	$= 2.92 - 0.94 * LDEFF + 0.62 * LLMMPC - 0.36 * D0302$ (0.94) (0.43) (0.13) (0.19)	0.94		-0.30
Utilization rate	$= 0.86 + 0.62 * PRPET + 0.36 * LMMCUZ - 0.008 * T$ (0.28) (0.29) (0.18) (0.004)	0.44		-0.63
Fibre demand				
Textile consumption	$= 0.85 + 5.24 * CTWH1 + 0.22 * GDPIND + 0.08 * T$ (0.28) (1.26) (0.07) (0.03)	0.96	1.29	
Cotton share	$= 2.31 + 0.16 * \gamma_1 - 0.14 * \gamma_2 - 0.01 * \gamma_3 - 0.12 * \beta_1$ (0.30) (0.015) (0.015) (0.02)			
Man-made fibre share	$= -1.44 - 0.14 * \gamma_1 + 0.15 * \gamma_2 - 0.003 * \gamma_3 + 0.13 * \beta_1$ (0.30) (0.015) (0.015) (0.02)			
Cotton exports	$= 174.188 + 0.01 * CSU - 145900 * WW$ (76321) (0.01) (67850)	0.11	1.83	
Cotton imports	$= 52489 + 27854 * PRCTAI + 96421 * D9901$ (44954) (25953) (16840)	0.59	1.83	
Man-made fibre net Trade	$= -166.39 + 457.85 * DUSPP - 13.65 * DPP + 0.92 * LMMTR$ (161.29) (208.36) (63.76) (4.16)	0.88		1.22
Cotton ending stocks	$= 636.077 - 511.311 * DPC + 0.40 * LCES + 505.539 * D95$ (208293) (308920) (0.15) (176136)	0.40	1.79	

Table A2 Variable definition

Variables	Definition
CSU	Total cotton supply
CTWH1	Food price index/textile price index
D01	Dummy variable for 2001
D02	Dummy variable for 2002
D0302	Dummy 2003 + Dummy 2002
D86	Dummy variable for 1986
D95	Dummy variable for 1995
D9901	Dummy 1999 + Dummy 2001
DPC	Deflated domestic price of cotton
DPP	Deflated domestic polyester price
DUSPP	Deflated US 1.5 denier polyester price
EPC	Expected price of cotton
EPCM1	Expected price of rice
EPCM2	Expected price of groundnut
GDPIND	Per capita gross domestic product
LAC1	Northern India cotton acreage lagged one year
LCES	Cotton endings stocks lagged one year
LDEFF	Log of polyester price lagged 3-6 years/ log of crude oil price lagged 3-6 years
LLMMPC	Log of man-made fibre production capacity lagged one year
LMMCUZ	Man-made fibre capacity utilization lagged one year
LMMTR	Man-made fibre trade lagged 1 year
LYC1	Northern India cotton yield lagged 1 year
LYC2	Central India cotton yield lagged 1 year
LYC3	Southern India cotton yield lagged 1 year
PERCVIRG	Percentage area covered under irrigation
PRCTAI	Deflated domestic price of cotton/deflated and adjusted A-index price for tariff and exchange rate
PRPET	Polyester price/crude oil price
T	Time trend
WW	Deflated domestic price of cotton/deflated and adjusted A-index price
β_i	Coefficient associated with expenditure in i th share equation

Y_{f1}	Coefficient associated with cotton in i th share equation
Y_{f2}	Coefficient associated with man-made fibre in i th share equation
Y_{f3}	Coefficient associated with wool in i th share equation

For the northern region, in addition to expected price of cotton (EPC), expected price of rice (EPCM1) as the competing crops, lagged cotton acreage (LAC1), a dummy variable (D02) was included to represent drought in 2002. Cotton acreage for central region was specified as the function of expected price of cotton, price of groundnut (EPCM2), a time trend (T), and previous year's cotton yield (LYC2). The specification of cotton acreage in southern region includes the expected prices of cotton and rice and a dummy variable for 1986 (D86) to account for the drought experienced in that year. All the coefficients are statistically significant and have expected signs. The statistically significant coefficient on the lagged cotton acreage (LAC1) demonstrates fixity in cotton production in the northern region. Low R^2 's in all the three regions are mainly due to the use of expected prices instead of regional net return.

To obtain further insight, the point estimates for own and cross prices were converted into elasticities at the sample means. The estimates for regional own- and cross-price acreage elasticities are reported in Table A3. As expected, all the own-price elasticities are found to be positive and range from 0.15 to 0.36, with the highest for the southern region and the lowest for the central region.

Table A3 Elasticities of Indian regional cotton acreage model at sample mean

Acreage elasticities with respect to the expected price of			
Region	Cotton	Rice	Groundnut
Northern	0.20 (0.10)	-0.21 (0.11)	
Central	0.15 (0.07)		-0.35 (0.10)
Southern	0.36 (0.11)	-0.22 (0.10)	

Notes: SEs are reported in the parentheses below the coefficients.

The estimated parameters along with the diagnostic for regional cotton yield equations are reported in Table A1. The yield equation in the northern region was specified as the function of the percentage of area under irrigation (PERCVIRG), lagged cotton acreage (LAC1) and lagged cotton yield (LYC1). In addition to the expected price of cotton, a time trend (T) and dummy variable for 2001 (D01) were also included in the cotton yield equation for central region. The estimated coefficient on time trend (T) is statistically significant and positive, implying that yields have increased over time and it is likely due to varietal and technological improvements in the central region. D01 captures the effect of sudden decrease in yields in the 2001 crop season. Similarly, cotton yield equation in the southern region included time trend (T), and yield-lagged 1 year (LYC3) variables. The coefficients on the both these variables are statistically significant with positive signs, which imply that improved technology and yield realized in the previous year influence the current cotton yields in this region. The coefficient of expected price of cotton was found to be positive and statistically significant only for the central region. For the other two regions, results suggest a lesser role of price in influencing the yield level. The statistically significant and negative coefficient for the lagged cotton acreage in the northern region yield equation suggests that the average yield in the northern region has declined as the marginal lands were brought into the cotton production. The adjusted R^2 values range from 0.37 to 0.91, with the highest for the southern region and the lowest for the northern region. The possible cause of the low adjusted R^2 value in the northern region may be that weather variability is more severe, and monsoon rainfall is erratic which are not being captured by the model.

Man-made fibre production is calculated as the product of production capacity and utilization rate. The man-made fibre production capacity is specified as the function of the ratio of three to six year lagged prices of polyester and crude oil (LDEFF) and production capacity lagged one year (LLMMP). Similarly, the man-made fibre capacity utilization rate is explained by the ratio of prices of polyester and crude oil (PRPET), as well as one year lagged capacity utilization (LMMCUIZ). The lag structure in the production capacity equation was determined using Akaike Information criterion (AIC). The estimated parameters along with the diagnostic statistics are reported in Table A1. The lagged-dependent variables (LLMMP for capacity and LMMCUIZ for utilization rate) are found to be statistically significant in both of these equations, implying high degree of fixity in man-made fibre production process. The adjusted R^2 values are 0.94 and 0.44 for capacity and capacity utilization equations.

Fibre demand models

The fibre demand was derived using a two-step process. In the first step, Indian per capita textile consumption in fibre equivalent was estimated, and then it was allocated among the raw fibres in the second stage to derive the mill use of individual fibres. The per capita textile consumption was estimated using OLS for the period 1970 to 2003. The consumption equation was specified as the function of per capita real GDP (GDPIND), the ratio of food price index to textile price index (CTWH1), and a time trend variable (T). Time trend variable was added in the equation to capture the rise in textile consumption over time. The estimated parameters along with the diagnostic statistics are presented in Table A1. All the coefficients are statistically significant and have the expected signs. Results show that the income variable is found to be dominant in determining per capita textile consumption in India. The income elasticity calculated at the sample mean is 0.74. The statistically significant and positive coefficient for the price ratio suggests that an increase in the ratio, either due to rise in food price index or decline in textile price index, increases textile consumption and vice versa. The statistically significant trend variable (T) shows that factors other than income and population such as greater choices of textile products and brand name availability because of textile and apparel trade liberalizations, and shift in consumer preferences in India can be attributed to increase in textile consumption. The adjusted R^2 for this model is 0.96.

In the second stage, total textile demand was allocated among competing fibres, i.e. cotton, wool and man-made fibres using the AIDS demand system. The demand system was estimated using nonlinear SUR with symmetry and homogeneity imposed. The wool equation was omitted from the estimated system and was later obtained through the adding-up constraint. The estimated parameters along with standard errors are presented in Table A1. All the estimated parameters are statistically significant at the 1% level. The coefficients for the estimated parameters of the total fibre expenditures are found to be negative for cotton and wool, and positive for man-made fibres.

The estimated parameters were converted into price and expenditure elasticities at the sample mean and are reported in Tables A4 and A5. As expected, all the expenditure elasticities are positive and range between 0.47 and 1.39. Interestingly, expenditure elasticity for man-made fibre was found to be highly elastic as compared to cotton and wool. All uncompensated own-price elasticities are found to be negative and range from -0.04 to -0.63, with the lowest for wool and the highest for the man-made fibres (Table A4). Own price elasticity of cotton is more or less the same as that of man-made fibre. On the other hand, compensated own price elasticities in Table A5 are much smaller in magnitude, and range between -0.03 and -0.18. The positive compensated cross-price elasticities between cotton and man-made fibres demonstrate that they are net substitute at the mill level. Similarly, cross-price elasticities between man-made fibres and wool are found to be positive and small, suggesting weaker substitutional relationship between these two fibres at the mill level. However, compensated cross-price elasticities between cotton and wool, and wool and cotton are small and negative, implying weaker complementary relationship between cotton and wool at the mill level.

Table A4 Estimated uncompensated fibre price and income elasticities Demand elasticities with respect to the price of

	Cotton	Man-made fibres	Wool	Expenditure elasticities
Cotton	-0.63	-0.18	-0.02	0.82
Man-made fibres	-0.73	-0.63	-0.02	1.39
Wool	-0.36	-0.08	-0.04	0.47

Table A5 Estimated compensated fibres price elasticities Demand elasticities with respect to the price of

	Cotton	Man-made fibres	Wool
Cotton	-0.09		0.09
Man-made fibres	0.18		-0.18
Wool	-0.05		0.08
			-0.03

Fibre trade and ending stocks equations

The equations for cotton exports and imports were estimated separately using OLS. Cotton exports equation are specified as the function of domestic to A-index price ratio (WW), and cotton supply (CSU) variable to account for the government restrictions on the cotton exports. Cotton imports in India are explained by the ratio of domestic cotton market price to the world cotton price (PRCTAI) and a binary variable for 1999 and 2001 (D9901) jointly to capture the effects of change in trade policy and price effects. In order to avoid multicollinearity between the domestic and the international prices, the ratio of domestic to world price was included as the explanatory variable rather than individual prices. The world cotton price, represented by the A-index price, was converted into the local currency using the market exchange rate, and the import/export tariffs were added to the international prices.

The regression results along with the diagnostic statistics are reported in Table A1. The coefficient on the domestic to A-index price ratio (WW) was found to be negative and statistically significant in the cotton exports equation. This implies that the cotton exports from India would increase as the domestic price of cotton decreases relative to the world price and vice versa. However, the estimated coefficient for the cotton supply variable (CSU) was not statistically different from zero, indicating a lesser role of domestic supply in determining export level. The coefficient on PRCTAI, is however, not statistically significantly different from zero but has the hypothesized positive sign. The binary variable D9901 captures the effects of change in trade policy on cotton imports for 1999 and 2001. Low R^2 's in both the equations are due to government intervention in trade through state agencies, which are not being captured by the models.

In the case of man-made fibres, the net trade equation was estimated rather than separate equations for exports and imports, primarily because of nonavailability of data. The man-made fibre net trade equation was specified as the function of the international price represented by the US 1.5 denier polyester price (DUSPP), domestic polyester price (DPP), and man-made fibre net trade lagged 1 year (LMMTR). Since the share of cellulosic fibre is negligible, the polyester price was used as the representative price for the man-made fibres. The regression results reported in Table A1 indicate that the coefficient for DUSPP is positive and statistically significant, while that for DPP is not statistically significantly different from zero but has the expected negative sign. This implies the importance of the international price rather than the domestic price in determining the man-made fibre trade level. The coefficient for the lagged man-made fibre net trade (LMMTR) is statistically significant with positive sign, which indicates that man-made fibre net trade in the previous year influences the current man-made fibre net trade in India. The adjusted R^2 value of 0.88 suggests that majority of the variation in man-made fibre net trade is explained by the explanatory variables included in the equation.

The estimated parameters and the diagnostic statistics for the cotton ending stocks equation are reported in Table A1. The ending stocks was explained by cotton price (DPC), beginning stocks (LCES) and a dummy variable for 1995 (D95) to capture the effect of sudden rise in stocks in 1995. The coefficient for DPC is found to be negative and statistically significant at the 10% level, suggesting an inverse relationship between price and carryover stocks. As hypothesized, the LCES is statistically significant and directly related with the cotton ending stocks. The low R^2 value for the cotton ending stocks equation is not surprising in the presence of the government procurement program. Historically, more than half of the carryover stock is held by the government.

Model validation

After estimating all the equations, the model was solved simultaneously in a simulation program using SAS (statistical analysis system). Historical simulation of the model's equations was used to validate the estimated model using the components of the mean squared error (MSE) and the Theil inequality coefficients. Theil's U statistic performed better than the decomposition of mean squared error. Overall, the model validation statistics suggest that the simulation model has reasonably good forecasting ability.

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[Enlarge Image]

Fig. 1. Impacts of MFA quota elimination on world cotton and textile markets.

[Enlarge Image]

Fig. 2. Schematic representation of the Indian fibre model

[Enlarge Image]

Fig. 3. Indian cotton net trade projections (baseline vs. scenarios)

[Enlarge Image]

Fig. 4. Indian man-made fiber net trade projections (baseline vs. scenarios)

List of Tables

Table 1. Effects of MFA quota elimination on Indian fibre consumption and fibre prices

	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Average
Cotton consumption	Thousand metric tons											
Baseline	3397.16	3459.06	3453.83	3506.99	3544.42	3575.55	3609.59	3677.39	3729.88	3786.31	3849.48	3599.06
Percentage change												
Scenario 1	0.15	1.79	1.41	1.43	1.36	1.20	1.18	1.15	1.15	0.97	1.09	1.17
Scenario 2	0.19	2.37	1.78	1.67	2.32	2.62	2.69	2.77	2.55	2.57	2.70	2.20
Scenario 3	0.36	3.35	2.62	2.49	2.41	2.60	2.70	3.53	3.76	3.20	3.43	2.77
MMF consumption	Thousand metric tons											
Baseline	1348.15	1511.23	1635.70	1759.64	1863.98	1952.73	2076.35	2148.92	2210.48	2259.29	2316.72	1916.65
Percentage change												
Scenario 1	8.53	4.23	4.89	4.71	4.74	4.95	4.86	4.87	4.84	5.13	4.90	5.15
Scenario 2	17.34	11.22	11.98	11.79	10.25	9.51	9.16	8.95	9.26	9.20	8.94	10.69
Scenario 3	25.81	17.29	18.06	17.73	17.41	16.69	16.06	14.50	14.01	14.90	14.45	16.99
Indian cotton price	Rupees per kilogram											
Baseline	52.50	56.58	59.26	60.07	60.54	60.59	61.75	62.75	63.96	64.55	64.65	60.65
Percentage change												
Scenario 1	7.99	5.07	5.52	5.55	5.17	5.44	5.53	5.76	4.81	5.71	6.85	5.76
Scenario 2	10.77	6.58	6.33	9.84	11.68	12.53	13.63	12.82	13.31	14.52	15.59	11.60
Scenario 3	15.13	10.04	9.93	9.95	11.74	12.49	17.41	19.13	16.30	18.32	21.70	14.74
Indian polyester price	Rupees per kilogram											
Baseline	77.78	80.34	84.48	83.89	81.41	77.34	77.20	81.13	85.46	87.93	88.25	82.29
Percentage change												
Scenario 1	14.63	12.34	8.43	8.58	10.02	13.74	13.95	14.55	15.73	15.82	16.01	13.07
Scenario 2	18.98	16.53	11.96	17.28	21.74	29.72	31.25	30.36	24.57	22.64	23.11	22.56
Scenario 3	25.35	25.70	20.82	22.07	25.91	30.51	34.63	35.86	36.53	39.34	42.50	30.84

Notes: Scenario 1 indicates a 10% increase in textile exports, scenario 2 indicates a 20% increase in textile exports and scenario 3 indicates a 30% increase in textile exports.

Table 2. Effects of MFA quota elimination on fibre production

	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Average
Panel A												
Northern cotton production												
Baseline (1000MT)	432.35	452.91	465.17	471.20	472.13	470.79	468.67	467.49	466.87	466.83	466.67	463.73
Percentage change												
Scenario 1	0.00	0.82	0.66	0.46	0.21	-0.04	-0.19	-0.27	-0.29	-0.38	-0.31	0.06
Scenario 2	0.00	1.10	0.85	0.48	0.47	0.38	0.20	0.04	-0.23	-0.38	-0.38	0.23
Scenario 3	0.00	1.54	1.25	0.75	0.24	-0.04	-0.26	-0.08	-0.05	-0.44	-0.50	0.22
Central cotton production												
Baseline (1000MT)	1739.08	1779.26	1817.94	1869.16	1908.35	1945.31	1981.04	2024.02	2067.98	2114.18	2158.25	1945.87
Percentage change												
Scenario 1	0.00	1.61	1.21	1.22	1.18	1.06	1.05	1.03	1.03	0.85	0.94	1.02

Scenario 2	0.00	2.17	1.58	1.41	2.03	2.35	2.41	2.53	2.33	2.31	2.42	1.96
Scenario 3	0.00	3.05	2.38	2.22	2.13	2.36	2.41	3.17	3.42	2.90	3.04	2.46
Southern cotton production												
Baseline (1000MT)	890.42	934.17	908.97	935.69	951.42	964.69	975.43	991.34	1006.15	1021.08	1034.36	964.96
Percentage change												
Scenario 1	0.00	2.49	1.71	1.86	1.83	1.66	1.69	1.69	1.73	1.42	1.65	1.61
Scenario 2	0.00	3.35	2.22	2.13	3.24	3.74	3.89	4.16	3.64	3.93	4.19	3.15
Scenario 3	0.00	4.71	3.39	3.34	3.28	3.76	3.88	5.32	5.73	4.81	5.29	3.96
Panel B												
Total cotton production												
Baseline (1000MT)	3180.48	3284.97	3310.70	3394.68	3450.53	3499.42	3543.77	3601.48	3659.62	3721.51	3777.90	3493.19
Percentage change												
Scenario 1	0.00	1.69	1.23	1.25	1.19	1.04	1.03	1.01	1.02	0.83	0.95	1.02
Scenario 2	0.00	2.28	1.59	1.43	2.08	2.39	2.45	2.57	2.34	2.35	2.48	2.00
Scenario 3	0.00	3.20	2.41	2.25	2.11	2.34	2.38	3.23	3.50	2.91	3.12	2.50
MMF production												
Baseline (1000MT)	1640.02	1747.94	1847.88	1963.02	2093.28	2174.96	2296.19	2361.13	2423.02	2481.92	2537.98	2142.49
Percentage change												
Scenario 1	2.56	2.25	1.93	1.57	1.16	0.83	0.50	1.49	0.12	0.43	0.65	1.23
Scenario 2	2.56	2.25	2.34	2.66	2.16	1.77	1.38	2.35	2.08	1.84	2.90	2.21
Scenario 3	3.80	3.75	4.40	4.60	3.53	4.96	4.33	4.16	4.17	4.28	4.44	4.22

Notes: Scenario 1 indicates a 10% increase in textile exports, scenario 2 indicates a 20% increase in textile exports and scenario 3 indicates a 30% increase in textile exports.

Table 3. Effects of MFA quota elimination on fibre trade and world prices

	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015	Average
Cotton net imports												
Thousand metric tons												
Baseline	155.62	167.88	169.11	169.00	168.56	167.95	167.65	167.32	167.24	167.15	197.06	174.96
Percentage change												
Scenario 1	3.20	3.81	4.78	4.71	4.30	3.96	3.78	3.23	2.95	3.11	3.17	3.73
Scenario 2	3.96	4.24	5.02	5.98	6.19	5.98	6.06	4.98	5.05	5.28	5.20	5.27
Scenario 3	7.73	6.41	6.09	6.60	7.40	6.56	7.72	7.08	6.32	6.75	7.13	6.89
MMF net exports												
Thousand metric tons												
Baseline	291.88	236.71	212.19	203.38	229.31	222.22	219.84	212.21	212.54	222.62	221.26	225.83
Percentage change												
Scenario 1	-24.98	-10.39	-20.85	-25.63	-27.96	-35.37	-40.71	-32.71	-48.97	-47.31	-43.84	-32.61
Scenario 2	-65.69	-55.01	-71.97	-76.34	-63.61	-66.27	-72.08	-84.49	-72.57	-72.87	-60.40	-67.39
Scenario 3	-97.87	-82.66	-101.03	-108.97	-109.28	-97.90	-106.47	-100.61	-98.19	-103.51	-100.30	-100.62
A-index price												
Cents per pound												
Baseline	64.40	63.09	61.94	61.86	62.44	63.22	64.51	65.91	66.94	67.46	67.46	64.47
Percentage change												
Scenario 1	0.28	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.05
Scenario 2	0.52	0.08	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.03	0.09
Scenario 3	0.58	0.08	0.08	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.10

Notes: Scenario 1 indicates a 10% increase in textile exports, scenario 2 indicates a 20% increase in textile exports and scenario 3 indicates a 30% increase in textile exports.

Table A1 Parameters estimates of Indian fibre model

Equations		Adj. R ²	D-W statistics	D-H statistics
Cotton acreage				
Northern	$= 587.06 + 0.88 \cdot \text{EPC} - 6.97 \cdot \text{EPCM1} + 0.64 \cdot \text{LAC1} - 309.94 \cdot \text{D02}$ (289.98) (0.46) (3.91) (0.14) (133.11)	0.73		1.92
Central	$= 4115.38 + 2.04 \cdot \text{EPC} - 19.71 \cdot \text{EPCM2} + 27.34 \cdot \text{T} + 4102.86 \cdot \text{LYC2}$ (593.03) (0.92) (5.83) (15.38) (1941.69)	0.62	1.70	
Southern	$= 1431.15 + 1.71 \cdot \text{EPC} - 7.94 \cdot \text{EPCM1} - 604.96 \cdot \text{D86}$ (185.73) (0.53) (3.77) (166.81)	0.49	2.10	
Cotton yield				
Northern	$= 0.098 + 0.006 \cdot \text{PERCVIRG} - 0.0001 \cdot \text{LAC1} + 0.65 \cdot \text{LYC1}$ (0.06) (0.003) (0.001) (0.16)	0.37		-2.34
Central	$= -0.08 + 0.0002 \cdot \text{EPC} + 0.006 \cdot \text{T} + 0.06 \cdot \text{D01}$ (0.05) (0.0001) (0.001) (0.03)	0.72	1.38	
Southern	$= 0.02 + 0.004 \cdot \text{T} + 0.49 \cdot \text{LYC3}$ (0.11) (0.001) (0.14)	0.91		-1.28
Man-made fibre				
Production capacity	$= 2.92 - 0.94 \cdot \text{LDEFF} + 0.62 \cdot \text{LLMMP} - 0.36 \cdot \text{D0302}$ (0.94) (0.43) (0.13) (0.19)	0.94		-0.30
Utilization rate	$= 0.86 + 0.62 \cdot \text{PRPET} + 0.36 \cdot \text{LMNCUZ} - 0.008 \cdot \text{T}$ (0.28) (0.29) (0.18) (0.004)	0.44		-0.63
Fibre demand				
Textile consumption	$= 0.85 + 5.24 \cdot \text{CTWHI} + 0.22 \cdot \text{GDPIND} + 0.08 \cdot \text{T}$ (0.28) (1.26) (0.07) (0.03)	0.96	1.29	
Cotton share	$= 2.31 + 0.16 \cdot \gamma_1 - 0.14 \cdot \gamma_2 - 0.01 \cdot \gamma_3 - 0.12 \cdot \beta_i$ (0.30) (0.015) (0.015) (0.02)			
Man-made fibre share	$= -1.44 - 0.14 \cdot \gamma_1 + 0.15 \cdot \gamma_2 - 0.003 \cdot \gamma_3 + 0.13 \cdot \beta_i$ (0.30) (0.015) (0.015) (0.02)			

Cotton exports	= $174.188 + 0.01 \cdot \text{CSU} - 145900 \cdot \text{WW}$ (76321) (0.01) (67850)	0.11	1.83
Cotton imports	= $52489 + 27854 \cdot \text{PRCTAI} + 96421 \cdot \text{D9901}$ (44954) (25953) (16840)	0.59	1.83
Man-made fibre net Trade	= $-166.39 + 457.85 \cdot \text{DUSPP} - 13.65 \cdot \text{DPP} + 0.92 \cdot \text{LMMTR}$ (160.29) (208.36) (65.76) (0.16)	0.88	1.22
Cotton ending stocks	= $636077 - 511311 \cdot \text{DPC} + 0.40 \cdot \text{LCES} + 505539 \cdot \text{D95}$ (206293) (208920) (0.15) (176136)	0.40	1.79

Table A2 Variable definition

Variables	Definition
CSU	Total cotton supply
CTWH1	Food price index/textile price index
D01	Dummy variable for 2001
D02	Dummy variable for 2002
D0302	Dummy 2003 + Dummy 2002
D86	Dummy variable for 1986
D95	Dummy variable for 1995
D9901	Dummy 1999 + Dummy 2001
DPC	Deflated domestic price of cotton
DPP	Deflated domestic polyester price
DUSPP	Deflated US 1.5 denier polyester price
EPC	Expected price of cotton
EPCM1	Expected price of rice
EPCM2	Expected price of groundnut
GDPIND	Per capita gross domestic product
LAC1	Northern India cotton acreage lagged one year
LCES	Cotton endings stocks lagged one year
LDEFF	Log of polyester price lagged 3-6 years/ log of crude oil price lagged 3-6 years
LLMPPC	Log of man-made fibre production capacity lagged one year
LMCMUZ	Man-made fibre capacity utilization lagged one year
LMMTR	Man-made fibre trade lagged 1 year
LYC1	Northern India cotton yield lagged 1 year
LYC2	Central India cotton yield lagged 1 year
LYC3	Southern India cotton yield lagged 1 year
PERCVIRG	Percentage area covered under irrigation
PRCTAI	Deflated domestic price of cotton/deflated and adjusted A-index price for tariff and exchange rate
PRPET	Polyester price/crude oil price
T	Time trend
WW	Deflated domestic price of cotton/deflated and adjusted A-index price
β_i	Coefficient associated with expenditure in i th share equation
γ_{1i}	Coefficient associated with cotton in i th share equation
γ_{2i}	Coefficient associated with man-made fibre in i th share equation
γ_{3i}	Coefficient associated with wool in i th share equation

Table A3 Elasticities of Indian regional cotton acreage model at sample mean

Acreage elasticities with respect to the expected price of			
Region	Cotton	Rice	Groundnut
Northern	0.20 (0.10)	-0.21 (0.11)	
Central	0.15 (0.07)		-0.35 (0.10)
Southern	0.36 (0.11)	-0.22 (0.10)	

Notes: SEs are reported in the parentheses below the coefficients.

Table A4 Estimated uncompensated fibre price and income elasticities

Demand elasticities with respect to the price of				
	Cotton	Man-made fibres	Wool	Expenditure elasticities
Cotton	-0.63	-0.18	-0.02	0.82
Man-made fibres	-0.73	-0.63	-0.02	1.39
Wool	-0.36	-0.08	-0.04	0.47

Table A5 Estimated compensated fibres price elasticities

Demand elasticities with respect to the price of			
	Cotton	Man-made fibres	Wool
Cotton	-0.09		0.09
Man-made fibres	0.18	-0.18	0.01
Wool	-0.05	0.08	-0.03