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Econometric Modelling of the Indian Cotton Industry for Forecasting and Policy Simulations

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Econometric models provide a systematic approach for analysing the behaviour of agricultural commodity system as the commodity markets are highly competitive. These models can quantify economic behavioural relationships of variables of a single market or a group of interrelated markets. They can be used for understanding the economic structure, forecasting and policy analysis. The models can capture complex nature of commodity system through a system of simultaneous equations. While voluminous literature related to agricultural commodity market modelling are available in the case of developed countries (Garcia and Leuthold, 1997), the use of econometric models has been limited in developing countries such as India. However, such models can provide valuable insights for a complex and dynamic commodity system such as Indian cotton industry.

Cotton is a major raw material of the textile industry accounting for 66 per cent of the fibre consumption in India. India is the third largest producer, the second largest consumer of cotton and ranks first in terms of area in the world. The textile industry accounts for 4 per cent of gross domestic product (GDP), about one-fifth of total industrial output, and approximately one-third of total export earnings of the country. Cotton-based textiles contribute for 73 per cent (1995-96) of all textile exports accounting for 22 per cent of total exports from India. With the objective of enhancing the growth of this important industry the Central and State Governments have been intensively intervening in all its major sectors, viz., cotton, yarn and fabrics. Therefore, several studies have developed models for addressing various forecasting/policy issues relating to cotton industry (Hitchings, 1985; Coleman and Thigpen, 1991; Hamdy *et al.*, 1994). However, these models generate limited information required for the purpose of policy formulation. In this study, a detailed econometric simulation model of the Indian cotton textile industry has been developed which helps in understanding and quantifying the magnitudes of relationships of major variables. The model can generate forecasts and simulate the effect of policy changes.

I

OVERVIEW OF THE INDIAN COTTON TEXTILE INDUSTRY

In the process of converting cotton into fabrics, raw cotton is ginned to separate lint from seeds and then the lint is spun into yarn either pure or blended with man-made fibres. Cotton yarn, produced mainly in organised mills, is woven into fabrics either pure or blended. Fabric production takes place in organised mill units, decentralised units which comprise powerlooms and handlooms, and *khadi* units.

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Cotton is grown mainly in the northern, central and southern regions of the country. The introduction of American and hybrid cotton, spread of cotton cultivation in new areas and increase in the productivity have contributed significantly to increasing cotton production. As a result, cotton production in India has reached 160 lakh bales during 1996-97 from 65.5 lakh bales in 1972-73. The share of cotton in total consumption of fibres has been continuously declining from 83 per cent during 1980-81 to 66.4 per cent during 1995-96. Expansion of spinning units, increase in small scale spinning units, structural and managerial changes in the textile industry, thrust on increasing exports of value added fabrics and growing preference for blended and man-made fibre fabrics have influenced the supply of and demand for cotton yarn. Although the production of cotton yarn is increasing, its share has declined and accounted for 75.2 per cent during 1995-96. Export of cotton yarn has increased at a very high growth rate (28.1 per cent per annum) during the early nineties owing to setting up of export oriented units (EOUs) and government liberalisation policy. As a result, export of cotton yarn has accounted for about 22 per cent of total production in 1996-97 as compared to 0.9 per cent during 1985-86. In the weaving sector, although production of cotton fabrics has been continuously increasing in absolute terms, the share of cotton fabrics in total fabrics has declined from 72.4 per cent during 1985-86 to 58.6 per cent during 1996-97. The share of mills in the total production of cotton fabrics has been continuously declining and that of powerloom has been increasing since the early seventies. Mill cotton fabrics accounted for 6.2 per cent in 1996-97 against 22 per cent during 1985-86. Powerloom cotton fabrics accounted for 62 per cent of the total fabrics in 1996-97. The share of handloom fabrics hovers between 30 and 35 per cent. After the late seventies, the export of decentralised cotton fabrics has been increasing and is substantially high since 1991. *Khadi* fabrics account for about 1 per cent of the total fabric production.

II

FRAMEWORK OF THE MODEL

This study considers mainly cotton farming, spinning and weaving sectors for modelling purpose. Separate equations for demand, supply and market equilibrium conditions are specified for these three sectors in the model. In cotton farming and spinning sectors, all equations are in aggregate terms and in the weaving sector, demand, supply, export and price of mills and decentralised units have been explained through separate equations. The conceptual model developed initially was modified as per the availability of the data, data problem like multicollinearity[1] and other limitations (Naik *et al.*, 1998). However, all major equations and variables in the system which satisfactorily explain the interlinkages among variables of sectors have been retained.

III

DATA

Annual data for the period 1971-72 through 1994-95 have been used in this study. Owing to lack of data on stock of mill and decentralised cotton fabrics, the change in supply is assumed to be equal to the change in production. The data on consumption of cotton fabrics of mill and decentralised units were derived by subtracting export from the supply of fabrics. All price variables were deflated by wholesale price index (WPI) of all commodities (base year 1970-71). The export prices of yarn and fabrics were adjusted by the exchange rate of rupee versus US dollar (base year 1980-81). Per capita income of importing countries has been represented by per capita income in the OECD (Organisation for Economic Co-operation and Development) countries at constant prices (1987). Wholesale price indices were used for all price variables except for export prices of yarn and fabrics. Per unit realisation values are taken as export prices.

IV

ESTIMATION AND VALIDATION

Rank and order conditions show that all equations of the system are over-identified. Therefore, this model has been estimated through three-stage least squares (3SLS) method (Kmenta, 1971). Statistical and econometric tests have been carried out to validate the performance of the model. The list of endogenous and exogenous variables along with their units used in the model is given in Appendix 1. The figures in parentheses in the estimated equations are asymptotic t-values.

Cotton Farming Sector

Total demand for cotton lint at time 't' (DC_t) is the cumulative demand for cotton lint for domestic consumption (DCC_t), export of cotton lint (EC_t) and domestic stock of cotton lint (DSC_t) at time 't'. Since an inverse demand function of cotton lint has been specified, market equilibrium identity has been used to explain domestic consumption of cotton lint. It has been explained as the difference between supply of cotton lint (SC_t), and sum of domestic stock (DSC_t) and export demand for cotton lint at time 't'.

$$DCC_t = SC_t - DSC_t - EC_t \qquad \text{.... (1)}$$

Export and stock of cotton lint have been considered as exogenous variables in the system.

Price of cotton lint (DPC_t) at time 't' is a function of domestic consumption of cotton, price of cotton yarn ($DPCY_t$) and its own previous year price at time 't' (DPC_{t-1}).

$$\begin{aligned} DPC_t = {} & \underset{(2.13)}{34.26} - \underset{(-3.51)}{0.328^*\, DCC_t} + \underset{(6.60)}{0.890^*\, DPCY_t} - \underset{(-1.14)}{0.123^*\, DPC_{t-1}} \qquad \text{.... (2)} \\ & R^2 = 0.68 \end{aligned}$$

Supply of cotton lint at time 't' is the sum of production of cotton lint (P_dC_t), import of cotton lint (IC_t), and domestic stock of cotton lint carried over from the previous year (DSC_{t-1}) at time 't'. Import of cotton lint and lagged domestic stock of cotton lint are exogenous variables in the equation.

$$SC_t = P_dC_t + IC_t + DSC_{t-1} \qquad \text{.... (3)}$$

Production of cotton at time 't' is a function of one year lagged real price of cotton, percentage area under hybrid cotton ($PHVCA_t$), deflated price of fertilisers (DPF_t), and the trend variable (TREND).

$$P_dC_t = \underset{(3.15)}{55.84} + \underset{(1.78)}{0.231^*} DPC_{t-1} + \underset{(3.00)}{1.231^*} PHVA_t - \underset{(-1.96)}{0.247^*} DPF_t + \underset{(1.82)}{1.438^*} TREND \quad \text{.... (4)}$$
$$R^2 = 0.92$$

The estimates of equations (1) to (4) suggest that consumption of cotton lint and real price of cotton yarn are important variables influencing the deflated price of cotton lint. The estimates show that an increase in the percentage area under hybrid cotton contributes significantly to the production. The trend variable representing the improvement in the technology has significant and positive influence on the production. It indicates that substantial improvement in productivity has been a major factor in increasing the production. Prices of cotton and fertilisers significantly influence the production. As pesticides are applied as a preventive measure in many parts of the country the variable was not significant and hence is not included in the equation.[2]

Spinning Sector

This study confines itself to only pure cotton yarn. Since cotton yarn is an input in the production of cotton fabrics, the demand for yarn can be represented by a factor demand equation. Total demand for cotton yarn at time 't' (DCY_t) is the cumulative demand for the domestic consumption of cotton yarn ($DCCY_t$), domestic stock of cotton yarn ($DSCY_t$) and export of cotton yarn at time 't' (ECY_t). Since an inverse demand function of cotton yarn has been specified, market equilibrium identity has been used to explain domestic consumption of yarn. Domestic consumption of cotton yarn at time 't' has been explained as the difference between supply of cotton yarn (SCY_t) and the sum of domestic stock and export of cotton yarn at time 't'.

$$DCCY_t = SCY_t - ECY_t - DSCY_t \quad \text{.... (5)}$$

Price of cotton yarn ($DPCY_t$) at time 't' is specified as a function of domestic consumption of cotton yarn, price of decentralised cotton fabrics ($DPDSCF_t$) and export of cotton yarn at time 't'.

$$DPCY_t = \underset{(2.37)}{60.37} - \underset{(-2.61)}{0.034^*} DCCY_t + \underset{(4.26)}{0.828^*} DPDSCF_t + \underset{(6.07)}{0.182^*} ECY_t \quad \text{.... (6)}$$
$$R^2 = 0.70$$

Export demand for cotton yarn at time 't' has been specified as a function of export price of cotton yarn ($DEPCY_t$) and domestic stock of cotton yarn, and the dummy variable using logarithm of trend to capture the phenomenal growth of export of cotton yarn after 1992-93 owing to setting up of export oriented units at time 't'. Domestic stock of cotton yarn at time 't' has been considered as an exogenous variable.

$$ECY_t = \underset{(0.73)}{17.27} - \underset{(-1.39)}{9.311^*} DEPCY_t + \underset{(6.09)}{0.947^*} DSCY_t + \underset{(6.86)}{110.67^*} DV_1 \quad \text{.... (7)}$$
$$R^2 = 0.92$$

Supply of cotton yarn is the sum of production of cotton yarn (P_dCY) and domestic stock of cotton yarn carried over from the previous year ($DSCY_{t-1}$).

$$SCY_t = P_dCY_t + DSCY_{t-1} \qquad \text{.... (8)}$$

Production of cotton yarn at time 't' has been explained as a function of price of cotton, price and export of cotton yarn, and one year lagged value of production of cotton yarn at time 't' (P_dCY_{t-1}).

$$P_dCY_t = \underset{(3.99)}{590.18} + \underset{(7.43)}{0.706^*} P_dCY_{t-1} - \underset{(-6.88)}{5.222^*} DPC_t + \underset{(2.86)}{0.951^*} ECY_t + \underset{(1.39)}{1.552^*} DPCY_t \qquad \text{.... (9)}$$

$$R^2 = 0.95$$

Estimated equations (5) to (9) in the spinning sector suggest that domestic consumption of cotton yarn, real price of decentralised cotton fabrics and export of cotton yarn significantly affect deflated price of cotton yarn. Domestic stock of cotton yarn is a major variable influencing export of cotton yarn. The dummy variable intended to capture the effect of policy changes owing to liberalisation has a strong influence on the export of cotton yarn. The estimated equation of production of cotton yarn shows that one year lagged production of cotton yarn, deflated price of cotton and export of cotton yarn are significant variables affecting cotton yarn production. While strong lag effect indicates asset fixity nature of the units in the sector and strong relationship with the price of cotton indicates flexibility available to spinning units in terms of changing the raw material base.

Weaving Sector

Cotton fabrics comprise pure and blended. This study confines itself to only pure cotton fabrics. Demand for and supply of fabrics produced in mills and decentralised weaving units which comprise powerlooms including hosiery, and handlooms have been explained through separate equations. The market clearing condition for each type of weaving unit has also been introduced separately. *Khadi* fabrics have been excluded because of their small share in total fabric supply.

Mills

An inverse demand function of mill cotton fabrics has been specified. Price of mill cotton fabrics at time 't' ($DPMCF_t$) is a function of demand for mill cotton fabrics ($DMCF_t$), one year lagged price of mill cotton fabrics ($DPMCF_{t-1}$) and price of blended and mixed nylon fabrics ($DNTMC_t$) at time 't'.

$$DPMCF_t = \underset{(1.70)}{13.27} - \underset{(0.354)}{0.0007^*} DMCF_t + \underset{(4.27)}{0.706^*} DPMCF_{t-1} + \underset{(1.42)}{0.230^*} DNTMC_t \qquad \text{.... (10)}$$

$$R^2 = 0.92$$

Export of mill cotton fabrics at time 't' ($EMCF_t$) has been specified as a function of logarithm of world (OECD countries) per capita income ($LNWY_t$), deflated export price of mill cotton fabrics ($DEPMCF_t$) and logarithm of trend (LNTREND) at time 't'. World per capita income has been used in the logarithm form instead of its level value to reduce multicollinearity among the variables in this equation.

$$\begin{aligned} EMCF_t = & -10247.0 - 20.560^* DEPMCF_t + 1164.9^* LNWY_t \\ & (-3.40) \quad (-0.11) \quad (3.66) \\ & - 230.09^* LNTREND \\ & (-4.60) \\ & R^2 = 0.46 \end{aligned} \quad \text{.... (11)}$$

Supply of mill cotton fabrics has been considered equal to production of mill cotton fabrics as there are negligible imports. Moreover, data on stock of cotton mill fabrics are also not available. Production of mill cotton fabrics at time 't' (P_dMCF_t) depends on price of mill cotton fabrics, one year lagged production of mill cotton fabrics (P_dMCF_{t-1}) and export of mill cotton fabrics at time 't'.

$$\begin{aligned} P_dMCF = & -1530.6 + 26.02^* DPMCF_t + 0.677^* P_dMCF_{t-1} + 0.659^* EMCF_t \\ & (-3.23) \quad (3.51) \quad (7.89) \quad (1.78) \\ & R^2 = 0.92 \end{aligned} \quad \text{.... (12)}$$

Market for mill cotton fabrics at time 't' is in equilibrium when demand equals to supply at time 't'. Since supply is considered to be equal to production, market equilibrium condition is expressed as follows:

$$DMCF_t = P_dMCF_t \quad \text{.... (13)}$$

The estimates of equations (10) to (13) suggest that one year lagged price of mill cotton fabrics is the only significant variable affecting price of mill cotton fabrics. The major variables influencing export of mill cotton fabrics are per capita income of OECD countries and the trend variable. Export price of mill cotton fabrics does not influence export of mill cotton fabrics as export of mill cotton fabrics is dependent more on the agreements and contracts with the importing countries. Deflated price and lagged production of mill cotton fabrics are significant variables influencing the production of mill cotton fabrics. The estimated equation suggests that price is the major variable influencing the production.

Decentralised Units

In the case of decentralised weaving units also, an inverse demand function has been specified instead of normal demand function. Domestic consumption of decentralised cotton fabrics ($DCDSCF_t$) at time 't' has been explained as the difference between its production (P_dDSCF) and its export demand ($EDSCF_t$) at time 't'.

$$DCDSCF_t = P_dDSCF_t - EDSCF_t \quad \text{....(14)}$$

Deflated price of decentralised cotton fabrics at time 't' is specified as a function of consumption of decentralised cotton fabrics, differences in domestic incomes of two consecutive years (GY_t), export of decentralised cotton fabrics and one year lagged price of decentralised cotton fabrics ($DPDSCF_{t-1}$) at time 't'. Here, the difference in domestic incomes is used instead of level values to reduce the presence of multicollinearity among variables as well as for better fit.

$$
\begin{aligned}
DPDSCF_t = & \underset{(-4.24)}{-49.69} - \underset{(-3.22)}{0.0026}* DCDSF_t + \underset{(0.56)}{0.000083}* GY_t + \underset{(2.14)}{0.0149}* EDSCF_t \\
& + \underset{(5.45)}{0.59}* DPDSCF_{t-1} \qquad \ldots (15) \\
& R^2 = 0.72
\end{aligned}
$$

Export demand for decentralised cotton fabrics at time 't' is a function of logarithm of export price of decentralised cotton fabrics ($LNEPDSCF_t$), logarithm of world (OECD countries) per capita income ($LNWY_t$) and a dummy variable (DV_t) using logarithm of the trend from 1992 onwards representing liberalisation in the policies. World income and export price of decentralised cotton fabrics have been used in logarithmic form instead of their level values to reduce multicollinearity among variables.

$$
\begin{aligned}
EDSCF_t = & \underset{(-6.40)}{-13597} + \underset{(6.28)}{1435.7}* LNWY_t - \underset{(-0.81)}{81.86}* LNDEPPCF_t + \underset{(5.68)}{472.12}* DV_t \qquad \ldots (16) \\
& R^2 = 0.91
\end{aligned}
$$

Owing to lack of data on stock of decentralised cotton fabrics, supply of decentralised cotton fabrics at time 't' has been assumed to be equal to its production. Production of decentralised cotton fabrics at time 't' (P_dDSCF_t) is a function of real price of decentralised cotton fabrics, price of cotton yarn, export of decentralised cotton fabrics and a dummy variable using the square root of trend for the period 1992 onwards (DV) to capture the effect of liberalisation of the economy. Price of powerloom fabrics has been used as it constitutes the major share in production of decentralised cotton fabrics.

$$
\begin{aligned}
P_dDSCF_t = & \underset{(4.40)}{9236.2} + \underset{(1.17)}{24.55}* DPDSCF_t - \underset{(-5.32)}{75.97}* DPCY_t + \underset{(3.44)}{0.453}* P_dDSCF_{t-1} \\
& + \underset{(3.24)}{3.630}* EDSCF_t + \underset{(4.09)}{1500.8}* DV \qquad \ldots (17) \\
& R^2 = 0.97
\end{aligned}
$$

Total Export

Export of cotton fabrics is explained as follows:

$$ECF_t = EMCF_t + EDSCF_t \qquad \ldots (18)$$

The estimates of equations (14) to (17) indicate that consumption of decentralised cotton fabrics, one year lagged deflated price of decentralised cotton fabrics and export of cotton fabrics significantly influence the price of decentralised cotton fabrics. Export of decentralised cotton fabrics has been explained mainly by per capita income of OECD countries and the dummy variable. The influence of per capita income of OECD countries is quite similar to that noticed in the case of mill fabrics. The dummy variable capturing the effect of liberalisation policy is significant in influencing exports. The non-significance of export price variable indicates that agreements and contracts with importing countries may be important in determining exports. Export of decentralised cotton fabrics, deflated price of cotton yarn and one year lagged production of decentralised cotton fabrics are important variables in determining the production of decentralised cotton fabrics. The results indicate that production of decentralised cotton fabrics is also determined by price of its raw material, cotton yarn.

V

VALIDATION OF THE MODEL

For checking the validity of the model as a dynamic system, stability of the model and its ability to simulate historical data have been examined. Stability condition of the model was examined by computing the latent roots of the matrix of the reduced form coefficients of the lagged endogenous variables (Pindyck and Rubinfeld, 1991). None of the latent roots of the matrix is greater than one indicating that the system is stable. Since the dominant root of this matrix is negative (-0.94), the system will show oscillating convergence. The performance of the model has been examined through percentage root mean square error (PRMSE), Theil inequality coefficients (U_2) and ex-post forecasts. Historical forecasts have been generated through static and dynamic simulations[3] for the period 1972-73 to 1994-95. Historical forecasts for recent five-year period (1990-91 to 1994-95) using both actual and forecasted values of exogenous variables have also been generated through dynamic simulations.

PRMSE

PRMSE values show that the model gives reasonably good forecasts for the endogenous variables for the historical period (Appendix 2). The values of all price variables in static simulation for complete historical period are sufficiently low except that of price of cotton lint. PRMSE values of quantity variables in static simulation are also sufficiently low except export variables. High PRMSE values of export of cotton yarn and decentralised cotton fabrics are mainly because of small quantities of exports in the early periods. PRMSE values of all endogenous variables except demand for and production of mill cotton fabrics and deflated price of decentralised cotton fabrics in dynamic simulation for complete historical period are either close to or less than PRMSE values in static simulation. In dynamic simulation using actual values of exogenous variables for five years of the historical period (1990-91 to 1994-95), PRMSE values of all endogenous variables except domestic consumption of cotton, and demand for and production of mill cotton fabrics are either low or close to the corresponding PRMSE values of static and dynamic simulations for complete historical period. This indicates that the model's tracking ability is good. PRMSE values of most endogenous variables in dynamic simulation for five-year period using forecasted values of exogenous variables are also either low or close to their PRMSE values in dynamic simulation for the five-year period using actual values. However, in the case of ECY, SCY, DPCY, EMCF, and ECF, the PRMSE values have increased marginally.

Theil's Coefficient

Theil's coefficients of all endogenous variables are less than one in static and dynamic simulations for the complete historical period and dynamic simulations for the five-year period using actual and forecasted values of exogenous variables (Appendix 3). Therefore, the performance of the model is reasonably good and is consistent with the findings of the PRMSE statistics.

Ex-Post Forecast Performance

The ex-post forecasts of this model for the year 1995-96 also show that the model's performance is satisfactory (Appendix 4).

VI

ADEQUACY OF THE MODEL SPECIFICATIONS

The values of the components of mean square error indicate reasonably good specification of the model (Appendix 5). In static and dynamic simulations for the complete historical period, the bias component of the mean square simulation error of all endogenous variables, except DMCF and P_dMCF in the dynamic simulation, are almost equal to zero. The variance components of the mean square simulation error of most of endogenous variables in both static and dynamic simulations are also close to zero. However, variance components of DPC, ECY, DPCY, EMCF and ECF are slightly higher than zero in both static and dynamic simulations. The variance components of DPC and DPCY in dynamic simulation are higher than the corresponding values in static simulation. Furthermore, variance components of the mean square simulation error of DCCY and DPDSCF are also slightly higher than zero in dynamic simulation. Overall, the proportion of unsystematic error accounts for most of the inequality between the predicted and actual values.

VII

BASE-LINE SIMULATION

Given the satisfactory performance of the models as a dynamic system, forecasts for 1995-96 to 2000-01 have been generated through dynamic simulation. The actual values of the endogenous variables for the year 1994-95 have been used as values for initial year lagged endogenous variables. Forecasts of the exogenous variables have been made using the best fit trend regression. However, the values of domestic stock, export and import of cotton have been set at their mean values for the period from 1990-91 to 1994-95 as the trend regressions showed poor fit.

The base-line simulation of the model shows that domestic consumption of cotton lint will increase at the rate of 3.6 per cent per annum during 1994-95[4] to 2000-01 and will reach 168.3 lakh bales by 2000-01 (Table 1). Total production of cotton will increase at the rate

TABLE 1. BASE-LINE SIMULATION VALUES OF THE ENDOGENOUS VARIABLES OF THE MODEL FOR THE PERIOD 1995-96 TO 2000-01

Year (1)	DCC (2)	SC (3)	P_dC (4)	DPC (5)	DCY (6)	ECY (7)	SCY (8)	P_dCY (9)	DPCY (10)
1995	147.8	184.1	151.5	81.9	1,448.9	293.2	1,888.4	1,758.3	123.1
1996	145.9	182.2	149.6	91.2	1,527.7	335.4	2,027.4	1,881.2	129.1
1997	152.7	189.0	156.4	92.6	1,611.6	376.5	2,172.9	2,008.5	134.4
1998	157.7	194.0	161.3	95.1	1,691.8	415.5	2,315.0	2,130.3	139.3
1999	162.9	199.2	166.6	97.8	1,767.3	455.0	2,456.3	2,248.6	144.6
2000	168.3	204.6	172.0	101.4	1,837.5	497.5	2,597.5	2,364.0	151.0
CGR	3.6	2.7	3.3	0.6	5.5	13.0	7.3	6.7	4.5

Year (1)	DCDSCF (11)	EDSCF (12)	P_dDSCF (13)	DPDSCF (14)	DMCF (15)	EMCF (16)	P_dMCF (17)	DPMCF (18)	ECF (19)
1995	15,476.5	1,303.4	16,780.0	69.8	1,395.3	469.6	1,395.3	68.1	1,773.1
1996	16,177.1	1436.3	17,613.4	70.9	1,433.2	484.0	1,433.2	65.8	1,920.3
1997	16,778.4	1,555.0	18,333.4	71.7	1,418.8	498.7	1,418.8	63.9	2,053.7
1998	17,240.3	1,640.4	18,880.7	72.3	1,370.5	502.1	1,370.5	62.3	2,142.5
1999	17,597.6	1,730.7	19,328.3	73.0	1,313.5	517.4	1,313.5	61.0	2,248.1
2000	17,819.8	1,821.0	19,640.8	74.2	1,255.8	532.9	1,255.8	59.8	2,353.9
CGR	3.3	7.6	3.7	1.3	-0.6	2.5	-0.6	-2.8	6.6

Note: CGR = Compound growth rate per cent per annum with base year 1994-95

of 3.3 per cent per annum during this period which is almost equal to the growth rate of consumption. It is expected that with this growth rate, cotton production would reach the level of 172 lakh bales by 2000-01. However, the growth rate of cotton production during 1994-95 to 2000-01 would be lower than the growth rate realised during 1990-91 to 1995-96 (5.6 per cent per annum). In the spinning sector, export of cotton yarn would increase at a high rate (13.0 per cent per annum) during 1994-95 to 2000-01. High growth rate of export of cotton yarn is expected mainly because of the setting-up of a large number of export oriented units in the spinning sector through which about 60 per cent of cotton yarn is exported. Supply and production of cotton yarn would increase at the rate of 7.3 and 6.7 per cent per annum respectively. The growth rate of production of cotton yarn during this period is slightly higher than the growth rate of the production during 1990-91 to 1996-97 (5.1 per cent per annum). Price of cotton yarn would increase at the rate of 4.5 per cent per annum. The spiral tendency in the deflated price of cotton yarn, in spite of a low growth rate of consumption than that of supply, can be attributed to expected high exports. In the weaving sector, the declining trends in the production and consumption of mills are expected to slow down during this period. Demand for and production of mill cotton fabrics will decline at the rate of 0.6 per cent per annum as compared to 7.76 per cent during 1990-91 to 1996-97. Export of mill cotton fabrics is expected to increase at the rate of 2.5 per cent per annum during this period. Owing to changes in consumer preferences, government policies and external and internal factors, mills are producing either high quality fabrics meant for export or shifting from production of fabrics to only yarn production. The forecast suggests that the deflated price of mill cotton fabrics will also decline at the rate of 2.8 per cent per annum. The consumption and production of decentralised cotton fabrics will increase at the rate of 3.3 and 3.7 per cent per annum respectively during the simulation period. The growth rate of production of decentralised cotton fabrics during forecast period is considerably lower than its growth rate during 1990-91 to 1996-97 (10.4 per cent per annum). Export of decentralised cotton fabrics is expected to increase at a higher rate (7.6 per cent per annum) than the export of mill cotton fabrics. Export of total cotton fabrics will increase at the rate of 6.6 per cent per annum.

VIII

POLICY SIMULATIONS

Dynamic simulations for different policy scenarios have been carried out to assess the impact of changes in the percentage area under hybrid cotton, export of cotton lint, cotton yarn and price of fertilisers on the industry.

Since percentage area under hybrid cotton is an important variable in determining production, efforts of the government to bring large area under hybrid cotton would play a vital role in increasing cotton production in the country as the scope for increasing the acreage under cotton is limited. Furthermore, total area under hybrid cotton in the country is less than 50 per cent of the area under the crop. Therefore, simulation has been carried out to assess the impact of the change in the percentage area under hybrid cotton from the base level under two different scenarios: 5 per cent and 10 per cent increase in the percentage area under hybrid cotton. The simulation results reveal that an increase in the percentage area under hybrid cotton would have a positive impact on all endogenous variables of cotton farming, spinning sectors and decentralised weaving units. Endogenous variables of mill weaving units will remain unchanged. The change will have no influence on all export variables in the system. The results indicate that the area under hybrid cotton can contribute significantly to increasing the production.

Simulations have been carried out to ascertain the impact of the policies directed towards increase in the exports of cotton on the industry under two different scenarios; increase of 5 lakh bales and increase of 10 lakh bales from the average export of cotton. The results show that change in the export of cotton does not influence endogenous variables of the weaving sector. Change in the export of cotton brings about only a very marginal change in the endogenous variables of the spinning sector. Change in the supply and production of cotton as a result of change in the export of cotton is also small (the supply and the production will increase by 0.54 per cent and 0.7 per cent respectively as a result of 10 lakh bales increase in the export from the base level during 2000-01). Therefore, the assumption that restriction in the export of raw cotton will help in increasing exports of the value-added products does not seem to hold true.

The export of cotton yarn is another policy variable which is regulated by the government. Simulation has been carried out to ascertain the impact of increase of 25 thousand tonnes of yarn from the base level. The results show that this increase in the export of cotton yarn would increase all endogenous variables of cotton farming and spinning sectors. Consumption and production of cotton fabrics will experience a decline. Prices of cotton, cotton yarn and cotton fabrics will also increase. Therefore, it is important to ensure that the production of yarn is enhanced sufficiently so that yarn prices do not increase substantially.

Since fertiliser is an important input for cotton crop and constitutes a significant share in total cost of cultivation, change in its price may encourage or discourage its application. Therefore, we have tried to ascertain the impact of 10 per cent increase in fertiliser price from the base level on the endogenous variables in the system. The results reveal that this change in the price of fertilisers will have no impact on endogenous variables of the spinning and weaving sectors. Change in the price of fertilisers will influence endogenous variables of the cotton farming sector. The production of cotton will decrease by 0.70 per cent from the base level with 10 per cent increase in fertiliser price during 2000-01.

IX

CONCLUSIONS AND POLICY IMPLICATIONS

The model explains interlinkages among major variables of cotton farming, spinning and weaving sectors through 18 equations. The estimated model performs satisfactorily in terms of goodness of fit, signs and significance of the coefficients, specifications and short- and long-term predictability. The system is of oscillating convergence nature. The results show that lagged price of cotton, trend variable representing the improvement in technology, price of fertilisers and percentage area under hybrid cotton are important variables which influence the production. High significance of the trend variable and percentage area under hybrid cotton in determining the production clearly indicates that technological improvement can help in enhancing the production significantly. Therefore, more efforts should be directed towards developing technologies and high-yielding varieties and hybrid of cotton and their adoption for higher productivity. Price also plays an important role in increasing the production. Therefore, cotton price should also be remunerative to cotton growers. In the spinning sector, export of cotton yarn, previous year's production and price of cotton and cotton yarn are important variables which influence the production of cotton yarn. Exports significantly influence production of cotton yarn. But, high spiral tendency in cotton price has adverse impact on cotton yarn production. Therefore, while maintaining remunerative cotton prices, the tendency in cotton prices to increase should be arrested through increasing the production of cotton. In the weaving sector, in both mill and decentralised units, export variable is important in determining the production of cotton fabrics. Production of fabrics in decentralised units is influenced by price of its raw material, cotton yarn. Production of mill cotton fabrics is influenced by fabric price. Prices of cotton and yarn are also influenced by the prices of their output. Hence, uniform changes in the prices of cotton, yarn and fabrics are important for high growth of the industry. Liberalisation process seems to have significant bearing on exports. Liberalisation has also contributed significantly to the growth of decentralised units. Popularisation of synthetic fibres, structural and managerial changes in the textile industry, new industrial policy, new emerging economic environment and government's priorities and targets have been influencing the demand for and the supply of yarn and fabrics. Demand for cotton fabrics has also been changing with time due to varying preferences for clothes, incomes of consumers and thrust of the government on export promotion. The effect of changes in these and other variables seems to keep the fabric prices more or less stagnant. Therefore, to achieve the higher growth of industry, it is important to curtail significant changes in yarn prices through increase in its production.

The base-line forecast and simulation results indicate that growth rates of most endogenous variables except export of cotton yarn and to some extent export of decentralised fabrics are not satisfactory. Further, expected high spiral tendency in the real price of yarn causes worry as they impede the overall growth of the industry. Therefore, if high growth of cotton yarn export has to be maintained, growth in production of cotton yarn should be enhanced further. Export of cotton as such does not have significant adverse effect on value added products such as cotton yarn and fabrics. Continuously declining trend in the production of mill fabrics is another matter for concern. The growth of the weaving sector as a whole is expected to be low. This is because of the squeeze caused by increasing raw material prices and more or less stagnant output prices. Therefore, improvement in the efficiency of weaving units through better technology, more efficient management and higher price realisation through quality improvement and value addition are essential for high growth in this sector.

The results indicate that for high and balanced growth of all sectors of this industry, price changes should be uniform for raw materials and outputs. Export of cotton yarn and fabrics can play an instrumental role in enhancing growth of the industry if the production of cotton and yarn keep pace with them. Therefore, policies should be directed towards increasing cotton production and strengthening the weaving sector rather than concentrating on restricting exports of cotton and yarn.

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APPENDIX I

ENDOGENOUS AND EXOGENOUS VARIABLES AND THEIR UNITS USED IN THE MODEL

Endogenous variables		Exogenous variables	
Variables (1)	Unit (2)	Variables (3)	Unit (4)
DCC	Lakh bales	DSC	Lakh bales
SC	Lakh bales	EC	Lakh bales
P_dC	Lakh bales	IC	Lakh bales
DPC	Wholesale price index	DSCY	Thousand tonnes
DCCY	Thousand tonnes	PHVA	Per cent
ECY	Thousand tonnes	DPF	Wholesale price index
SCY	Thousand tonnes	DPF	Wholesale price index
P_dCY	Thousand tonnes	DEPCY	Dollar/kg.
DPCY	Wholesale price index	GY	Crore Rs./annum
DCMCF	Million square metres	DNTMC	Wholesale price index
ECF	Million square metres	LNWY	US dollar
P_dMCF	Million square metres	LNDEPPCF	US dollar per sq. metre
DPMCF	Wholesale price index	DEPMCF	US dollar per sq. metre
DCDSCF	Million square metres	Time TREND	
EDSCF	Million square metres	Dummy variable (DV)	
P_dDSCF	Million square metres	Dummy variable (DV_1)	
DPDSCF	Wholesale price index		
ECF	Million square metres		

APPENDIX 2

PERCENTAGE ROOT MEAN SQUARE ERROR VALUES OF STATIC AND DYNAMIC SIMULATIONS

Endogenous variables	Types of simulations			
	Static simulation	Dynamic simulations		
		23 years[a]	5 years[a]	5 years[b]
(1)	(2)	(3)	(4)	(5)
DCC	7.07	7.69	9.06	9.14
SC	5.30	5.95	5.92	6.44
P_dC	6.92	7.88	7.19	7.79
DPC	18.35	16.43	16.27	12.66
DCCY	7.09	6.53	4.37	3.99
ECY	116.79	116.79	14.99	19.05
SCY	6.57	6.72	4.09	5.49
P_dCY	6.75	6.90	4.30	4.73
DPCY	10.79	11.67	9.49	11.71
DMCF	9.12	11.24	14.13	14.72
EMCF	17.61	17.61	4.98	7.71
P_dMCF	9.12	11.24	14.13	14.72
DPMCF	4.57	5.06	5.09	4.61
DCDSF	0.89	0.91	1.04	1.05
EDSCF	50.57	50.57	16.23	16.73
P_dDSCF	7.09	6.91	6.06	4.75
DPDSCF	5.92	8.28	4.63	4.24
ECF	20.55	20.55	10.54	11.62

Notes: a. Dynamic simulation with actual values of exogenous variables.
b. Dynamic simulation with forecasted values of exogenous variables.

APPENDIX 3

THEIL'S INEQUALITY COEFFICIENTS (U_2) OF STATIC AND DYNAMIC SIMULATIONS

Endogenous variables	Types of simulations			
	Static simulation	Dynamic simulations		
		23 years[a]	5 years[a]	5 years[b]
(1)	(2)	(3)	(4)	(5)
DCC	0.75	0.86	0.77	0.46
SC	0.14	0.17	0.11	0.10
P_dC	0.13	0.16	0.10	0.09
DPC	0.45	0.33	0.34	0.23
DCCY	0.54	0.45	0.37	0.31
ECY	0.23	0.23	0.16	0.29
SCY	0.41	0.42	0.33	0.57
P_dCY	0.45	0.45	0.34	0.41
DPCY	0.36	0.37	0.26	0.34
DMCF	0.31	0.43	0.56	0.60
EMCF	0.19	0.19	0.17	0.384
P_dMCF	0.31	0.43	0.56	0.60
DPMCF	0.40	0.49	0.85	0.70
DCDSF	0.006	0.009	0.005	0.007
EDSCF	0.57	0.57	0.39	0.41
P_dDSCF	0.29	0.31	0.22	0.15
DPDSCF	0.36	0.65	0.44	0.37
ECF	0.31	0.31	0.34	0.40

Notes: a. Dynamic simulation with actual values of exogenous variables.
b. Dynamic simulation with forecasted values of exogenous variables.

APPENDIX 4

COMPONENTS OF MEAN SQUARE ERROR FOR STATIC AND DYNAMIC SIMULATIONS AS PROPORTION OF TOTAL

Endogenous variables	Static simulation			Dynamic simulation		
	Ubias	Uvar	Ucov	Ubias	Uvar	Ucov
(1)	(2)	(3)	(4)	(5)	(6)	(7)
DCC	0.00	0.07	0.93	0.01	0.06	0.93
SC	0.00	0.00	1.00	0.00	0.01	0.99
P_dC	0.00	0.03	0.97	0.00	0.04	0.96
DPC	0.00	0.11	0.89	0.00	0.28	0.72
DCCY	0.00	0.01	0.99	0.00	0.13	0.87
ECY	0.00	0.16	0.84	0.00	0.16	0.84
SCY	0.01	0.03	0.96	0.00	0.00	1.00
P_dCY	0.01	0.03	0.96	0.00	0.00	1.00
DPCY	0.02	0.25	0.73	0.01	0.40	0.59
DMCF	0.03	0.04	0.93	0.28	0.08	0.64
EMCF	0.01	0.25	0.74	0.01	0.25	0.74
P_dMCF	0.03	0.04	0.93	0.28	0.08	0.64
DPMCF	0.03	0.00	0.97	0.03	0.03	0.94
DCDSF	0.00	0.06	0.94	0.00	0.03	0.97
EDSCF	0.00	0.08	0.92	0.00	0.08	0.92
P_dDSCF	0.00	0.01	0.99	0.02	0.04	0.94
DPDSCF	0.00	0.01	0.99	0.01	0.14	0.85
ECF	0.00	0.11	0.89	0.00	0.11	0.89

APPENDIX 5

EX-POST FORECAST PERFORMANCE OF THE MODEL FOR THE YEAR 1995-96

Endogenous Variables	Values of endogenous variables		Deviation from actual values in per cent
	Actual	Simulated values	
(1)	(2)	(3)	(4)
DCC	152.5	147.8	3.1
SC	196.0	184.1	6.1
P_dC	161.5	151.5	6.2
DPC	97.8	81.9	16.3
DCCY	1464.6	1448.9	1.1
ECY	262.6	293.2	-11.7
SCY	1914.5	1888.4	1.4
P_dCY	1788.0	1758.3	1.7
DPCY	123.2	123.1	0.1
DMCF	1159.0	1395.3	-20.4
EMCF	466.8	469.6	-0.6
P_dMCF	1159.0	1395.3	-20.4
DPMCF	78.5	68.1	13.2
DCDSCF	16683.0	15476.5	7.2
EDSCF	1058.4	1303.4	-23.1
P_dDSCF	17741.0	16780.0	5.4
DPDSCF	79.9	69.8	12.6

Note: Simulated values for 1995-96 have been obtained through base-line dynamic simulation.

NOTES

1. Multicollinearity problem has been examined through conditioning index which is the square root of the ratio of the largest eigen value of X′X, where X is the regressor matrix, to the smallest eigen value of X′X, where X has been properly scaled (see Belsley *et al.*, 1980).

2. Disaggregate analysis shows that pesticide is a significant variable in some regions (Jain and Naik, 1998) and for some staples (Naik and Jain, 1997).

3. Static simulation generates one year ahead predictions of the endogenous variables for a given set of conditions, i.e., the values of the pre-determined variables. In static simulation, the values of the exogenous variables and lagged endogenous variables are set at their actual values for each period. Dynamic simulation involves generating solutions for a system for more than one period. The values of exogenous variables and the initial period lagged endogenous variables are set at their actual values.

4. Growth rates were calculated using 1994-95 actual values.

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