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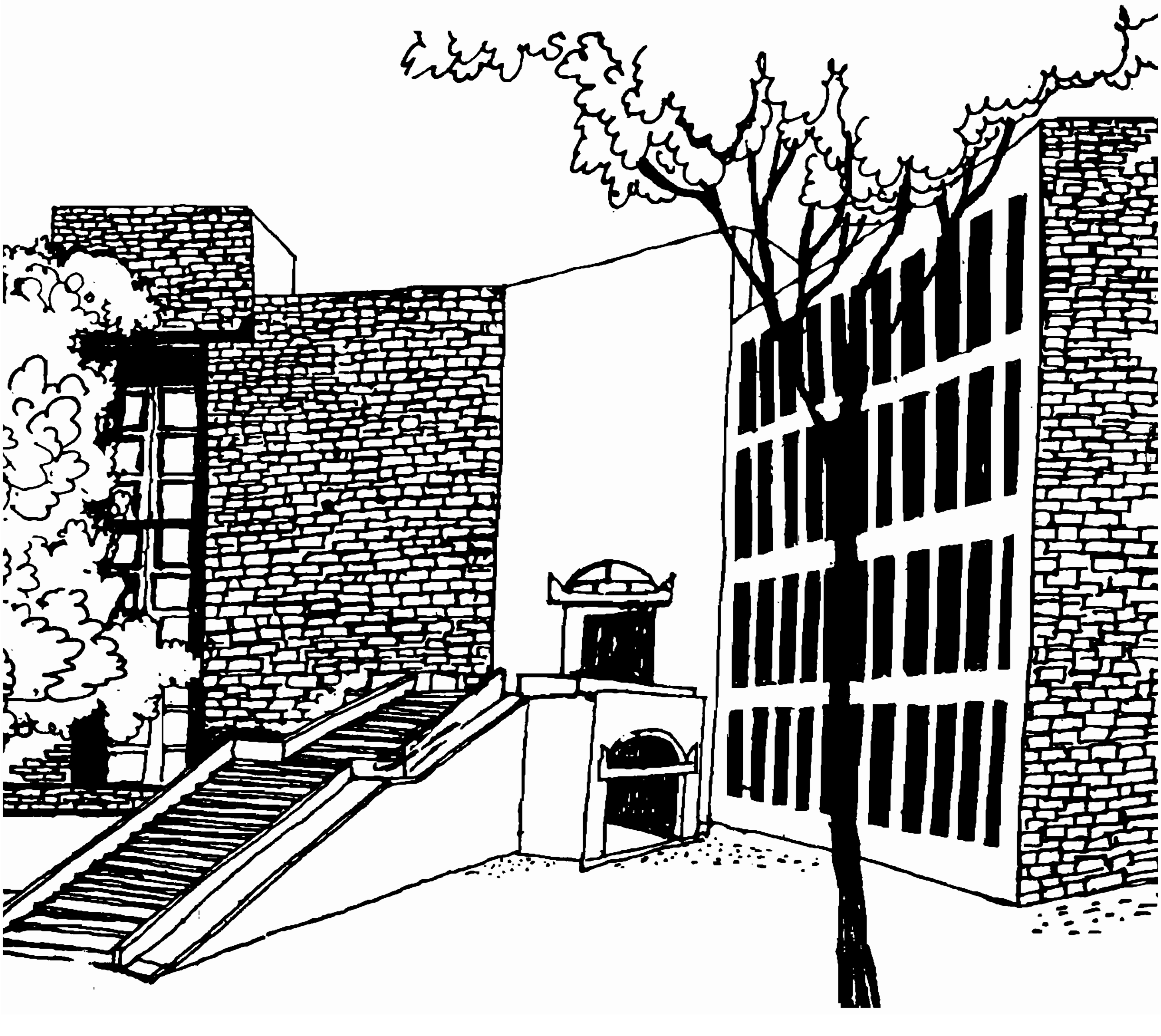

ECONOMETRIC SIMULATION OF THE INDIAN SILK INDUSTRY

BY

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Abstract

This study aims at understanding and quantifying the relationship between the important variables of the various sub-sectors of the Indian silk industry through an econometric simulation model, and using the model for forecasting as well as policy simulations. Forecasts of the endogenous variables of the system (demand, supply and prices of mulberry cocoons, raw silk and silk fabric) was made for the period 1991-92 to 2000-01 which indicated that the growth in the industry will slow down in future. Policy simulations were undertaken to assess the changes in the import price of raw silk, export price of fabrics and regulation of the quantity of imports of raw silk on the silk industry. While imports and exports were closely linked, their impact on the silk industry was not very high. It was also revealed that the income of the consumers and mulberry acreage have significant influence on the industry.

Introduction

The sericulture sector in India has been identified by the central government as one of the thrust areas for investment. Owing to the labour-intensive nature of silk industry and the ability to use low skilled personnel, the sector provides employment to more than 5 million people in the country. This sector is considered an efficient redistributor of income as the employment it generates is gainful and is available throughout the year to the poorer sections of the society and, the products, considered as luxury items, are mostly purchased by high income consumers. A well developed domestic market for silk and silk products provides a strong base for expansion of the industry. Increasing popularity of natural fibres among the environmentally conscious clientele and the availability of reasonably priced readymade silk goods within the reach of younger generation in the western countries have created considerable export potential for Indian silk goods.

To facilitate faster growth and proper alignment in the different sub-sectors of the industry, the central and state governments are involved in directing investments and other activities such as research and development, extension, silkworm egg production, regulation of cocoon and silk markets, market support operations, import restriction and export promotion. Such intensive involvement of the government requires knowledge on the relationship between variables within as well as across the sub-sectors so that the investments made and other intervention measures taken in different sub-sectors are in alignment with the long run profitability of the industry.

Several past studies on Indian agriculture have used econometric models for understanding and projecting demand for and supply of commodities. Some of these are only demand projection related studies (Biswas, 1959; Maddala, 1960; Datta-Majumdar, 1963; Patel and Vyas, 1972; Mehta and Sandhu, 1973; Sikka, 1986). Some studies have developed models for analysing demand and supply together for agricultural commodities in India (Maji, Jha and Venkataraman, 1971 and Sidhu, 1974). Hitchings (1984) used a simultaneous equation system framework to examine the cotton sector in India and for projecting supply of and demand for cotton for the period 1980-90. Tiwari and Rao (1994) have developed an econometric model of the international castor oil market and simulated the impacts of various policy changes on the castor economy of India.

So far no attempt has been made to develop an econometric model for simulation of the behaviour of the Indian silk industry. This study aims at developing a comprehensive econometric model for the Indian silk sector to generate long run forecasts and policy simulations.

Nature of Indian Silk Industry

The Indian silk industry consists of five major sub-sectors : mulberry cultivation, silkworm egg production, silkworm rearing, reeling and weaving, and other subsidiary sectors such as twisting, dyeing and printing. While all the four types of silk : **mulberry, tasar, eri** and **muga** are produced in India, only the mulberry silkworms are domesticated and contribute as much as 90 per cent to the Indian silk production. This study considers only mulberry silk for the purpose of modelling.

Raw Silk Supply

Production of mulberry raw silk is mainly confined to the states of Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal and Jammu and Kashmir, and together account for around 98 per cent of the production. Efforts are on to introduce mulberry cultivation in non-traditional belts of Karnataka, Maharashtra, Kerala, Gujarat, Uttar Pradesh, Rajasthan, Bihar, and Orissa.

India currently produces around 13,000 tonnes of raw silk with an annual growth rate of around 10 per cent. However, only about 10 to 12 per cent of the domestic production is comparable to the silk available in the international market in terms of quality (Naik and Babu, 1993). Since the demand for better quality silk is much higher than domestic supply, India imports large quantities of raw silk. The volume of imports in the past years have been as much as 15 to 20 per cent of the total raw silk supply in the country. Imports may increase as the economy is liberalized and raw silk prices in the international market decline.

Production Process

The production process in mulberry silk starts with the planting of mulberry cuttings, and the first harvest of the leaves for feeding silkworms is done six to eight months after planting. Silkworm rearing begins with brushing of eggs (which are also called seeds). Disease-free layings (dfls) from selective and hygienically bred silkworms are produced in government grainages or by licensed seed producers (LSPs). Farmers either buy eggs or *chawki*-reared worms depending on the convenience. Silkworms are fed for 25-30 days till they attain full growth. They are then transferred to mountages called *chandrike* to facilitate them to spin cocoons. The cocoons are harvested on the fifth day, when the pupae inside the cocoons are fully formed and become hard. At this stage the cocoons are ready for reeling.

The process of reeling starts with boiling cocoons to soften the sericin which holds the filaments together. In India three main types of reeling devices are used : *charka*, cottage/filature basin and multi-end basin. *Charka* is a crude reeling device which produces coarse raw silk. Cottage basin is an improved machine compared to *charka* but is still manually operated. Power-driven cottage basins are called filature units. Multi-ends are more sophisticated machines capable of producing good quality raw silk. The contribution of *charka*, cottage basin and filature and multi-end are approximately 50, 40 and 10 per cent of the total raw silk production respectively.

The silk obtained is first thrown or twisted with other strands of raw silk to form the silk yarn. A series of soaking, drying and winding processes are performed for this purpose. The silk yarn is woven into fabrics in either powerlooms or handlooms, and the approximate share of these two type of looms in the total silk is 35 and 65 per cent respectively. Dyeing is done either in the yarn stage itself or after weaving. The silk finishing sector produces varieties of goods such as saris, readymade garments and accessories, and furnishing fabrics.

Markets in Silk Industry

Marketing in the silk industry takes place mainly at four stages : silkworm egg, cocoon, raw silk and fabrics. The state sericulture departments and the Central Silk Board play a major role in the production and supply of silkworm eggs. In many places *chawki*-reared worms are supplied directly to farmers by the government. In Karnataka, there are private licensed seed producers and voluntary agencies producing silkworm eggs in addition to the government grainages.

The marketing of mulberry cocoons is regulated in all the major cocoon-producing states except West Bengal. The cocoons are sold in these regulated markets through open auctions. These markets have been working well and have been able to provide competitive prices to the farmers. However, since no scientific grading is undertaken in these markets, some doubts have been raised in recent years about the markets' ability to provide an incentive price for the improved quality cocoon.

After the establishment of silk exchanges in 1979, by the Karnataka government, silk produced in Karnataka is largely marketed through them. The reelers as sellers, and the merchants or the weavers as buyers have to register in these exchanges. Prices are determined through open auction. As far as the ability to assess quality is concerned, it is reported that the price linkage with the quality has been poor, resulting in higher risk to the reelers (Naik and Asopa, 1993). The cocoon markets and silk exchanges are reported to be well integrated indicating that information flow between these markets is efficient. However, expectations of traders in the silk exchange can unduly influence prices in both markets (Thomas, 1993).

Raw silk is imported from China (either directly or through Hongkong), Republic of Korea and Brazil. Powerloom weavers prefer imported silk as they consider the uniformity in size of these silk to be better, winding breaks fewer, and lower degumming losses compared to domestic silk (Naik and Babu, 1993). The need for higher quality silk is greater for export as the exporters have to satisfy stringent international quality requirements.

India has a large domestic market for finished silk products and only a small proportion of the production is exported (10-15 per cent). The markets for finished products are spread throughout the country. A study conducted by the Market Research Wing of the Textile Committee during 1982-83 reported that the sari market was growing annually at a rate of 20 to 25 per cent in terms of quantity and 11 to 15 per cent in terms of value suggesting a shift in the composition of this market to lower priced modern saris.

A wide range of products ranging from traditional saris, dress fabrics, ready-made garments to furnishings in a varied combination of blended weaves including cotton, tasar and waste silk yarns find their way to the export market. The major items of mulberry silk goods (accounting for 90 per cent of the total silk export) exports are saris, scarves/stoles, dress materials, and readymade garments. Readymade garments, dress materials, and furnishings are becoming increasingly important in the international market and India is a major suppliers of these items.

As silk goods are highly income elastic, the demand for these goods in international market for both traditional high valued fashion segment and non-traditional middle income segments has been growing. Efforts have been made by the producing countries to introduce new silk products, and other forms of silk products such as blended fabrics, T-shirts, shorts *etc*. The changes in the international silk products market and the liberalization process in progress in the domestic economy offer additional opportunities for Indian exporters.

Framework of the Indian Silk Model

This study has considered four major sub-sectors for the modelling purpose : mulberry, cocoon, raw silk, and the silk fabrics sector[1]. Based on the relationships between the various variables influencing demand and supply in each sub-sector, linear structural equations were specified to represent demand and supply conditions. Market clearing conditions were added to the last three sectors as the price in these sectors are determined by market forces[2].

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1 The silkworm egg sector consists of government grainages and licensed seed producers. The prices of eggs are determined by the government and they do not necessarily represent market equilibrium levels.

2 More details in Naik *et al* (1995).

MULBERRY SECTOR

Mulberry is a perennial crop, therefore, mulberry acreage is dependent on previous years acreage and the profitability of mulberry as compared to the competing crops. Since price is the major variable affecting profitability, the acreage is dependent on the prices of cocoons (PC) and competing crops (PCC) at time t-1. Irrigated and rainfed mulberry acreage have different responses to prices of cocoon and competing crops, and hence, are specified separately.

Therefore, irrigated mulberry acreage (MAI) function is,

$$MAI_t = f(MAI_{t-1} , PC_{t-1} , PCCI_{t-1}) \quad (1)$$

and rainfed mulberry acreage (MAR) function is,

$$MAR_t = f(MAR_{t-1} , PC_{t-1} , PCCR_{t-1}) \quad (2)$$

COCOON SECTOR

The demand for cocoons can be specified as a factor demand function as it is a derived demand. Hence, demand for cocoon (DC) at time t is dependent on price of cocoon at time t and price of raw silk[3] (PS) and demand for cocoon at time t-1.

$$DC_t = f(DC_{t-1} , PC_t , PS_{t-1}) \quad (3)$$

Assuming assured supply of silkworm eggs from government grainages and LSPs, cocoon production would depend on the mulberry leaves availability. Since mulberry is a perennial crop, mulberry leaves availability in the current year would depend on the mulberry acreage in the previous year. Therefore, supply of cocoon (SC) in the current year is influenced by the previous years mulberry acreage and time trend. Trend variable was introduced to account for the changes in cocoon production per hectare.

$$SC_t = f(MAI_{t-1} , MAR_{t-1} , TREND) \quad (4)$$

The market for cocoon is competitive, and therefore, equilibrium condition specifies, that

$$DC_t = SC_t. \quad (5)$$

RAW SILK SECTOR

As supply of raw silk is less elastic in the short run, a price dependent demand function for raw silk was specified in the model. That is, silk price is dependent on demand for raw silk (DRS), price of cocoon, price of fabrics (PF) and import price of silk (IMP).

$$PS_t = f(DRS_t , PC_t , PF_t , IMP_t) \quad (6)$$

Total supply of raw silk mainly comes from domestic production and imports. Domestic silk production (DSP) is influenced by demand for cocoons and price of silk at time t.

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3 Previous year price of silk was incorporated in the model as the coefficient on current year price was not consistent with the theory.

$$DSP_t = f(DC_t , PS_t) \tag{7}$$

Since import of raw silk was restricted by the government and is only allowed to silk good exporters to meet their raw material needs, the raw silk imports is dependent on amount of silk fabrics exported (EDF) in the previous year, and the difference in the domestic silk price and import price of raw silk (DFPIMP) at time t.

$$IM_t = f(DFPIMP_t , EDF_{t-1}) \tag{8}$$

The market for raw silk is in equilibrium when the demand for raw silk equals the supply.

$$DRS_t = DSP_t + IM_t \tag{9}$$

SILK FABRICS SECTOR

Total demand for silk fabrics consists of domestic demand and export demand. In this sector also, an inverse consumer demand function was introduced. The price of silk fabrics (PF) is dependent on domestic demand for fabrics (DDF), per capita income (Y) at time t and price of fabrics at time t-1.

$$PF_t = f(DDF_t , Y_t , PF_{t-1}) \tag{10}$$

The export demand for fabrics (EDF) is determined by world per capita income (WY) and export price of fabrics adjusted for exchange rate (EPFA) at time t.

$$EDF_t = f(WY_t , EPFA_t) \tag{11}$$

Supply of fabrics at time t is determined by demand for raw silk at time t and a time trend.

$$SF_t = f(DRS_t , TREND) \tag{12}$$

The fabrics sector is in equilibrium when,

$$SF_t = DDF_t + EDF_t \tag{13}$$

In the mulberry sector, mulberry leaves producers (farmers) are also the cocoon producers as a result there is no explicit market for mulberry leaves. Therefore, the mulberry sector equations were kept outside the system, and mulberry acreages were introduced as exogenous variables in the supply of cocoon equation. Therefore, equations 3 to 13 were estimated using system estimator, and equations 1 and 2 were estimated separately using OLS. The identification of the system was done using rank and order conditions to examine the estimability of the model and all the eight equations of the model were found to be overidentified.

Data Base and Data Adjustment

Annual data of the various variables collected from various sources for the period 1971-72 through 1991-92 were used in this study. As raw silk price was not available at the aggregate level, filature silk price (PFIL) was taken to represent the price of silk. Data on world per capita income pertained to the OECD countries only as they are the major consumers of silk products. The export price of Indian silk fabrics (EPF) was obtained by dividing the total value of exports by total quantity exported.

In order to isolate the true relationships, monetary variables were transformed into real variables by using appropriate deflators. All price and wage variables were deflated by the wholesale consumer price index (CPI) except the export price of fabrics (EPF) which was adjusted by the exchange rate of rupee versus U.S. dollar (ER1). Prefix D is added to the new series of the deflated variables.

Estimation of the Model

The results of the 3SLS estimation of the model are presented below.

COCOON SECTOR

$$DC_t = \underset{(1.44)}{10809} + \underset{(16.89)}{1.085}*DC_{t-1} - \underset{(-2.04)}{1054.5}*DPC_t + \underset{(0.26)}{11.164}*DPFIL_{t-1} \quad (3)$$

$R^2 = 0.97$

$$SC_t = -\underset{(-0.87)}{6927.4} + \underset{(5.69)}{0.345}*MAI_{t-1} + \underset{(2.41)}{0.228}*MAR_{t-1} + \underset{(1.10)}{708.65}*TREND \quad (4)$$

$R^2 = 0.97$

RAW SILK SECTOR

$$DPFIL_t = \underset{(2.91)}{37.766} - \underset{(-2.01)}{0.002}*DRS_t + \underset{(2.90)}{4.532}*DPC_t + \underset{(1.58)}{3.094}*DPF_t + \underset{(6.37)}{0.468}*DIMP_t \quad (6)$$

$R^2 = 0.85$

$$DSP_t = -\underset{(-6.83)}{2711.7} + \underset{(44.35)}{0.118}*DC_t + \underset{(1.71)}{3.852}*DPFIL_t \quad (7)$$

$R^2 = 0.99$

$$IM_t = -\underset{(-4.14)}{777.02} + \underset{(7.64)}{5.35}*EDF_{t-1} + \underset{(5.87)}{11.95}*DDFPIMP_t \quad (8)$$

$R^2 = 0.78$

FABRICS SECTOR

$$DPF_t = -\underset{(-2.02)}{19.641} - \underset{(-1.36)}{0.006}*DDF_t + \underset{(4.13)}{0.989}*DPF_{t-1} + \underset{(2.14)}{0.015}*Y_t \quad (10)$$

$R^2 = 0.77$

$$EDF_t = -\underset{(-20.8)}{851.49} - \underset{(-5.50)}{18.79}*EPFA_t + \underset{(21.3)}{0.076}*WY_t \quad (11)$$

$R^2 = 0.97$

$$SF_t = -107.38 + 0.150{*}DRS_t - 11.679{*}TREND \quad (12)$$

(-6.03) (24.65) (-3.05)

$R^2 = 0.99$

(Figures in parentheses are asymptotic t-values)

IDENTITIES

$$DC_t = SC_t \quad (5)$$

$$DRS_t = DSP_t + IM_t \quad (9)$$

$$SFt = DDF_t + EDF_t \quad (13)$$

DEFINITIONS OF VARIABLES USED :

Endogenous Variables

DC	Demand for cocoons	(tonnes)
SC	Supply of cocoons	(tonnes)
DRS	Demand for raw silk	(tonnes)
DSP	Domestic raw silk production	(tonnes)
IM	Quantity of imports of raw silk	(tonnes)
DDF	Domestic demand for silk fabrics	(lakh sq mtrs)
EDF	Export demand for silk fabrics	(lakh sq mtrs)
SF	Supply of silk fabrics	(lakh sq mtrs)
DPC	Deflated average price of cocoons	(Rs/kg)
DPFIL	Deflated price of silk (Filature)	(Rs/kg)
DPF	Deflated price of silk fabrics	(Rs/sq mtr)

Exogenous Variables

EPFA[4]	Export price of fabrics (U.S.Dollars/sq mtr)
WY	Per capita income of OECD countries (U.S.Dollars)
Y	Deflated per capita income in India (Rupees)
DIMP	Deflated import price of raw silk (Rs/kg)
DDFPIMP	Deflated domestic and imported silk price difference (Rs/kg)
MAI	Mulberry area under irrigated condition (hectares)
MAR	Mulberry area under rainfed condition (hectares)
TREND	Time trend variable

The estimated equations of the model have reasonably good fits as evident from their R^2 values. The extent of variation of the dependent variables explained varies from 77 to 99 per cent, and the regression coefficients of the explanatory variables have expected signs.

The lagged demand has the major influence on the current demand for cocoon which highlights the asset fixity nature of the reeling units. The price of cocoon also has a significant influence on its demand. Mulberry acreage, both irrigated and rainfed, have significant influence on supply of

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4 Deflation of EPFA and WY was not done as the inflation rates in USA are very low.

cocoons. As expected the coefficient of irrigated mulberry acreage is larger than the coefficient of rainfed mulberry acreage. An additional hectare of mulberry under irrigated conditions can increase the production of cocoons by about 0.35 tonne whereas an additional hectare of rainfed mulberry produces 0.23 tonne of cocoon.

The estimated inverse demand function for raw silk reveals the significant influence of the demand for raw silk, price of cocoon, and import price of raw silk on the price of raw silk. The result indicates that the filature silk price is responsive to the raw silk price in the international market. The coefficient of demand for cocoon is highly significant in the domestic silk production equation. The value of the coefficient indicates that the average renditta has been around 11.8. The raw silk import equation has a reasonably good fit and both the explanatory variables have a significant influence at 5 per cent level.

The price of silk fabrics in the current period is primarily influenced by the price in the previous year and the per capita income. The export price of fabrics and world per capita income are significantly influencing export demand for fabrics. The supply of fabrics is influenced by demand for raw silk and the trend variables. The coefficient of the demand for raw silk (0.15) suggests that, for every kilogram of raw silk, 15 square meters of fabrics are produced which is consistent with the ratio in practice. However, the negative and significant influence of the trend variable indicates the probable shift of the product mix towards heavier silk goods over the years.

Validation of the Model

The purpose of model validation is to assess the ability of the model to represent the real world accurately. For the present model, appropriateness of the theoretical specifications and the statistical tests of the estimated equations/parameters along with the performance of the model in tracking the historical period of fit have determined its validity. For validating the model as a dynamic system, evaluation of the stability of the model, its ability to simulate historical data, and its response to shocks in the system were examined.

Each one of the equation in the model has been developed based on economic theory and contextual familiarity of the industry. Therefore, the model specifications appears to be logically sound and are supported by statistically significant coefficient estimates that have signs and magnitudes consistent with theoretical specifications.

The 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. None of the latent roots of the matrix were found to have a value more than one which indicates that the system is stable. Since the dominant root of the matrix was negative (-0.982), the system will show oscillating convergence.

Predictive Performance of The Model

Tracking the model through historical period of fit can be done in different ways. For validation of the performance of the model, both static and dynamic simulation were conducted[5]. Static simulation, which gives the short term predictability of the model, was done for the period 1972 to 1991. Dynamic simulation using the actual values of exogenous variables and initial year lagged endogenous

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5 Static simulation generates one year ahead predictions of the endogenous variables for a given set of conditions, i.e., the values of predetermined variables. Dynamic simulation involves generating solutions for a system for a period of time *ie*, a single multi-period simulation. Dynamic and static simulation can also be done using forecasted values of exogenous variables rather than the actual values.

variables was carried out for two periods : a twenty year period (1972-1991) and a ten year period (1982- 1991). Dynamic simulation using forecasted values of exogenous variables was also done for a ten year period (1982-1991). Evaluation of the results of the dynamic simulation will reveal the long term predictability of the model.

Comparison of the model generated historical predictions with the actual values of the endogenous variables were made using the following criteria:

(a) Percentage root mean square error (PRMSE)
(b) Theils inequality coefficients (U_2)

PRMSE

The PRMSE values for all endogenous variables for different simulations are given in Table 1. They indicate that the model gives a reasonably good forecast of the endogenous variables of the system for the historical period. The values of price variables were , however, comparatively higher than quantity variables. However, further improvement could not be made in the performance of the model with alternative specifications. Among the quantity variables, PRMSE values for import of raw silk and export of fabrics were comparatively higher. This was because the levels of imports of raw silk and exports of fabrics were very low in the initial years of historical period.

Table 1 : PRMSE Values of Static and Dynamic Simulations

Endogenous Variable	Type of Simulation			
	Static Simulation	Dynamic Simulation		
		20 Yrs[(a)]	10 Yrs[(a)]	10 Yrs[(b)]
DC/SC	7.12	7.12	5.39	6.08
DRS	8.76	9.02	5.87	5.46
IM*	28.85	28.13	27.93	36.83
DSP	7.43	7.85	7.08	8.26
DDF	10.94	11.27	11.02	7.97
EDF	16.28	16.28	10.20	22.47
SF	8.16	8.37	8.31	6.86
DPC	27.41	18.39	28.24	30.29
DPFIL	14.83	8.70	12.57	14.33
DPF	10.56	14.38	18.30	26.54

Notes:
* PRMSE value is for the last 10 years as the initial year figures were not very reliable
(a) dynamic simulation with actual values of exogenous variables
(b) dynamic simulation with forecasted values of exogenous variables

PRMSE values of static and dynamic simulations for the complete historical period were quite similar except for the price variables. PRMSE values for DPC and DPFIL were lower for dynamic simulations, whereas for DPF PRMSE values for dynamic simulations were higher as compared to static simulations. This indicates that, given the actual values of exogenous variables, the dynamic simulation was able to track the values of endogenous variable as accurately as the static simulation. The model's tracking ability of the actual values of endogenous variables for the last 10 years seems to be better as evident from the lower values of the PRMSE values.

Comparison of PRMSE values of 10 years dynamic simulation with actual and forecasted values of exogenous variables reveals that the performance of IM, EDF, and price variables was more sensitive to the forecasted values of exogenous variables. Therefore, emphasis should be given to obtain more accurate forecasts of the exogenous variables if the objective is to obtain more accurate forecasts of these endogenous variables.

THEIL'S COEFFICIENT

The U_2 statistics for the endogenous variables in the model for different types of historical simulations are given in Table 2. The values indicate that the model performed reasonably well and are consistent with the findings of the PRMSE statistics. The U_2 coefficients for raw silk import, prices of cocoon and silk fabrics, and domestic demand for fabrics were marginally greater than one indicating that the forecasts of these vahiables are not very accurate. The U_2 coefficients further reveal that dynamic simulation performance was comparable to that of static simulation which indicates that the model can be used for long run forecasts.

Table 2 : Theil's Inequality Coefficients (U_2) of Static and Dynamic Simulations

Endogenous Variable	Type of Simulation			
	Static Simulation	Dynamic Simulation		
		20 Yrs[a]	10 Yrs[a]	10 Yrs[b]
DC/SC	0.76	0.76	0.78	0.89
DRS	0.74	0.80	0.81	0.73
IM	1.14	1.15	1.05	1.09
DSP	0.82	0.83	0.82	0.88
DDF	1.01	1.08	1.00	0.83
EDF	0.59	0.59	0.49	0.99
SF	0.88	0.95	0.92	0.82
DPCC	1.26	1.07	1.15	1.10
DPFIL	0.99	0.66	0.73	0.95
DPF	0.94	1.30	1.28	1.83

Note: (a) dynamic simulation with actual values of exogenous variables
(b) dynamic simulation with forecasted values of exogenous variables

Adequacy of Model Specifications

The mean square simulation error was decomposed into bias, variance, and covariance components to examine the adequacy of the model specifications. The value of bias and variance proportion closer to zero indicates the adequacy of the model's specifications[6].

Table 3 gives the decomposition of the mean square prediction error expressed as proportions for each of the endogenous variables for static and dynamic (20 years) simulations. The values of these components indicate reasonably good specification of the model. In both simulations the bias components were almost zero for all the endogenous variables, thereby indicating the absence of systematic error in the model. The variance components of the endogenous variables for static simulation were also close to zero. However, the variance components of the price variables in dynamic simulation were slightly high.

Table 3 : Components of Mean Squared Error for Static and Dynamic Simulations as Proportion of Total

Endogenous Variable	Static Simulation			Dynamic Simulation		
	Ubias	Uvar	Ucov	Ubias	Uvar	Ucov
DC/SC	0.00	0.01	0.99	0.00	0.01	0.99
DRS	0.00	0.02	0.98	0.00	0.02	0.98
IM	0.00	0.04	0.96	0.00	0.04	0.96
DSP	0.00	0.00	1.00	0.00	0.01	0.99
DDF	0.00	0.00	1.00	0.00	0.00	1.00
EDF	0.00	0.01	0.99	0.00	0.01	0.99
SF	0.00	0.01	0.99	0.00	0.01	0.99
DPC	0.00	0.09	0.91	0.03	0.14	0.82
DPFIL	0.00	0.03	0.97	0.02	0.11	0.86
DPF	0.00	0.02	0.98	0.00	0.29	0.71

Ex-post Forecast Performance

Given the satisfactory historical predictive performance of the model obtained so far, it would be of interest to evaluate the ex-post predictive performance of the model. Predictions of the endogenous variables were made for the year 1992-93 by updating the exogenous variables and lagged endogenous variables. Since accurate prediction of imports of raw silk was difficult, another set of predictions of the endogenous variables were made by replacing the import equation in the model by actual values of imports. However, no significant difference in the predicted values of the endogenous variables from the two set of simulations were found.

The two sets of predictions along with the actual values of endogenous variables are presented in Table 4. The simulated values reveal that the accuracy of the predictions of imports of raw silk and exports of silk fabrics was low. This was because the liberalization of the economy had begun in that

6 see Pindyck and Rubinfeld, 1991 for details.

particular year which had its impact on both exports and imports sectors of the silk industry. Relatively large errors for some of the other endogenous variables were also because of the liberalization process. This was evident from the predictions of Sim B where when actual values of imports of raw silk was used, the prediction errors were low for different endogenous variables except for export demand for fabrics and price of cocoon. Large errors in the prediction of cocoon prices could be from large fluctuations in the prices in the previous year as a result of speculation in the market (Thomas, 1993). The model is expected to perform better for subsequent years unless structural changes take place in the system.

Table 4 : Ex-post forecast performance of the model for the year 1992-93

Endogenous Variables	Values of Endogenous Variables			Deviation/Actual	
	Actual	Sim-A	Sim-B	Sim-A	Sim-B
DC/SC	129685.0	121068.4	121068.4	6.6	6.6
DRS	15827.0	14001.0	15057.3	11.5	4.9
IM	2827.0	1754.6	2827.0	37.9	0.0
DSP	13000.0	12246.4	12230.3	5.8	5.9
DDF	1960.4	1584.4	1742.3	19.2	11.1
EDF	264.8	371.8	371.8	-40.4	-40.4
SF	2225.2	1956.1	2114.1	12.1	5.0
DPC	13.5	8.1	8.1	40.0	40.0
DPFIL	165.3	161.6	157.4	2.2	4.8
DPF	26.4	30.7	29.7	-16.2	-12.5

Notes:
Sim-A : Static simulation using actual values of lagged endogenous and exogenous variable.
Sim-B : Static simulation using actual values of lagged endogenous and exogenous variables and imports of raw silk.

Multipliers

Multipliers are potentially useful tools for assessing the impact of a definite change in the exogenous variable on the values of endogenous variable in a dynamic system. A short-run multiplier (impact multiplier) gives the estimated effect of a change in any of the exogenous variables or lagged endogenous variables on the current period values of the endogenous variables. A long run multiplier gives the effect of one time change in the exogenous variable[7] or once for all change in the behaviour of the exogenous variable[8] on the final values (long run) of the endogenous variable in a converging system.

Table 5 gives the impact multipliers of the lagged endogenous variables for the estimated empirical model. An increase in the demand for cocoon by one tonne would lead to increase in silk production

7 A system with the exogenous variable at a fixed level.

8 A system with varying levels of exogenous variable.

by 0.02 tonnes and supply of fabrics by 0.003 lakh square meters in the following year. Although no apparent reason can be attributed to this relationship, increase in investments on improved reeling machinery, *etc.*, could lead to slightly more production in the next year.

Table 5 : Short Term Multiplier of the Lagged Endogenous Variable for the Endogenous Variables

Endogenous Variable	Lagged Endogenous Variable			
	DCt-1	EDFt-1	DPFILt-1	DPFt-1
DC/SC				
DRS	0.018	5.27	0.182	7.555
IM		5.35		
DSP	0.018	-0.08	0.182	7.555
DDF	0.003	0.788	0.027	1.13
EDF				
SF	0.003	0.788	0.027	1.13
DPC	0.001		0.011	
DPFIL	0.005	-0.02	0.047	1.961
DPF				0.982

An increase in the export demand for fabrics by one lakh square meters increases the imports of raw silk in the succeeding year by 5.35 tonnes and thereby leads to Re. 0.02/kg decline in the real price of raw silk. A unit increase in the real price of raw silk (filature) in the previous year increase domestic silk production by 0.18 tonnes and real prices of cocoons and raw silk by Re. 0.01 and Re. 0.05 per kilogram respectively. An increase in the real price of fabrics by Re. 1 raises the silk production by 7.55 tonnes, fabrics production by 1.13 lakh square meters and price of raw silk by Rs. 1.96/kg in the succeeding year.

The impact multipliers for the exogenous variables given in Table 6 indicate that a unit increase in the real price of imported raw silk would have an initial impact of increasing domestic silk production by 1.78 tonnes, supply of fabrics by 0.26 lakh square meters, and real raw silk price by Re. 0.46/kg. The long run multipliers (Table 7) indicate that the increase in the real price of imported raw silk in the long run would lead to increase in domestic silk production by 1.1 tonnes and price of raw silk by Re. 0.29/kg only. This was supported by low import price elasticities (both long run and short run) of domestic silk production, supply of fabrics and price of raw silk (Appendix 1). Since imported raw silk competes with a very specific segment, domestic high quality silk, its effect on the domestic raw silk sector is expected to be low.

An increase in the import price of raw silk results in a decrease in the difference between prices of domestic filature silk and imported raw silk (DDFPIMP). A unit decrease in DDFPIMP would lead to a decline in the imports of raw silk by 12.14 tonnes and increase in domestic silk production, real prices of raw silk, and silk fabrics by 0.18 tonnes, Re. 0.05/kg and Re. 0.01/square meter, respectively for the current year. This decrease would be beneficial to the domestic silk industry in the long run. In the long run, the domestic industry would make adjustment to a unit decrease in DDFPIMP in the form of reduced imports of raw silk (11.95 tonnes), increased domestic raw silk production (5.01

tonnes), and the price realization of cocoons (Re. 0.01/kg), raw silk (Rs 1.31/kg) and fabrics (Re. 0.60/square meter).

Table 6 : Short Term Multiplier of the Exogenous Variable for Endogenous Variable

Endogenous Variable	Exogenous Variable							
	TREND	DIMP	DDFPIMP	WY	DPCI	DEPF	MAIt-1	MARt-1
DC/SC	708.7						0.345	0.228
DRS	71.65	1.777	11.77	0.004	0.111	-0.89	0.035	0.023
IM			11.95					
DSP	71.65	1.777	-0.18	0.004	0.111	-0.89	0.035	0.023
DDF	-0.96	0.266	1.76	-0.08	0.017	18.66	0.005	0.003
EDF				0.076		-18.8		
SF	-0.96	0.266	1.76		0.017	-0.13	0.005	0.003
DPC	-0.67							
DPFIL	-3.18	0.461	-0.05		0.029	-0.23		
DPF	0.006		-0.01		0.014	-0.12		

Table 7 : Long Term Multiplier of the Exogenous Variable for the Endogenous Variable

Endogenous Variable	Exogenous Variable							
	TREND	DIMP	DDFPIMP	WY	DPCI	DEPF	MAIt-1	MARt-1
DC/SC	708.7						0.345	0.228
DRS	81.69	1.1	6.933	0.447	6.488	-110	0.024	0.016
IM			11.95	0.406		-101		
DSP	81.69	1.1	-5.02	0.04	6.488	-9.92	0.024	0.016
DDF	0.538	0.164	1.037		0.97	2.271	0.004	0.002
EDF				0.076		-18.8		
SF	0.538	0.164	1.037	0.067	0.97	-16.5	0.004	0.002
DPC	0.051	0.003	-0.01		0.018	-0.03		
DPFIL	-0.58	0.285	-1.3	0.01	1.684	-2.58		
DPF	-0.32	-0.1	-0.61	0.005	0.803	-1.33		

Increase in income, both world (OECD) and domestic, would lead to an increase in the demand for silk fabrics. The multipliers indicate that the impact of the increase in the per capita income (both world and domestic) would be larger in the long run as the industry takes time to adjust. This observation was also supported by the income elasticities (Appendix 1). World income elasticities for demand of fabrics was same for both short run and long run, and was also higher than domestic income elasticities. High income elasticities of demand of silk fabrics is expected as silk is a luxury good.

An increase in the real export price of fabrics by one dollar/square meters would result in a decline in exports by 18.8 lakh square meters in the current year. The supply of fabrics would decline by 0.13 units only as 18.66 units would be diverted to the domestic market. As a result, the raw silk and fabrics prices decline by Rc. 0.23/kg and Rc. 0.12/square meter, respectively. An increase in the export price of fabrics by a dollar would have adverse impact on the silk industry in the long run. The reduction in the export demand for fabrics (18.8 lakh square meters) cannot be diverted to the domestic market and the total demand for fabrics would go down by 16.5 lakh square meters in the long run. As a result, imports of raw silk and domestic silk production would reduce by 110 metric tonnes and 10 metric tonnes respectively. The prices in the domestic market would also decline in the long run. However, the export price elasticities of the different endogenous variables were low.

The multipliers also indicate that an additional hectare of irrigated and rainfed mulberry would increase cocoon production by 0.34 and 0.23 tonnes respectively. As expected, the short run acreage elasticity of cocoon price was high, whereas in the long run it was low. The signs and magnitude of the other impact multipliers were also consistent with the theoretical expectations and actual observations.

The multipliers reveal the strong interlinkages between the import of raw silk and export of fabrics sectors. However, the impact of changes in the income (both world and domestic) and mulberry acreage was more pronounced on the domestic silk industry as compared to the changes in import price of raw silk and export price of fabrics.

Simulation of the Model

Given the adequate performance of the model as a dynamic system, dynamic simulation were made for the period 1991-92 to 2000-01. Different policy scenarios were also simulated to assess their impact on the silk industry.

Baseline Simulation of the Model

The model was simulated to generate forecasts for the endogenous variables for the period 1991-92 to 2000-01. The actual values of the endogenous variables for the year 1990-91 were used as values of initial year lagged endogenous variables. Forecasts of the exogenous variables were made using best fit trend regression. However, import price of raw silk was set at the mean value of the period from 1989-90 to 1991-92 as the trend regressions for the variable had a poor fit. Mulberry acreages (rainfed and irrigated), exogenous variables in the supply of cocoon equation, were estimated by separate equations and are recursively linked to the system.

The base line simulation forecasts are presented in Table 8. Cocoon production will grow at the rate of 4.03 per cent per annum and will reach 166.5 thousand tonnes by the year 2000-01. Domestic silk production will increase at a slightly higher rate of 4.99 per cent per annum which is indicative of the increase in the production of good quality silk. This can be seen from the reduction of mean renditta from 9.8 in 1991-92 to 9.3 in 2000-01.

Imports of raw silk are expected to grow at an average rate of 7.5 per cent per annum in the simulation period. However, the interaction between the impact of the import price of raw silk and quantity of imports on the domestic raw silk price, and the impact of domestic raw silk prices on import of raw silk leads to oscillating movements in the forecasted values of the raw silk imports. The export demand for fabrics will increase at an average rate of 6.01 per cent per annum and reaches 573 lakh square meters by 2000-01.

Table 8 : Base-line Simulation Values of the Endogenous Variables of the System for the period 1991-92 to 2000-01.

YEAR	DC\SC	DRS	IM	DSP	DDF	EDF	SF	DPC	DPFIL	DPF
1991	117157	13806	1841	11964	1599	339	1939	20.9	208.6	22.9
1992	120885	14295	1924	12371	1637	363	2000	18.3	199.6	24.8
1993	130092	15185	1803	13382	1735	387	2122	13.3	179.0	26.7
1994	136635	16327	2112	14215	1869	412	2281	16.4	194.0	28.5
1995	138877	17104	2532	14573	1948	437	2385	21.1	218.0	30.6
1996	143588	17718	2607	15111	2002	463	2465	19.2	213.0	33.0
1997	151871	18667	2617	16050	2106	490	2595	16.2	202.1	35.5
1998	158103	19768	2926	16842	2232	517	2749	18.7	216.1	37.9
1999	161572	20617	3293	17324	2319	545	2864	21.9	234.6	40.6
2000	166938	21378	3425	17953	2393	573	2966	20.6	233.1	43.7

The forecasted values of real price of cocoon and raw silk also show oscillating fluctuation converging towards an upward trend. The average rate of increase in the real prices of these goods will be lower than the growth in other endogenous variables. However, the forecasted price of fabrics increases from Rs 23/sq mtr in 1991-92 to Rs 44/square meter in 2000-01 at an average rate of 7.4 per cent per annum. This may have been owing to high income elasticities of demand for silk fabrics.

Effect of Changes in the Import Price of Raw Silk

China plays a dominant role in the international silk trade, and therefore is a major player in determining silk prices in the international market. China's policies on price of silk so far has been difficult to predict as they are not determined solely based on market forces. Since more than 20 per cent of the raw silk consumed in India is imported mainly from China, the impact of possible changes in import prices have to be assessed in order to take appropriate actions. This will also help to assess the impact of tariff, if any, put on raw silk imports.

Simulations were conducted to assess the impact of change in the import price of raw silk (DIMP) on the silk industry. Two runs of the model were made : one with a 25 per cent increase and the other with a 25 per cent decrease in the import price of raw silk over the base level for the simulation period (1991-92 to 2000-01). The simulated values of the endogenous variables of the base run projection and the two alternative runs are presented in Appendix 2.

As a result of a 25 per cent increase in DIMP, the immediate impact on the industry will be a reduction in the quantity of imports by about 190 tonnes, increase in domestic silk production by about 60 tonnes and increase in the price of raw silk by Rs. 15/kg over the base level. Fabrics supply will be 20 lakh square meters lower than the base level. The industry gears up to the shock in the succeeding years. There will be a slight increase in cocoon production over the base level. There will be an improvement in the quality of cocoon production and silk reeling process (lower renditta). As a result, there is progressive increase in the domestic silk production, and by 2000 AD production will be about 130 tonnes above the base level. Thus, the supply of fabrics will be only 6 lakh square meters lower than the base level by the end of the period. The changes in the simulated values of the imports of raw silk and the filature price as compared to the base level will remain almost same over the simulation period.

The model for the silk industry being a linear system, the magnitude of a change in the endogenous variables as a result of the 25 per cent decrease in DIMP is equal but opposite to the magnitude of change as a consequence of 25 per cent increase in DIMP. Therefore, the decrease in the import price of raw silk will have an adverse impact on the domestic silk industry leading to a fall in domestic silk production and prices.

Effect of Regulation of Raw Silk Imports

India imports raw silk to meet the demand for high quality silk to produce silk goods for the domestic and export markets. Prices of raw silk in the international market are often lower than domestic raw silk prices. As better quality fabrics are being demanded in domestic and export markets, the demand for quality silk is increasing. However, government restricts raw silk imports to encourage domestic reelers to produce high quality silk. Though a clear analysis of the effects of increased imports on production of high quality silk in the country is beyond the scope of this model, its overall impact on the silk industry can be assessed.

Simulations were carried out to assess the impact of the policies intended towards increase/decrease in the import of raw silk by 1000 metric tonnes over the base line level. For these simulations, the intercept of the import of raw silk equation were modified[9]. The values of the two simulation runs along with the base run simulation are presented in Appendix 3.

A decrease in the quantity of imports for the initial year will lead to a reduction in the supply of fabrics for the domestic sector and increase in the prices of raw silk and fabrics as compared to the base value. In the long run, import restriction seems to have lesser influence[10] on the domestic silk industry as compared to an increase in import price as evident from a marginal increase in cocoon production and domestic silk production over the base value. However, under the import restriction regime, there is a progressive increase in the price of raw silk and silk fabrics over the base run value.

The policies intended to increase the quantity of import of raw silk by 1000 metric tonnes over the base level will depress the prices in the domestic raw silk and fabrics markets.

Effect of Changes in the Export Price of Fabrics

In the international market the demand for silk goods from new customer segments and appreciable demand for non-traditional apparels have increased the scope of Indian silk goods. The liberalization process in progress in the country offers considerable opportunity to the fabrics sector for exports. The changes in the international and domestic markets may lead to a change in export price realizations of silk fabrics. Therefore, it would be of interest to examine the impact of changes in the export price of fabrics on the silk industry.

Simulation of the model for the period 1991-92 to 2000-01 were made with 20 per cent increase/decrease in the export price of fabrics over the projected base run values. The simulated values of the endogenous variables along with their base run values are presented in the Appendix 4. The impact of a 20 per cent increase in the export price of fabrics will result in a reduction in the

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9 To assess the effect of the policy desiring reduction in the import of raw silk by 1000 mt. over the base level, the intercept was reduced by 1000 and vice-versa.

10 As we had seen in the previous section, a unit increase in import price had decreased the import of raw silk of by around 170 tonnes and increased the domestic silk production by 130 tonnes through out the simulation period. However, an import restriction of 1000 tonnes has increased domestic silk production by 100 tonnes over the same period.

export demand for fabrics by about 35 lakh square meters over the base value in the initial year. This in turn leads to sharp reduction (about 180 tonnes) in the import of raw silk in the next year over the base value. The decline in the export of fabrics and import of raw silk increases progressively over the base values throughout the simulation period. This strong linkage between import of raw silk and exports of fabrics is because of the government policy of export-linked imports and use of imported silk in production of silk goods for exports.

However, the influence of an increase in DEPF and a resultant decline in the fabrics exports will be very marginal on the domestic sectors as is evident from the negligible shifts in the simulated cocoon supply, domestic silk production, demand for fibre in the domestic market, and the prices of cocoon, raw silk and fabrics. This is probably because of the low share of exports in the total silk fabrics produced in the country.

Conclusions and Policy Implications

The Indian silk industry consists of various interlinked sub-sectors involved in the production of final silk goods. The overall growth of the industry requires sequentially consistent growth in all the sub-sectors. Designing and implementation of appropriate policies for this industry requires an indepth understanding of demand and supply relationships in these sub-sectors and their interlinkages. This study aimed at understanding and quantifying the relationship between important variables of the various sub-sectors of the Indian silk industry by developing an appropriate econometric simulation model, and using it for policy simulations.

An integrated simultaneous system of the silk industry was developed to represent the inter-relationship between the important variables affecting the demand and supply of the products of each sub-sector. The empirically estimatable 11 equation model represents the cocoon, raw silk and silk fabrics sectors. Mulberry sector was incorporated in the cocoon sector equations. Mulberry acreages (irrigated and rainfed) equations were estimated separately and used as recursive equations in the system for dynamic forecasting purpose. The data for the period 1972-73 to 1991-92 was used to estimate the model. Most of the equations in the model had performed reasonably well in terms of signs and significance of the coefficients and the goodness of fit (R^2). The model is of oscillating convergence nature and can be used for long term forecasting.

The models ability to track historical data was good in both static and dynamic simulations. Predictive performance of quantity variables were better than price variables except for imports of raw silk. Imports of raw silk had shown large fluctuations over the years due to various unaccounted factors and the model could not replicate it adequately. The dynamic simulation using the forecasted exogenous variables revealed that the imports of raw silk, exports of fabrics and price variables were very sensitive to the accuracy of the values of the exogenous variables. The decomposition of the mean square prediction error reveal that the model has been adequately specified. Due to instability in the markets as a result of ongoing liberalization of the economy, the ex-post forecasts for the year 1992-93 were not very accurate.

The major variables affecting the silk industry seem to be mulberry acreage and incomes of consumers. Among these, mulberry acreage is more amenable to policy actions. Increase in mulberry acreage would depend on cocoon prices, prices of competing crops as well as supply of inputs of mulberry and cocoon sub-sectors. In places where mulberry is presently grown, there is increasing competition for acreage from other sectors such as horticulture. Therefore, it would be of crucial importance to improve the productivity of the existing areas to sustain or improve the growth of the silk industry. Potential for improving the cocoon productivity in the mulberry growing areas already exists (Naik and Babu, 1993). Therefore, in the coming years, emphasis needs to be placed on exports and productivity of mulberry areas.

Forecasts of the endogenous variables of the system was made for the period 1991-92 to 2000-01 using the forecasted values of exogenous variables (trend functions) and actual values of the lagged endogenous variables for the initial year. The cocoon and raw silk production in the decade will grow at an average annual growth rate of 4 and 5 per cent per annum, respectively which is much lower than the 15 per cent growth experienced in the previous decade. However, a higher growth in the export demand and domestic demand for fabrics (around 6 per cent per annum) will be experienced which will necessitate higher growth in raw silk imports (7.5 per cent per annum) and increase in the production of better quality silk. The imports of raw silk and real prices of cocoon and raw silk would show oscillations and have an upward trend.

Policy simulations were undertaken for the period to assess the impact of changes in the import price of raw silk, export price of fabrics and regulation of the quantities of imports of raw silk by comparing the simulated values of the endogenous variables with the base run forecasts. These simulations reveal that the impact of the changes in the export does not seem to be very high on the silk industry except for the price variables. This may be due to the small share of exports in the final product of the industry. But as liberalization takes place, this sub-sector is expected to play an important role and changes are expected in the export and import equations. Therefore, emphasis has to be placed to orient production towards export market to improve growth in the Indian silk industry.

The results of the study reveal that the econometric model developed for the silk sector performs satisfactorily in forecasting and policy simulations and can be of practical use to the organizations associated with the silk sector. The modelling approach used for this study can be used in other commodity sectors for forecasting and policy simulations. To the users of this model we suggest that efforts should be made to replace price variables by more reliable price series. Also, possible changes during the liberalization process have to be carefully incorporated to generate more accurate forecasts from the model.

Appendix 1

1. Short Run Elasticities of the Exogenous Variable

Endogen. Variable	Exogenous Variable						
	DIMP	DDFPIMP	WY	DPCI	DEPF	MAIt-1	MARt-1
DC/SC						0.527	0.311
DRS	0.024	0.123	0.007	0.029		0.532	0.314
IM		1.018					
DSP	0.028		0.009	0.033		0.606	0.358
DDF	0.030	0.149	-1.34	0.035	0.119	0.645	0.380
EDF			6.990		-0.62		
SF	0.025	0.124	0.008	0.029		0.540	0.319
DPC						-2.49	-1.47
DPFIL	0.264	-0.01	0.084	0.312		-1.02	-0.60
DPF		-0.04	0.402	1.492	-0.03	-0.19	-0.11

2. Long Run Elasticities of the Exogenous Variable

Endogen. Variable	Exogenous Variable						
	DIMP	DDFPIMP	WY	DPCI	DEPF	MAIt-1	MARt-1
DC/SC						0.527	0.311
DRS	0.015	0.072	0.980	1.716	-0.08	0.369	0.217
IM		1.018	7.273		-0.65		
DSP	0.017	-0.05	0.10	1.957		0.420	0.248
DDF	0.018	0.087	-0.16	2.08	0.014	0.447	0.263
EDF			6.990		-0.62		
SF	0.015	0.073	0.995	1.743	-0.08	0.374	0.221
DPC	0.02	-0.07	0.12	2.34	-0.01	-0.14	-0.08
DPFIL	0.163	-0.55	0.935	18.24	-0.08	-2.75	-1.62
DPF	-0.52	-2.48	4.614	82.91	-0.41	-12.6	-7.45

Appendix 2

Simulated Values of the Endogenous Variables for the Period 1991-92 to 2000-01 {base run (b) and 25 % decrease (n) and 25 % increase (p) in DIMP}

Year	DC\SCn	DC\SCb	DC\SCp	DRSn	DRSb	DRSp	IMn	IMb	IMp	DSPn	DSPb	DSPp	DDFn	DDFb
1991	117157	117157	117157	13940	13806	13672	2034	1841	1649	11906	11964	12023	1620	1599
1992	120885	120885	120885	14414	14295	14175	2105	1924	1742	12309	12371	12433	1655	1637
1993	130092	130092	130092	15301	15185	15070	1982	1803	1625	13319	13382	13445	1752	1735
1994	136507	136635	136762	16433	16327	16220	2295	2112	1929	14138	14215	14291	1885	1869
1995	138627	138877	139126	17193	17104	17015	2713	2532	2351	14481	14573	14665	1962	1948
1996	143320	143588	143855	17795	17718	17640	2781	2607	2433	15014	15111	15207	2014	2002
1997	151579	151871	152163	18739	18667	18594	2789	2617	2444	15950	16050	16150	2117	2106
1998	157700	158103	158506	19832	19768	19704	3102	2926	2751	16730	16842	16954	2241	2232
1999	161067	161572	162076	20667	20617	20567	3467	3293	3119	17199	17324	17448	2326	2319
2000	166403	166938	167472	21419	21378	21338	3595	3425	3256	17824	17953	18083	2399	2393

Year	DDFp	EDFn	EDFb	EDFp	SFn	SFb	SFp	DPCn	DPCb	DPCp	DPFILn	DPFILb	DPFILp	DPFn	DPFb	DPFp
1991	1579	339	339	339	1959	1939	1919	20.9	20.9	20.9	193.3	208.6	223.8	22.8	22.9	23.1
1992	1620	363	363	363	2018	2000	1982	18.2	18.3	18.5	183.4	199.6	215.7	24.6	24.8	25.0
1993	1717	387	387	387	2139	2122	2104	13.2	13.3	13.5	162.6	179.0	195.4	26.4	26.7	27.1
1994	1853	412	412	412	2297	2281	2265	16.3	16.4	16.4	178.0	194.0	210.0	28.1	28.5	29.0
1995	1935	437	437	437	2399	2385	2372	21.1	21.1	21.2	201.8	218.0	234.2	30.0	30.6	31.1
1996	1991	463	463	463	2477	2465	2454	19.1	19.2	19.4	196.2	213.0	229.8	32.4	33.0	33.5
1997	2095	490	490	490	2606	2595	2585	16.0	16.2	16.4	185.2	202.1	219.1	34.8	35.5	36.1
1998	2222	517	517	517	2758	2749	2739	18.6	18.7	18.8	199.5	216.1	232.8	37.2	37.9	38.6
1999	2312	545	545	545	2871	2864	2856	21.8	21.9	22.1	217.8	234.6	251.4	39.9	40.6	41.4
2000	2387	573	573	573	2972	2966	2960	20.4	20.6	20.8	215.9	233.1	250.3	42.9	43.7	44.4

Appendix 3

Simulated Values of the Endogeneous Variables for the Period 1991-91 to 2000-01 {base run (b) and 1000 metric tonne decrease (n) and 1000 metric tonne increase (p) in IM}

Year	DC\SCn	DC\SCb	DC\SCp	DRSn	DRSb	DRSp	IMn	IMb	IMp	DSPn	DSPb	DSPp	DDFn	DDFb	DDFp
1991	117157	117157	117157	12865	13806	14753	886	1841	2804	11979	11964	11950	1459	1599	1741
1992	120885	120885	120885	13382	14295	15213	990	1924	2864	12392	12371	12350	1501	1637	1775
1993	130092	130092	130092	14299	15185	16078	889	1803	2724	13410	13382	13354	1602	1735	1868
1994	136666	136635	136603	15467	16327	17192	1216	2112	3015	14252	14215	14177	1741	1869	1999
1995	138951	138877	138802	16273	17104	17942	1652	2532	3417	14620	14573	14525	1824	1948	2074
1996	143692	143588	143483	16914	17718	18527	1746	2607	3474	15168	15111	15053	1882	2002	2123
1997	152007	151871	151734	17888	18667	19451	1772	2617	3467	16116	16050	15983	1989	2106	2223
1998	158293	158103	157911	19015	19768	20526	2096	2926	3762	16919	16842	16764	2119	2232	2345
1999	161824	161572	161318	19891	20617	21348	2478	3293	4114	17413	17324	17234	2210	2319	2428
2000	167243	166938	166630	20678	21378	22084	2624	3425	4231	18054	17953	17852	2288	2393	2498

Year	EDFn	EDFb	EDFp	SFn	SFb	SFp	DPCn	DPCb	DPCp	DPFILn	DPFILb	DPFILp	DPFn	DPFb	DPFp
1991	339	339	339	1798	1939	2080	20.9	20.9	20.9	212.3	208.6	204.8	23.8	22.9	22.0
1992	363	363	363	1864	2000	2137	18.4	18.3	18.3	205.1	199.6	194.0	26.5	24.8	23.1
1993	387	387	387	1989	2122	2255	13.4	13.3	13.3	186.2	179.0	171.7	29.3	26.7	24.2
1994	412	412	412	2152	2281	2410	16.4	16.4	16.3	202.7	194.0	185.3	31.8	28.5	25.2
1995	437	437	437	2261	2385	2510	21.2	21.1	21.1	228.1	218.0	207.9	34.6	30.6	26.5
1996	463	463	463	2345	2465	2586	19.3	19.2	19.2	224.6	213.0	201.3	37.7	33.0	28.2
1997	490	490	490	2479	2595	2713	16.3	16.2	16.1	215.1	202.1	189.0	40.9	35.5	30.0
1998	517	517	517	2636	2749	2862	18.8	18.7	18.6	230.3	216.1	201.8	44.0	37.9	31.8
1999	545	545	545	2755	2864	2973	22.0	21.9	21.8	250.0	234.6	219.1	47.3	40.6	33.9
2000	573	573	573	2861	2966	3072	20.7	20.6	20.5	249.8	233.1	216.3	50.9	43.7	36.4

Appendix 4

Simulated Values of the Endogeneous Variables for the Period 1991-91 to 2000-01 {base run (b) and 25 % decrease (n) and 25 % increase (p) in DEPF}

Year	DC\SCn	DC\SCb	DC\SCp	DRSn	DRSb	DRSp	IMn	IMb	IMp	DSPn	DSPb	DSPp	DDFn	DDFb	DDFp
1991	117157	117157	117157	13812	13806	13799	1846	1841	1836	11966	11964	11963	1565	1599	1634
1992	120885	120885	120885	14485	14295	14105	2113	1924	1734	12372	12371	12370	1630	1637	1645
1993	130092	130092	130092	15381	15185	14990	1998	1803	1609	13383	13382	13381	1727	1735	1742
1994	136638	136635	136631	16528	16327	16126	2312	2112	1913	14216	14215	14213	1862	1869	1877
1995	138881	138877	138872	17311	17104	16898	2737	2532	2327	14574	14573	14571	1941	1948	1956
1996	143591	143588	143585	17930	17718	17506	2817	2607	2397	15113	15111	15109	1995	2002	2010
1997	151876	151871	151867	18884	18667	18449	2831	2617	2402	16052	16050	16048	2099	2106	2113
1998	158111	158103	158094	19991	19768	19546	3146	2926	2707	16845	16842	16839	2225	2232	2239
1999	161582	161572	161561	20845	20617	20389	3517	3293	3069	17327	17324	17320	2312	2319	2326
2000	166949	166938	166927	21611	21378	21146	3654	3425	3196	17957	17953	17949	2386	2393	2400

Year	EDFn	EDFb	EDFp	SFn	SFb	SFp	DPCn	DPCb	DPCp	DPFILn	DPFILb	DPFILp	DPFn	DPFb	DPFp
1991	374	339	304	1940	1939	1938	20.9	20.9	20.9	209.0	208.6	208.1	23.1	22.9	22.7
1992	399	363	327	2028	2000	1972	18.3	18.3	18.3	199.7	199.6	199.4	25.1	24.8	24.5
1993	423	387	350	2151	2122	2092	13.3	13.3	13.3	179.2	179.0	178.8	27.0	26.7	26.4
1994	449	412	374	2311	2281	2251	16.4	16.4	16.4	194.3	194.0	193.8	28.9	28.5	28.2
1995	475	437	399	2416	2385	2354	21.1	21.1	21.1	218.4	218.0	217.7	30.9	30.6	30.2
1996	502	463	424	2497	2465	2434	19.2	19.2	19.2	213.4	213.0	212.5	33.4	33.0	32.5
1997	529	490	450	2628	2595	2563	16.2	16.2	16.2	202.6	202.1	201.6	35.9	35.5	35.0
1998	557	517	476	2782	2749	2715	18.7	18.7	18.7	216.7	216.1	215.6	38.4	37.9	37.4
1999	586	545	504	2898	2864	2830	21.9	21.9	21.9	235.2	234.6	234.0	41.2	40.6	40.1
2000	615	573	532	3001	2966	2931	20.6	20.6	20.6	233.8	233.1	232.4	44.3	43.7	43.1

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