FORECASTING OF U.S. COTTON DEMAND FOR APPAREL - AN ANALYSIS BASED ON GOVERNMENT AND PRIVATE DATA SOURCES

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Abstract

A structural model and a statistical model have been developed to estimate the amount of cotton used for apparent apparel consumption by employing two independent approaches. Three government and private databases were employed for the modeling and analysis work; U.S. Census Bureau data, NPD consumer panel data, and NCC fiber shipment data. Analyses were made to investigate the impact of foreign exchange rate and the hourly wage on cotton demand in apparel using a multi-variate regression model. The cotton consumption for year 2000 and 2001 was forecasted by using a time series model. The results show that both the foreign exchange rate and the hourly wage have significant impacts on cotton demand in domestic apparel market. The overall cotton demand in apparel market is likely to decrease steadily whereas the import/export will increase rapidly. The results from two different data sources were quite comparable and have shown little difference in the forecasted demands. This study has demonstrated a possibility of estimating the mill consumption of cotton for U.S. apparel by segmenting it into mill level and consumer level.

Introduction

How much cotton will the U.S. textile industry consume? That is one of the fundamental questions posed by the industry leaders. Cotton is one of the most important agricultural commodities and a large portion of cotton fibers is processed for apparel. While cotton's share in U.S. and international apparel and other textile markets has steadily increased, there is a growing concern as to how much of the consumer demand will have to be met by the U.S. textile industries. As the future of U.S. cotton production and import/export prospects hinge on the size and wellbeing of textile industry, the U.S. textile mill share of the consumed goods has large implications.

To estimate the U.S. textile mill share of the consumed cotton apparel, we must first estimate the total cotton demand within U.S. The total cotton demand depends on overall consumer demand for cotton and the competitiveness of the industry against its competitors overseas. While the apparent cotton consumption can be derived from the relationship among 1) the shipment by manufacturers, 2) exports of domestic merchandise and 3) apparel imports using such government data as U.S. Census Bureau-MQ23A, the figures should match that estimated from such consumer panel data as NPD. The methods of estimations are quite different for the two data sources - NPD from consumer panel data and Census from industry reporting. It is known that NPD panel data are adjusted for demographic information from Census, but no details are available to properly evaluate the gap between the two data sources. On the other hand, in the competitive arena, the apparel supply chain is changing rapidly under such trade issues as NAFTA, GATT, Trade Development Act (TDA) and CBI parity. Under these legislative provisions, the foreign exchange rate and hourly wage in manufacturing are known to play key roles in determining the competitiveness of U.S. manufacturing. In this study, the impact of the foreign exchange rate and the hourly wage on cotton demand in apparel will be analyzed.

It is noted that total cotton demand can be estimated at two levels: consumer level and mill level, as it is important for making key strategic decisions. The primary objective here is to devise an analytic method which will demonstrate that the cotton usages at various sectors of consumer market can be better estimated by consolidating the different data sources presently available.

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Modeling and Data Structure

In this study, three major analyses were made; 1) estimation of cotton share out of the total apparel demand in all fibers using two different data sources, 2) estimation of the impact of foreign exchange rate and the hourly wage on the apparel demand and 3) the forecasting of cotton demand in domestic apparel market.

In order to study U.S. cotton demand for apparel sector, the total apparel demand encompassing all fibers must be analyzed first. For this reason, modeling and estimation were attempted in two stages; the total apparel consumption with all fiber types and that for cotton only. At each stage, the estimation was made at mill level and at consumer level.

Modeling Strategy for Estimation of Cotton Demand in Apparel Market

From raw material to delivery of final product to consumers, the supply chain consists of a long sequence of material and product flows. Figure 1 shows the schematics of the supply chain and the modeling processes. As shown in the figure, demand at mill level is estimated from the manufacturers' apparel shipment data whereas demand at consumer level is estimated from the total apparel consumption data.

The conceptual frame for estimation at two different levels may be written in a simple linear algebraic form as follows:

$$Y = X_1 - X_2 + X_3$$

- Y = NPD (Total Apparel Consumption; Consumer Level Apparel Demand)
- X_1 = U.S. Census Bureau, MQ23A (Manufacturer's Apparel Shipment; Mill Level Apparel Demand)
- X_2 = U.S. Census Bureau MQ23A (Exported Apparel)
- X_3 = U.S. Census Bureau MQ23A (Imported Apparel)

If the conventional logic holds, the total apparel consumption (Y) based on NPD data should be equal to $(X_1 - X_2 + X_3)$ in concept.

The data structure is also shown in Figure 2. If the equation is valid, the overlapping area, or the intersection of the *apparel shipment* and the *apparent consumption*, is the amount of cotton goods produced and consumed in U.S.

Based on the modeling concept derived above, cotton demand for apparel was estimated at mill level as well as at consumer level. Figure 3 shows the modeling strategy and the method of estimation for the cotton share from the total. As shown in Figure 3, the total cotton apparel shipment data at mill level was extracted from the Census data (MQ23A) and then the cotton share was estimated. On the other hand, at consumer level, annual NCC cotton share for apparel uses was applied to estimate the cotton consumption for total apparel. The estimated cotton share at mill level and the cotton share published by NCC were compared and averaged for each year in order to obtain the forecast values.

Modeling of the Impact of the Foreign Exchange Rate And the Hourly Wage on Total Cotton Demand

The proportion of apparel imports relative to the apparent apparel consumption was modeled by using the weighted averages of foreign exchange rates and hourly wages obtained from 7 major trading countries. The cotton demand was analyzed using the same method. The seven

countries used were Mexico, Honduras, Bangladesh, China, Hong Kong, Dominican Republic, and Korea. The weights for the seven countries were obtained based on the volume of the trade in each country. Foreign exchange rates were referenced from the Federal Reserve database and hourly wages for apparel manufacturing from the International Labor Organization. Hourly wages for the seven countries were converted to U.S. dollars.

Forecasting of Total Cotton Demand for 2000-2001

Based on the population projection and the median income projection for 4-person families, the total cotton demand for 2000-2001 was forecasted using NPD data. Population projection and the income projection were referenced from the U.S.Census Bureau database. These forecasted figures were compared with that from Census data using the model introduced above. First, the MQ23A data from U.S. Census Bureau were applied in forecasting the percentage changes of imports and exports through time series models. Subsequently, the apparent cotton consumption was derived from the conceptual relationship introduced earlier; Apparent Consumption = Manufacturers' Shipment - Export + Import. Finally, the average annual cotton shares (%) were applied to the forecasted values in obtaining the cotton portions out of the total apparel consumption estimates. In the final stages, the forecasted values based on NPD and Census data sources will be compared.

Data Structures

- ***MQ23A U.S. Census Bureau data;*** The quarterly reports present data for the current and preceding quarters. Data include quantity of production and shipment figures for men's and junior boys', misses' and juniors', children's and infants, and women's apparel for all fibers. The annual summary includes revisions of the quarterly data originally estimated and a table containing domestic output, exports, and imports. Table 1 shows the apparent apparel consumption derived from the manufacturers' shipment, import and export data from 1991 to 1999. All the data points are in units of 1000.
- ***NPD Data;*** NPD data consist of panel members' diaries with detailed information on the products (style, color, size, fiber contents, and etc.), the consumers (age, sex, income, education, and etc.), and purchase specifics (store type, price, and etc.). Table 2 shows the total apparel consumption for Men's & Boys', Women's & Girls' and Infants' from 1991 to 1999. The NPD data reported here exclude the items not included in the MQ23A data.
- **National Cotton Council (NCC) Data**; The data consists of the amount of cotton and competing fibers consumed for producing specific textile products manufactured in the United States. The data reflects the total shipment to textile processing mills for each category. For this study, only the annual cotton share (%) reported for apparel was applied in estimating the cotton portions from the NPD data in Table 2.

Estimation and Results

Table 3 shows the total apparent apparel consumption for 1991-1999 from the two different data sources, U.S.Census Bureau MQ23A and NPD. The total apparent apparel consumption based on MQ23A was estimated by the conceptual equation whereas the same based on NPD data was obtained by excluding only those items not included in the MQ23A. The results are plotted in Figure 4. As shown in Figure 4, the two set estimates match quite well except in 1995 and 1999. The abrupt decrease in domestic apparel consumption in 1995 may be explained by the dramatic surge of U.S. made apparel fabrics to Mexico for sewing in 1995 with enactment of NAFTA in 1994. Figure 5 shows the apparel import and export trends from 1991 to 1999.

Table 4 shows the total cotton demand and the cotton share estimated based on the flow chart illustrated in Figure 3. The first column in Table 4, total estimated cotton demand from NPD data, was obtained by multiplying Column (7), cotton share published from NCC, to Column (2), the total apparel consumption. This represents the total cotton demand at the consumer level. For the mill level cotton demand, cotton share should be estimated first. While we could apply cotton share (%) by NCC, the same obtained from Census data was examined. The results are tabulated in Column (8) that is the percentage share of the Column (5) and (6). Since we find somewhat sizeable differences (3-10%), we decided to apply the average of the two indicated in Column (7) and (8). For the final stage, estimated cotton share is applied to the total apparent apparel consumption from Census data (column (4)) and the final results were shown in column (3). Column (1) and (3) matched quite well.

Tables 5, 6 and Figures 6, 7 and 8 show the results of statistical analyses concerning the effects of the foreign exchange rate and hourly wage on apparel trades. Table 5 and Figure 6 show the analysis of these two factors with total apparel imports/export. The rest of the table and the figures are the ones with the cotton demand in apparel. In both analyses, the foreign exchange rate and the hourly wage were highly significant. As shown in Table 5, the R^2-value (0.9683) based on foreign exchange rate and the hourly wage as independent variables is shown to be highly significant in determining the apparel import. In Table 6, the cotton demand is also shown to be significantly affected by the foreign exchange rate, hourly wage and the interactions of the two. The estimated demand and the actual data were plotted in Figures 6-8. As shown in the figures, our regression models explain the apparel imports and cotton demand quite well at both consumer level and mill level.

By applying the NPD data, table 7 show the forecasted of cotton demands for 2000 and 2001 based on projected U.S. population and the projected income using NPD data. Estimated and actual cotton demands are tabulated in Table 7 and are shown in Figures 9 and 10. In the figures, cotton demand at consumer level is projected to increase slightly in 2000 and decrease in 2001. At mill level, however, decrease is projected to continuously till 2001. Table 7 also shows the parameter estimate of selected model. At consumer level as well as at mill level, population and income are shown to be significant at 5% - 10% error levels. The model has shown somewhat higher R^2 at consumer level than at mill level.

Table 8 shows the projected import and export shares (%) of apparel based on the total. Predicted and the actual data are plotted in Figures 11 and 12. In the figures, the import shares are projected to increase continuously and expected to reach about 90% of the total apparel consumption in 2001 accompanied with a continuous decline in the export.

Based on the projected of import and export shares, total apparent apparel consumption was estimated from the Census data following the same logic used in the modeling process. Table 9 and Figure 13 show the comparison of results projected from NPD data and Census data. As shown in Figure 13, the projection based on Census data shows an abrupt increase during 2000-2001. This, however, is quite different from the projection made from the NPD data due to an abrupt increase in the import projection. It might be possible to see smaller differences if the units were in dollar values rather than unit volumes.

Table 10 shows the changes (%) of the cotton demand projected at consumer level as well as at mill level using 1999 as baseline. At both levels, the overall cotton demands decrease in the next two years.

Summary and Conclusions

An attempt has been made to estimate the total cotton demand for apparel consumed in U.S. by U.S. Census Bureau data, NPD data and NCC data through a conceptual model, linear models and time-series. The results are highly encouraging in that the two different data sources and analytic

techniques have generated comparable estimates. For the first time, the conceptual framework for estimating the apparent cotton consumption for apparel is shown to be valid based on the two independent routes of estimation.

Both the foreign exchange rate and the hourly wage of the importing countries are shown to be significant independent variables in estimating the percentage of imports and total cotton demand based on the total.

The total cotton consumption for apparel has been projected by applying two different methods. The estimates from the time-series models show that the cotton demand at consumer level will increase moderately and subsequently decrease in 2001whereas demand at mill level is expected to decrease continuously till 2001.

Reference

1. Note That Data From NPD were revalidated in 1995.

Table 1. Derived Apparent Apparel Consumption: 1991-1999. *Total Apparel for All Fibers.*

unit = 000	Manu-facturers' Shipment Q	Exports of Domst. Merchnd. Q	Imports for Consumption Q	Apparent Consumption Q=Shipment-Export+Import
1991	5,557,500	953,952	4,021,392	8,624,940
1992	6,031,368	1,274,088	4,807,416	9,564,696
1993	6,276,588	1,546,728	5,464,968	10,194,828
1994	6,454,892	1,746,060	5,958,552	10,667,384
1995	6,201,468	3,366,723	4,671,024	7,505,769
1996	5,998,365	2,282,232	7,379,304	11,095,437
1997	6,201,978	2,779,644	8,612,760	12,035,094
1998	5,379,922	2,921,232	10,076,892	12,535,582
1999	5,697,230	3,074,307	11,327,105	13,950,028

(Source: U.S. Census Bureau Apparel - MQ23A)

Table 2. Total Apparel Consumption: 1991-1999. *Total Apparel for All Fibers*

unit = 000	M&B Q	W&G Q	Infant Q	Total Q
1991	3,455,984	4,056,820	641,861	8,154,666
1992	3,701,969	4,504,429	697,475	8,903,874
1993	4,102,646	4,878,224	718,623	9,699,492
1994	4,381,348	5,196,444	793,454	10,371,246
1995	4,152,802	5,397,924	812,001	10,362,728
1996	4,351,290	5,506,332	903,116	10,760,738
1997	4,607,802	5,770,159	981,643	11,359,603
1998	4,666,506	5,839,667	1,053,536	11,559,709
1999	4,056,012	5,521,549	1,118,250	10,695,811

(Source: NPD)

Table 3. Comparison of Total Apparel Consumption: MQ23A vs. NPD for 1991-1999. *Total Apparel for All Fibers*

unit = 000	MQ23A	NPD
1991	8,624,940	8,154,666
1992	9,564,696	8,903,874
1993	10,194,828	9,699,492
1994	10,667,384	10,371,246
1995	7,505,769	10,362,728
1996	11,095,437	10,760,738
1997	12,035,094	11,359,603
1998	12,535,582	11,559,709
1999	13,950,028	10,695,811

Table 4. Estimation of Total Cotton Demand and Cotton Share for Apparel.

Unit= 000	Total Cotton Consumpt.(1) From NPD	Total Apparel Consumpt.(2) From NPD	Apparent Cotton Consumpt.(3) From MQ23A	Apparent Apparel Consumpt.(4) From MQ23A
1991	*5,055,893*	8,154,666	*5,135,656*	8,624,940
1992	*5,698,479*	8,903,874	*5,890,941*	9,564,696
1993	*6,304,670*	9,699,492	*6,181,656*	10,194,828
1994	*6,741,310*	10,371,246	*6,460,771*	10,667,384
1995	*7,046,655*	10,362,728	*4,707,741*	7,505,769
1996	*7,317,302*	10,760,738	*7,156,018*	11,095,437
1997	*7,724,530*	11,359,603	*7,914,638*	12,035,094
1998	*7,745,005*	11,559,709	*8,219,801*	12,535,582
1999	*7,166,193*	10,695,811	*8,982,335*	13,950,028

Unit = 000	Maufctrer's Shipment(5)	Cotton Shipment(6)	NCC % Cotton(7)	Census % Cotton(8)	Avg. % Cotton(9)
1991	5,557,500	3,172,693	62	57.09	59.54
1992	6,031,368	3,569,420	64	59.18	61.59
1993	6,276,588	3,531,863	65	56.27	60.64
1994	6,454,892	3,623,215	65	56.13	60.57
1995	6,201,468	3,562,326	68	57.44	62.72
1996	5,998,365	3,658,420	68	60.99	64.50
1997	6,201,978	3,939,868	68	63.53	65.76
1998	5,379,922	3,450,871	67	64.14	65.57
1999	5,697,230	3,519,677	67	61.78	64.39

(1) = (2)*(7),
(3) = (4)*(9),
(8) = (5)/(6)*100,
(9) = Avg. of (7)&(8)

Table 5. Results of Statistical Analysis for the Impact of the Foreign Exchange Rate and the Hourly Wage on Apparel Market.

	weighted ex. rate	weighted wage	Export Share(%) ex/shipment	Import Share(%) im/consmp. actual	Import Share(%) im/consmp. estimated
1991	6.25	0.19	17.17	46.63	48.65
1992	10.98	0.20	21.12	50.26	49.76
1993	15.23	0.23	24.64	53.61	50.42
1994	33.38	0.24	27.05	55.86	54.83
1995	70.56	0.21	54.29	62.23	64.50
1996	91.17	0.21	38.05	66.51	69.69
1997	102.27	0.20	44.82	71.56	72.56
1998	122.41	0.17	54.30	80.39	77.98
1999	128.57	0.18	53.96	81.20	79.35

(source: Federal Reserve, Stat-USA, ILO, U.S.Census Bureau MQ23A)
Y=49.62+0.25*ER-13.20*W (ER:Exchange Rate, W:Hourly Wage)
R^2=0.9683

Parameter	Estimate	St. Error	Pr>|t|
Intercept	49.62	10.95	0.0040*
er	0.25	0.0225	<0.0001*
wage	-13.2	49.42	0.7983
er: exchange rate			

Table 6. Results of Statistical Analysis for the Impact of the Foreign Exchange Rate and the Hourly Wage on Cotton Demand at Mill Level and at Consumer Level.

unit=	Consumer Level From NPD		Mill Level From MQ23A	
000	actual	estimated	actual	estimated
1991	5,055,893	-	3,172,693	-
1992	5,698,479	6,654,301	3,569,420	3,472,666
1993	6,304,670	6,669,273	3,531,863	3,525,146
1994	6,741,310	6,698,458	3,623,215	3,571,731
1995	7,046,655	6,881,757	3,562,326	3,605,697
1996	7,317,302	7,208,587	3,658,420	3,760,428
1997	7,724,530	7,395,401	3,939,868	3,763,308
1998	7,745,005	7,517,214	3,450,871	3,431,557
1999	7,166,193	7,682,123	3,519,677	3,624,931

Consumer Level; Y = 6769168.936 + 8741.91* LER-858240.204* W, R^2=0.889

Mill Level; Y = 3488006.01 - 21835.12* LER-9471.890* W + 126855.713* LER* W R^2=*0.8358*

(*W*:Hourly Wage, *LER*:1-period lagged exchange rate)

Parameter	Estimate	St. Error	Pr>|t|
Consumer Level			
Intercept	6769168.936	279296.65	<.0001*
LER	8741.91	3261.74	0.0438*
Wage	-858240.204	240338.9	0.0160*
LER:1-period lagged exchange rate			
Mill Level			
Intercept	3488006.01	109577.19	<.0001*
LER	-21835.12	7966.65	0.0519**
Wage	-179471.89	82267.33	0.0946**
LER*wage	126855.71	45563.28	0.0496*

*:5% Level Significant

**:10%Level Significant

Table 7. Forecasting of Total Cotton Demand for 2000-20001.

Unit =	Cotton Consmp. at consumer level		Cotton Consmp. at mill level	
000	Actual	Estimated	*Actual*	*Estimated*
1991	5055893	5243905	3172693	3326941
1992	5698479	5564063	3569420	3356292
1993	6304670	6340444	3531863	3557950
1994	6741310	6581531	3623215	3568154
1995	7046655	6997119	3562326	3644955
1996	7317302	7532212	3658420	3767522
1997	7724530	7656767	3939868	3734300
1998	7745005	7376459	3450871	3551361
1999	7166193	7497478	3519677	3517856
2000		7603822		3480012
2001		7282305		3283638

(Source: U.S.Census Bureau MQ23A)

Consumer Level; Y=-77716544.91+405.22*P-491.83*I, R^2=0.9434

Mill Level; Y=-19519670.29+118.78*P-181.84*I, R^2=0.5533

P: Population, I: Median Income for 4-Person Families

Parameter	Estimate	St. Error	Pr>|t|
Consumer Level			
Intercept	-77716544.91	14943496.5	0.002*
Population	405.22	79.25	0.0022*
Income	-491.83	133.9	0.0104*
Mill Level			
Intercept	-19519670.3	9211448.36	0.0784**
Population	118.78	48.85	0.0511**
Income	-181.84	82.54	0.0698**

*:5% Level Significant

**:10% Level Significant

Table 8. Projection of % Imports and % Exports for 2000-2001.

	%Import Actual	% Import Estimated(Y1)	% Export Actual	% Export Estimated(Y2)
1991	46.63	33.61	17.17	0.00
1992	50.26	41.28	21.12	0.00
1993	53.61	48.49	24.64	0.00
1994	55.86	55.25	27.05	8.21
1995	62.23	61.56	54.29	24.59
1996	66.51	67.42	38.05	37.42
1997	71.56	72.83	44.82	46.70
1998	80.39	77.79	54.30	52.42
1999	81.20	82.29	53.96	54.59
2000		86.34		53.20
2001		89.95		48.25

$Y_1 = 55.252+6.5363*t-0.2257*t^2$ (Y_1: Import Share, t: Time)

$Y_2 = 24.5925+14.6085*t-1.7775*t^2$ (Y_2: Export Share, t: Time)

Table 9. Comparison of Projected Cottton Consumption from NPD with Census.

unit= 000	Apparent Consmp. Cotton from NPD	Derived Apparent Consmp. Cotton from Census
1991	5,055,893	4,923,848
1992	5,698,479	5,660,477
1993	6,304,670	5,736,673
1994	6,741,310	5,987,742
1995	7,046,655	4,311,559
1996	7,317,302	6,767,139
1997	7,724,530	7,645,413
1998	7,745,005	8,040,763
1999	7,166,193	8,618,152
2000	*7,603,822*	12,694,438
2001	*7,282,305*	18,966,655

Table 10. The Estimates of the Total Mill Consumption of Cotton for Apparel.

unit= 000	Cotton Consumption at Consumer Level	Cotton Consumption at Mill Level
2000	11331952	3480012
% Change	1.40	-1.08
2001	11030784	3283638
% Change	-1.30	-6.66

(% Change is based on 1999)

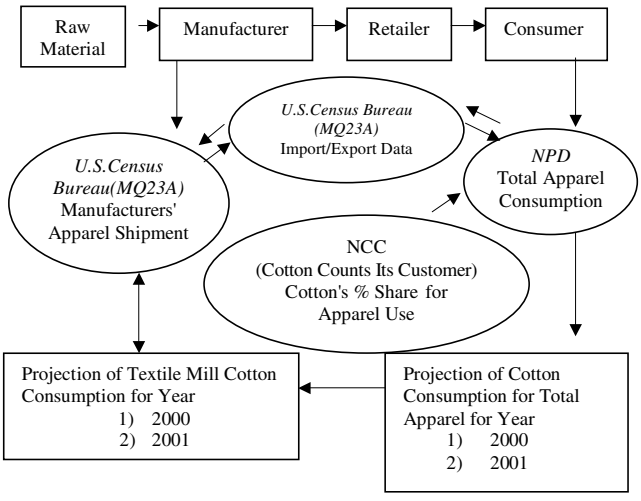

Figure 1. Flow Chart of the Modeling Process.

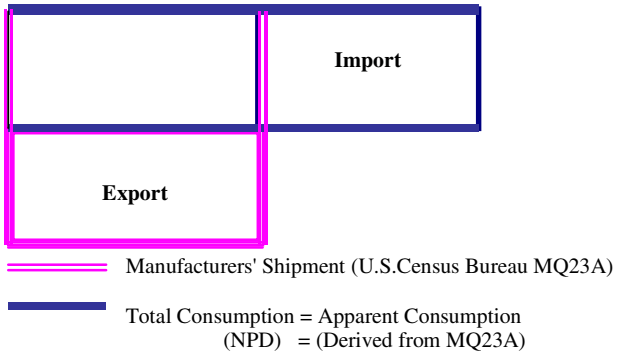

Figure 2. Modeling of Data Structure.

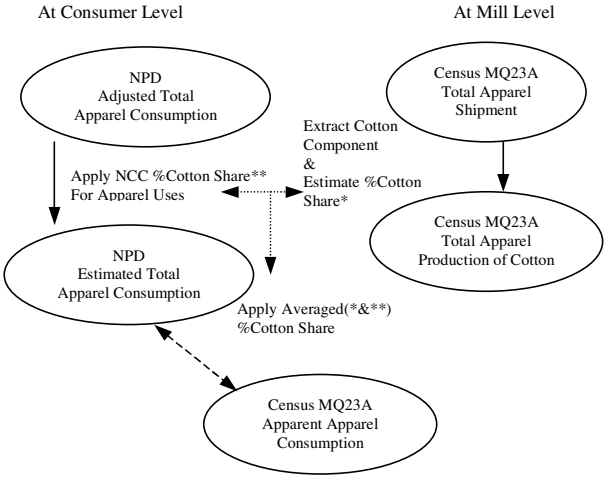

Figure 3. Flow Chart of Estimation of Cotton Demand.

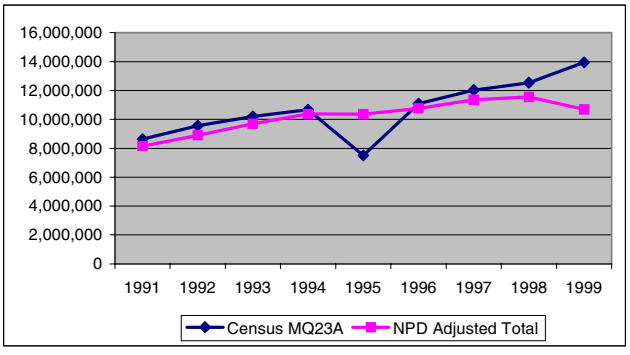

Figure 4. Comparison NPD with Census - Total Apparel Consumption: 1991-1999.

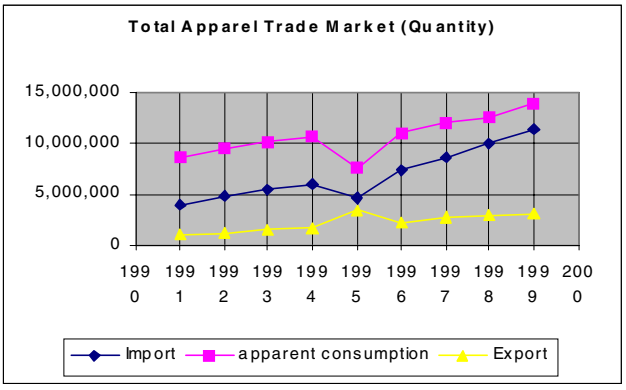

Figure 5. Total Apparel Trade Market.

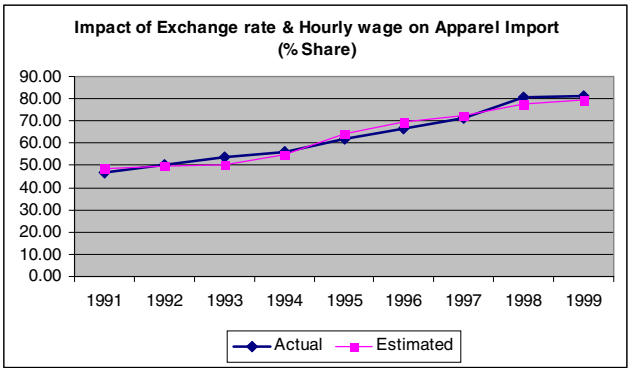

Figure 6. Impact of Exchange Rate and Hourly Wage on Apparel Import.

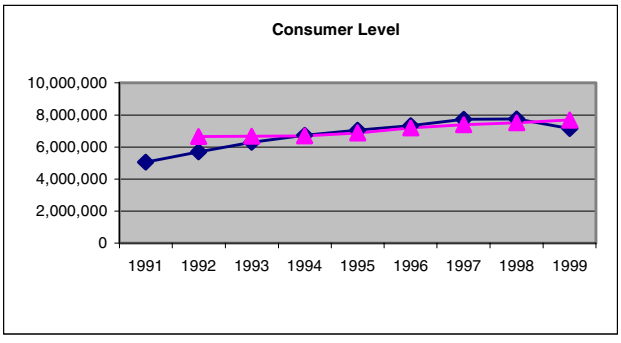

Figure 7. Impact of Exchange Rate and Hourly Wage on Cotton Demand at Consumer Level.

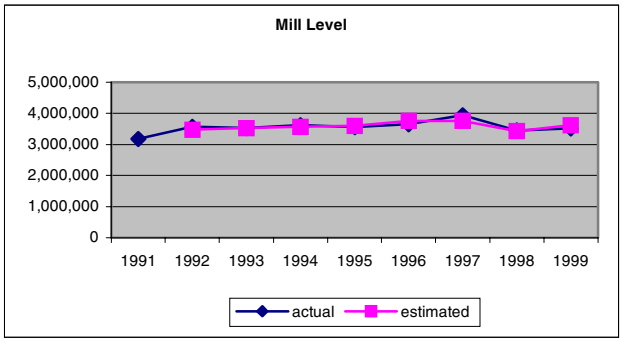

Figure 8. Impact of Exchange Rate and Hourly Wage on Cotton Demand at mill level.

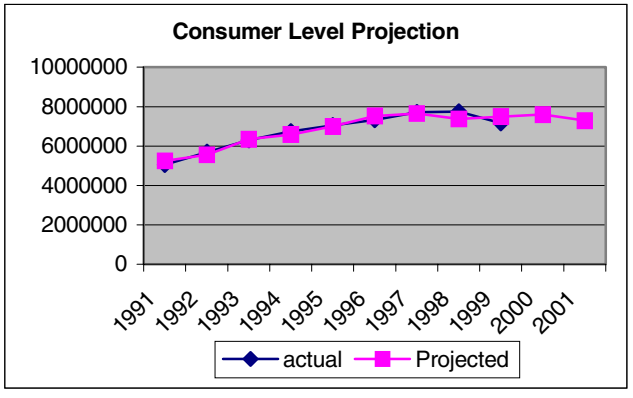

Figure 9. Forecasting of Total Cotton Demand for 2000-2001 at Consumer Level.

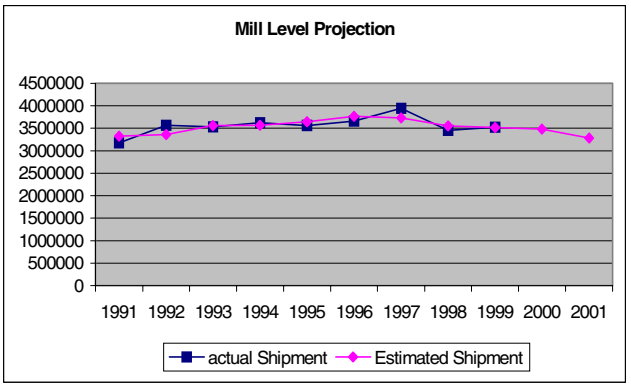

Figure 10. Forecasting of Total Cotton Demand for 2000-2001 at Mill Level.

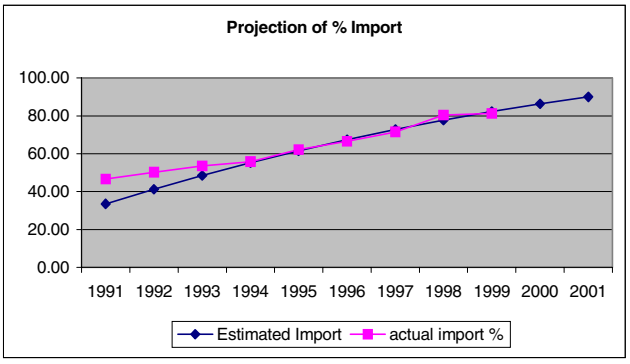

Figure 11. Projection of % Imports for 2000-2001.

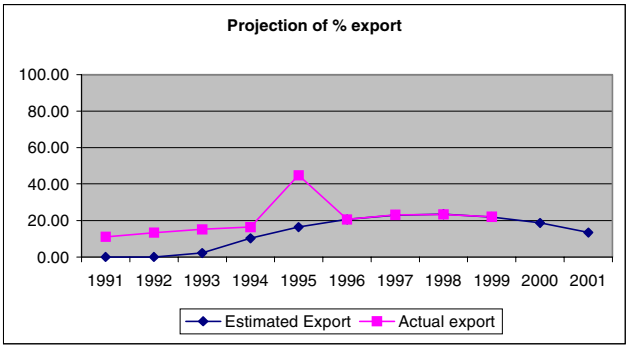

Figure 12. Projection of % Exports for 2000-2001.

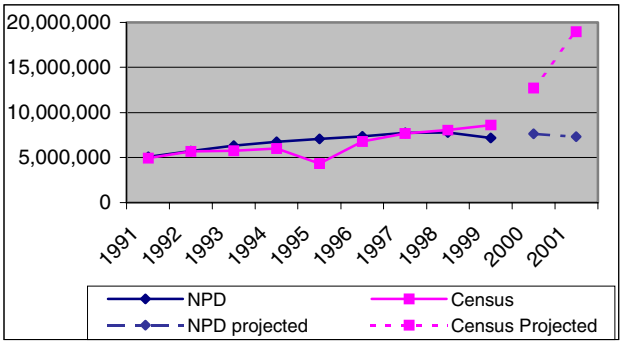

Figure 13. Comparison of Projected Cotton Consumption Estimated from NPD with Census.