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Factors Affecting the Domestic Mill Consumption of Cotton

By Frank Lowenstein

Analyses of fluctuations in cotton consumption based on pre-1940 data must be modified in the light of recent experience. In particular, rayon has now become a highly important and measurable influence on the consumption of cotton by domestic mills. This article presents estimates of the effects on cotton consumption of cotton prices, rayon consumption, and industrial activity, during the years 1921 to 1940 and 1947 to 1950. The paper also considers problems of measuring and forecasting the growth of rayon consumption itself. (Research for this article was made under authority of the Research and Marketing Act of 1946.)

MILL CONSUMPTION of cotton in the United States since 1921 has varied widely from year to year. These variations and their causes have long been of concern to growers, manufacturers, and others who are directly or indirectly associated with cotton and cotton textiles. In peacetime years since 1921, mill consumption has ranged between 2,601 million pounds in 1921 and 4,685 million in 1950 (table 1). Obviously, strong forces in the economy of the United States have caused these large variations. It is the major purpose of this report to identify the principal causes and to measure their effects.

As a consequence of the development of additional information and of the growth of synthetic fiber consumption, earlier studies¹ which analyzed factors affecting the consumption of cotton are no longer adequate. The most recent study included data only through 1938, and none of the earlier analyses applied measurements of the effect of the consumption of synthetic fibers. This paper extends the analysis to the years following World War II, incorporates some additional data now available, and analyzes the effect of synthetic fiber consumption.

¹ See SMITH, BRADFORD B. FACTORS AFFECTING THE PRICE OF COTTON. U. S. Dept. Agr., Tech. Bul. 50, January 1928; COX, ALONZO B., COTTON PRICES AND MARKETS. U. S. Dept. Agr., Dept. Bul. 1444, December 1926; HOWELL, L. D. COTTON PRICE RELATIONSHIPS AND OUTLETS FOR AMERICAN COTTON. U. S. Dept. Agr. Tech. Bul. 755, January 1941; SCHULTZ, HENRY. THE THEORY AND MEASUREMENT OF DEMAND. The University of Chicago Press, Chicago, Ill., 1938, Chapter VIII; BEAN, L. H. A SIMPLIFIED METHOD OF GRAPHIC CORRELATION. Amer. Statist. Assoc. Jour., December 1929, page 396.

How Demand for Cotton Consumption Is Ascertained

Cotton used by domestic mills to manufacture fabrics and end products is called "mill consumption of cotton." As the United States exports only small quantities of cotton fabrics and end products, the mill consumption in this country depends upon the domestic demand by industry and by ultimate consumers for end products made from cotton. This demand is determined by the number of people who use cotton products, the level of consumer income and industrial activity, the availability of substitute fibers, and the price of cotton as reflected in cotton products.

POPULATION.—In the period covered by this analysis—1921 to 1950—the population of the United States increased from 109.3 to 152.6 million persons (table 1). As each new individual creates eventual demand for virtually all products, this increase in population would tend to cause increases in cotton consumption, in industrial activity, and in consumption of substitute fibers. To remove intercorrelation caused by this common growth factor, all three series are expressed in per capita terms.

INDUSTRIAL PRODUCTION.—In price and consumption analyses of food products, consumer income—"disposable personal income"—is often used to represent changes in the general level of demand.²

² FOX, KARL A. FACTORS AFFECTING FARM INCOME, FARM PRICES AND FOOD CONSUMPTION. Agricultural Economics Research, July 1951, Vol. III, No. 3, pp. 65-82.

TABLE 1.—United States population, cotton consumption, rayon consumption, and cotton price, 1921 to 1950

Year	Population U. S. July 1	Cotton mill consumption	Federal Reserve Board Index of Industrial Production	Rayon consumption	Price Middling 7/8 inch cotton July year	BLS wholesale price index July year	Deflated price Middling 7/8 inch cotton
	<i>Millions</i>	<i>1,000 lb.</i>	<i>1935-39=100</i>	<i>1,000 lb.</i>	<i>Cents per lb.</i>	<i>1926=100</i>	<i>Cents per lb.</i>
1921	109.3	2,600,580	58	19,751	19.03	124.2	15.32
1922	110.9	2,911,265	73	24,757	17.16	93.7	18.31
1923	112.7	3,122,571	88	32,558	25.54	101.2	25.24
1924	114.9	2,636,082	82	42,243	29.85	98.1	30.43
1925	116.6	3,074,038	90	53,277	24.63	100.5	24.51
1926	118.2	3,211,993	96	60,629	20.23	102.5	19.74
1927	119.8	3,587,931	95	100,055	14.45	97.0	14.90
1928	121.3	3,184,867	99	100,493	18.39	96.1	20.18
1929	122.6	3,422,823	110	133,401	18.92	96.2	19.67
1930	123.8	2,615,066	91	118,835	16.29	92.5	17.61
1931	124.8	2,653,343	75	158,955	9.91	79.0	12.54
1932	125.6	2,461,793	58	155,331	6.15	68.2	9.02
1933	126.3	3,047,910	69	217,303	6.74	62.9	10.72
1934	127.1	2,657,754	75	196,882	10.64	72.0	14.78
1935	128.0	2,754,253	87	259,017	12.39	78.0	15.88
1936	128.9	3,469,973	103	322,430	11.49	80.1	14.34
1937	129.6	3,645,452	113	304,715	12.76	84.5	15.10
1938	130.7	2,917,737	89	329,390	8.93	82.4	10.84
1939	131.7	3,628,580	109	458,711	8.66	77.2	11.22
1940	133.0	3,958,718	125	482,045	9.83	78.2	12.57
1941	134.2	5,191,471	162	591,837	10.36	80.8	12.82
1942	135.7	5,633,146	199	620,624	17.66	94.6	18.67
1943	137.6	5,270,634	239	656,066	19.13	101.5	18.85
1944	139.3	4,790,406	235	704,741	19.51	103.4	18.87
1945	140.8	4,515,338	203	770,000	20.54	104.9	19.58
1946	142.3	4,809,128	170	875,500	23.51	107.9	21.79
1947	145.0	4,665,560	187	987,900	32.98	139.4	23.66
1948	147.5	4,463,480	192	1,149,458	32.80	160.4	20.45
1949	150.0	3,839,127	176	992,000	30.09	162.0	18.57
1950	152.6	4,685,139	200	1,351,400	29.85	153.2	19.48

Consumption of cotton depends upon the demand for cotton products from many sources, indirectly as well as directly associated with demand by ultimate consumers. For example, the National Cotton Council of America³ estimates that about one-third of a total of 7,964,330⁴ bales of cotton were used for industrial purposes in 1950. These uses include such items as bags, machinery belts, cordage and twine, electrical insulation, fabrics, and yarn used in automobiles, and laundry equipment and supplies. On the other hand, items of apparel accounted for 37 percent, and household uses for 31 percent of the total consumption.

In view of the importance of industrial uses, consumer income alone is not an adequate measure of the demand for cotton. Even with respect to

household and apparel uses, consumer demand expresses itself at the retail-store level and is felt at the fabrics-manufacturing level only after passing through several intermediate marketing steps. Consumer purchases of cotton products during a given year may be out of line with mill consumption of raw cotton because of changes in inventories at different levels of manufacture and distribution. Total inventories of cotton products on hand or in process are equivalent to a substantial part of a year's consumption. With retailers and wholesalers trying to anticipate consumer demand, and with mills and manufacturers trying to anticipate orders from distributors, large fluctuations in inventories occur. Complete explanation of mill consumption of cotton for household and apparel fabrics would require accurate data on inventories at several market levels and the fitting of demand curves for each major class of manufacturers and distributors, as well as for final consumers.

³ COTTON COUNTS ITS CUSTOMERS, PRELIMINARY 1950, National Cotton Council of America, Memphis, Tenn., May 1951.

⁴ This total does not include 1,923,920 bales for which no division by use was estimated.

Distribution channels for industrial fabrics are shorter. At any given time, the consumption of such fabrics is directly related to the output of the finished products in which, or with which, they are used. A full explanation of the demand for raw cotton in these uses would require an analysis of the demand for the finished products. This approach would give us a large number of chains of "technical coefficients," such as pounds of cotton per pound of tire-cord yarn; pounds of yarn per tire; average number of tires sold as standard equipment per new automobile produced; and average number of tires bought for replacement per registered automobile. Some of these chains end in final consumer demand, as for passenger automobiles; others end in military goods, or in items such as machinery belts, and bags which bear no simple relationship to consumer demand. In addition, fluctuations may appear in inventories at various levels in each chain, though perhaps not so large as those of household textiles and apparel.

Apparently none of the commonly used indicators of demand are fully satisfactory for measuring mill consumption of cotton. A combination of consumer income and certain components of the index of industrial production might be appropriate to represent final demand for cotton products. But the level of mill demand for raw cotton would depend also upon the anticipations and uncertainties which lead to fluctuations in inventories.

In the analysis reported in this paper, the demand indicator⁵ used was industrial production per capita. The major cyclical swings in this series are associated with similar swings in consumer income. In addition, the industrial-production series appears to be more closely associated with mill consumption of cotton in some of its sharper year-to-year changes, including some that are thought to be caused by inventory changes. The closer association may result partly from technical relationships between cotton consumption and the output of cotton-using industrial products, partly from waves of optimism or pessimism which affect large segments of the business community at the same time.

⁵ The Index of Industrial Production includes cotton consumption as one component. Elimination of the cotton component alters the index by less than 2 percent in all but 2 of the 24 years used in this analysis. Therefore, the statistical analysis is based on the published index.

During World War II special circumstances caused mill consumption of cotton to depart drastically from its usual peacetime relationship to total industrial production. Stockpiling of military textiles contributed to a sharp increase in mill consumption during 1941 and 1942. Industrial production in 1943-44 was swollen with shipbuilding, aircraft, and other war manufactures which used relatively little cotton. From 1942 to 1945 scarcities of labor available to cotton mills caused consumption to fall. In view of these abnormalities, the years 1941 through 1946 are excluded from the statistical analysis.

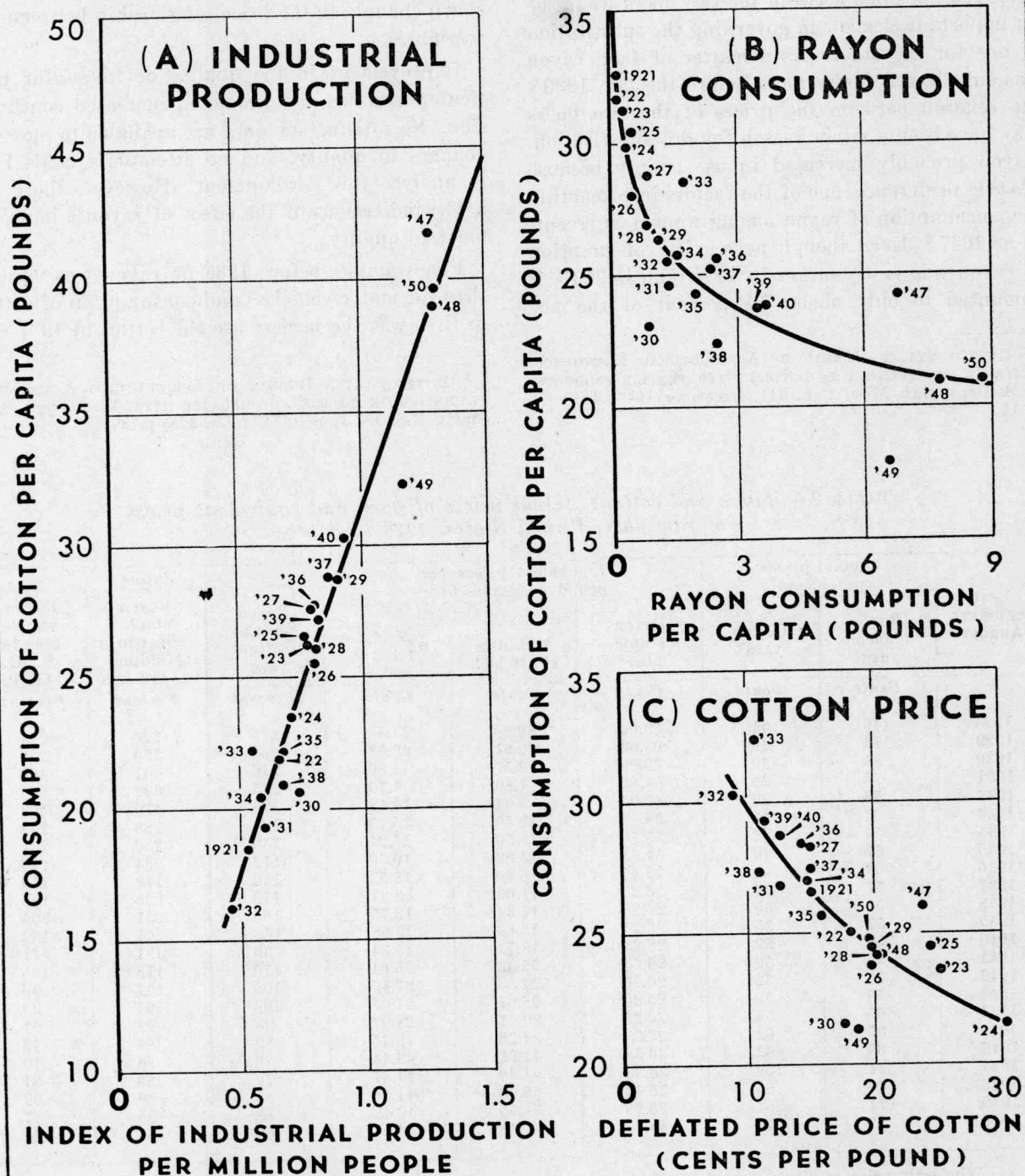
SUBSTITUTE FIBERS.—Rayon consumption is used here to represent the consumption of substitute fibers. Synthetic fibers other than rayon have been produced in substantial quantities only since the end of World War II. Even in 1950 rayon accounted for more than 90 percent of the production of all synthetic fibers.⁶ Additional data on consumption of other synthetics would be unlikely to alter the relationship significantly, though it is possible, as time goes on, that the effects of these other fibers may assume measurable importance.

Consumption of rayon in the United States increased from 0.07 pounds per capita in 1915 to 8.85 pounds in 1950. The increase in its consumption has followed a well-defined trend (fig. 1). Over the 36-year period, a Gompertz curve appears to fit this trend rather closely. This suggests that rayon consumption has not reached the half-way mark on its rise toward an ultimate saturation point. In a forecast from a curve of this type the standard error is very large. Therefore we are not justified in extrapolating the trend in figure 1 very far into the future. Nevertheless, consumption of rayon increased more than 5 pounds per capita between 1940 and 1950 and a further substantial increase is indicated in the next decade.

One of the factors that caused this rapidly increasing trend may have been the relation of the price of rayon to the price of cotton. From 1928 to 1945 the price of rayon yarn and staple fiber declined rather steadily, while the price of comparable cotton yarn and raw cotton after 1931 showed an increasing trend. The price of rayon has increased since 1945, but the price of cotton and cotton yarn has increased even more. Rayon

⁶ In 1950, 1,351 million pounds of rayon and 145 million pounds of other synthetic fibers were produced in the United States.

MILL CONSUMPTION OF COTTON AS RELATED TO THREE FACTORS, 1921-50



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FIGURE 1.

has been cheaper than cotton and cotton yarn since 1943 (table 2 and fig. 2).

Assuming other factors constant—such as style preference, durability, and launderability—the price relationships between the two fibers would be an important element in governing the substitution of one for the other. As a matter of fact, rayon was substituted for cotton. Before the late 1930's the relation between the prices of the two fibers may have been a minor reason for this substitution. Rayon probably increased in use mainly because of style preference, one of the factors in promoting the consumption of rayon among women as recently as 1947.⁷ Even though per capita consumption of rayon was vastly larger in 1937 than in 1915, it amounted to only about 8.4 percent of the per

capita consumption of cotton, or 2.35 pounds. Since 1937, its consumption has increased to 28.8 percent of that of cotton, 8.85 pounds per capita in 1950. This striking increase coincided with sharp changes in the price relationship between the two fibers.

Improvement in the quality of rayon for particular uses has also promoted increased consumption. No satisfactory data are available to measure changes in quality, and no attempt is made here to analyze this development. However, there are a few indications of the effect of rayon's improvement in quality.

For example, before 1936 no rayon was used in tires for motor vehicles⁸ and consumption of cotton in tires was the largest use for cotton in 1937 and

⁷ UNITED STATES BUREAU OF AGRICULTURAL ECONOMICS. WOMEN'S PREFERENCES AMONG SELECTED TEXTILE PRODUCTS. U. S. Dept. Agr. Misc. Pub. 641, December 1947, Table 5, p. 11.

⁸ UNITED STATES BUREAU OF AGRICULTURAL ECONOMICS. STATISTICS ON COTTON AND RELATED DATA. U. S. Dept. Agr. Statis. Bul. 99, June 1951, table 328, p. 391.

TABLE 2.—Rayon and cotton: Actual prices of yarn and equivalent prices of raw fiber, United States, 1928 to date

Year beginning August	Actual price per pound		Equivalent prices per pound of usable fiber			Ratios		
	Rayon filament yarn ¹	Cotton yarn ²	Rayon staple fiber ³	Cotton ⁴		Rayon yarn to cotton yarn	Rayon staple fiber to Middling 15/16 inch	Rayon staple fiber to S. M. 1-1/16 inch
				Middling 15/16 inch	S. M. 1-1/16 inches			
	Cents	Cents	Cents	Cents	Cents	Percent	Percent	Percent
1928	140	51	63.00	22.88	25.84	275	276	244
1929	114	49	63.00	19.81	22.53	235	320	279
1930	84	39	63.00	12.57	14.80	216	501	426
1931	72	29	54.60	7.89	9.75	245	692	560
1932	58	29	42.00	8.94	10.48	198	470	401
1933	63	47	38.85	13.50	15.40	134	288	252
1934	57	42	35.70	15.50	17.27	135	230	207
1935	57	40	34.65	14.82	16.50	142	234	210
1936	60	42	29.40	16.40	18.53	142	179	159
1937	57	34	26.25	11.65	13.27	170	225	198
1938	51	30	26.25	11.34	12.75	168	231	206
1939	53	35	26.25	12.66	13.68	152	207	192
1940	53	39	26.25	13.71	15.34	136	191	171
1941	55	50	26.25	22.33	25.01	110	118	105
1942	55	52	26.25	24.55	27.45	106	107	96
1943	55	52	25.20	25.07	27.97	106	101	90
1944	55	56	26.25	26.47	28.97	98	99	91
1945	55	62	26.25	31.26	33.15	89	84	79
1946	63	83	30.58	41.83	43.44	76	78	70
1947	71	102	36.33	41.39	44.87	70	88	81
1948	76	86	38.43	38.90	41.58	88	99	92
1949	71	81	36.75	38.55	42.42	88	95	87
1950	77	112	40.95	51.18	54.53	69	80	75

¹ Wholesale price of Viscose on skeins first-quality yarn, 150 denier until June 1947, since July 1947 "on cones."

² Wholesale price of Single 40's carded until July 1946, since August 1946, twisted carded.

³ Wholesale price of Viscose, 1-1/2 denier. Assumes net waste multiplier of 1.05.

⁴ Price of Memphis Territory growths, landed Group B mill points and assuming net waste multiplier of 1.15.

Compiled from data from Bureau of Labor Statistics and Cotton Branch, Production and Marketing Administration.

RAYON CONSUMPTION PER CAPITA

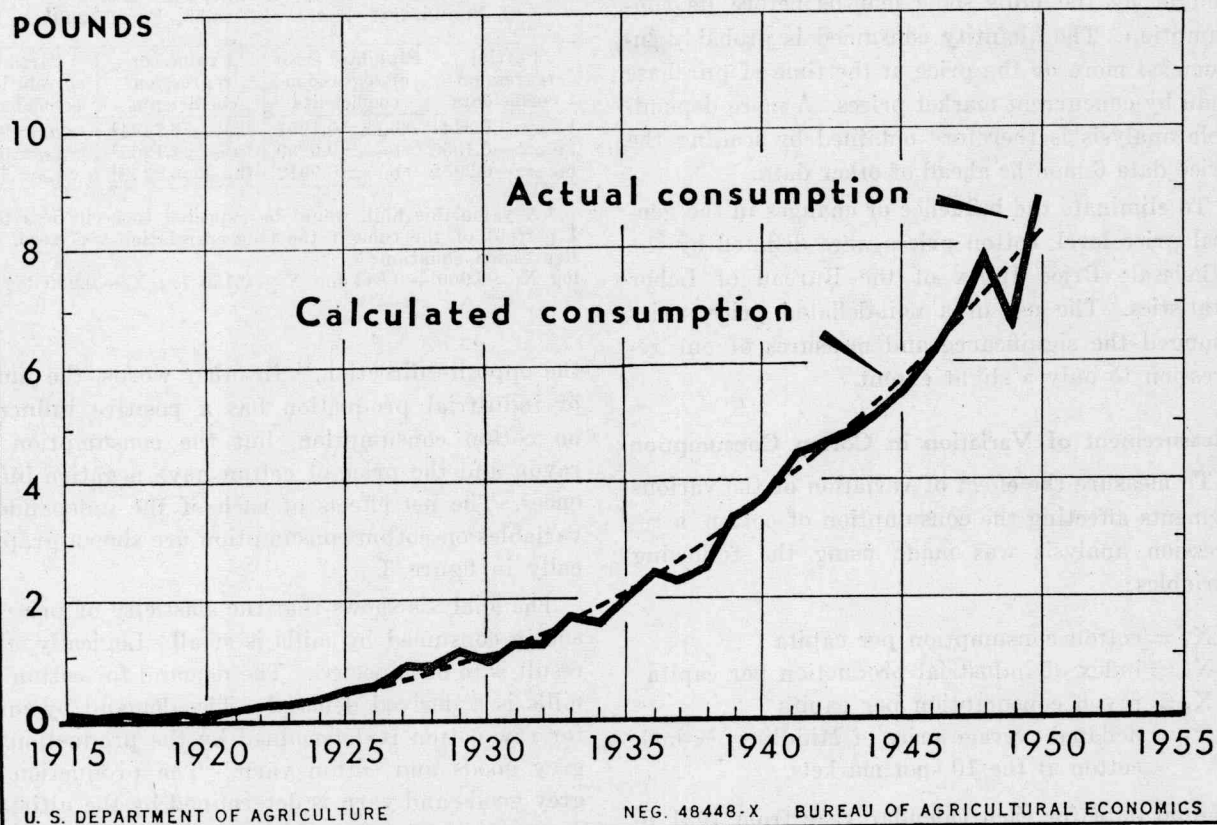


FIGURE 2.

1939,⁹ about 633,000 bales. By 1950, 301 million pounds⁸ of rayon¹⁰ were used in tires, and consumption of cotton in tires had declined to about 525,000 bales.¹¹ The increase in the consumption of all fibers¹² and rayon, and the decrease in the consumption of cotton in tires, coincided with the development and production of high-tenacity rayon yarn. Before this development in the quality of rayon, the fiber was unsuitable for use in tire cord.

PRICE OF COTTON.—The prices of cotton consumed in mills in the United States vary from time to time, reflecting changes in the general price

level, supply and demand conditions, and, to some extent, variation in the quality of cotton used. More than 600 qualities of upland cotton are consumed in the United States. It is obviously impracticable to use the price of each quality to indicate price changes. In this study the price of Middling, $\frac{7}{8}$ -inch cotton at the 10 spot markets was used to indicate the price changes of cotton. This quality was the base quality before 1939¹³ and indicates the average price changes adequately for the purpose of this analysis.

From August 1933 to February 1936 a processing tax of 4 cents a pound was applied to all cotton

⁹ COTTON COUNTS ITS CUSTOMERS, 1937 AND 1939, p. 14.

¹⁰ Equivalent to about 708,000 bales of cotton.

¹¹ COTTON COUNTS ITS CUSTOMERS, PRELIMINARY 1950, p. 14.

¹² Total fiber consumption increased from about 311 million pounds in 1939 to about 552 million pounds in 1950.

¹³ Middling, 15/16-inch cotton has been the base quality since 1939. Ten spot market quotations for its price were not available back to 1921, therefore the price of Middling, $\frac{7}{8}$ -inch was used.

used in the United States. Hence, for that period 4 cents a pound was added to the actual price.

Cotton used at a particular time is actually bought by the mills some months before its consumption. The quantity consumed is probably influenced more by the price at the time of purchase than by concurrent market prices. A more dependable analysis is therefore obtained by leading the price data 6 months ahead of other data.

To eliminate the influence of changes in the general price level, cotton prices were deflated by the Wholesale Price Index of the Bureau of Labor Statistics. The use of a non-deflated price series changed the significance and measures of our regression to only a slight extent.

Measurement of Variation in Cotton Consumption

To measure the effect of variation of the various elements affecting the consumption of cotton, a regression analysis was made using the following variables:

- X_1 = cotton consumption per capita
- X_2 = index of industrial production per capita
- X_3 = rayon consumption per capita
- X_4 = deflated average price of Middling, $\frac{7}{8}$ -inch cotton at the 10 spot markets.

Annual data for each calendar year from 1921 to 1940 and from 1947 to 1950 were used for X_1 , X_2 , and X_3 . Annual data for a year beginning with July before the calendar year were used for X_4 . As the relation between these variables approximated a percentage relationship, the regression analysis was made after converting all the original observations to logarithms. The regression equation and related measures are shown in table 3.

The analysis shows that about 79 percent of the variation in the consumption of cotton is associated with changes in the index of industrial production, in rayon consumption, and in the price of cotton. A change of 1 percent in industrial production was associated with a change in cotton consumption of 0.84 percent, ± 0.12 percent, in the same direction.¹⁴ A change of 1 percent in rayon consumption was associated with a change in cotton consumption of 0.12 percent, ± 0.03 percent, in the opposite direction. A change in the price of cotton of 1 percent was associated with a change in cotton consumption of 0.30 percent, ± 0.09 percent, in

TABLE 3.—Measures of the regression analysis

Coefficient of determination, $R^2_{1.234} = 0.791$
 Coefficient of correlation, $R_{1.234} = 0.889$
 Standard error of estimate, $S_{1.234} = 0.030$
 Significance of the regression, $F = 25.260^1$

Partial regression coefficients	Standard error of regression coefficients	t value for regression coefficients	Partial correlation coefficients
$b_{12.34} = 0.8441$	$sb_{12.34} = 0.1251$	$tb_{12.34} = 6.7494^1$	$r_{12.34} = .8336$
$b_{13.24} = -0.1555$	$sb_{13.24} = 0.0280$	$tb_{13.24} = 4.1265^1$	$r_{13.24} = .6782$
$b_{14.23} = -0.2952$	$sb_{14.23} = 0.0912$	$tb_{14.23} = 3.2359^1$	$r_{14.23} = .5862$

¹ A value this high would be expected to occur less than 1 percent of the time if the true correlation was zero.

Regression equation:

$$\log X_1 = 6.900 + 0.844 \log X_2 - 0.155 \log X_3 - 0.295 \log X_4$$

the opposite direction.¹⁴ In other words, the index of industrial production has a positive influence on cotton consumption, but the consumption of rayon and the price of cotton have negative influences. The net effects of each of the independent variables on cotton consumption are shown graphically in figure 3.

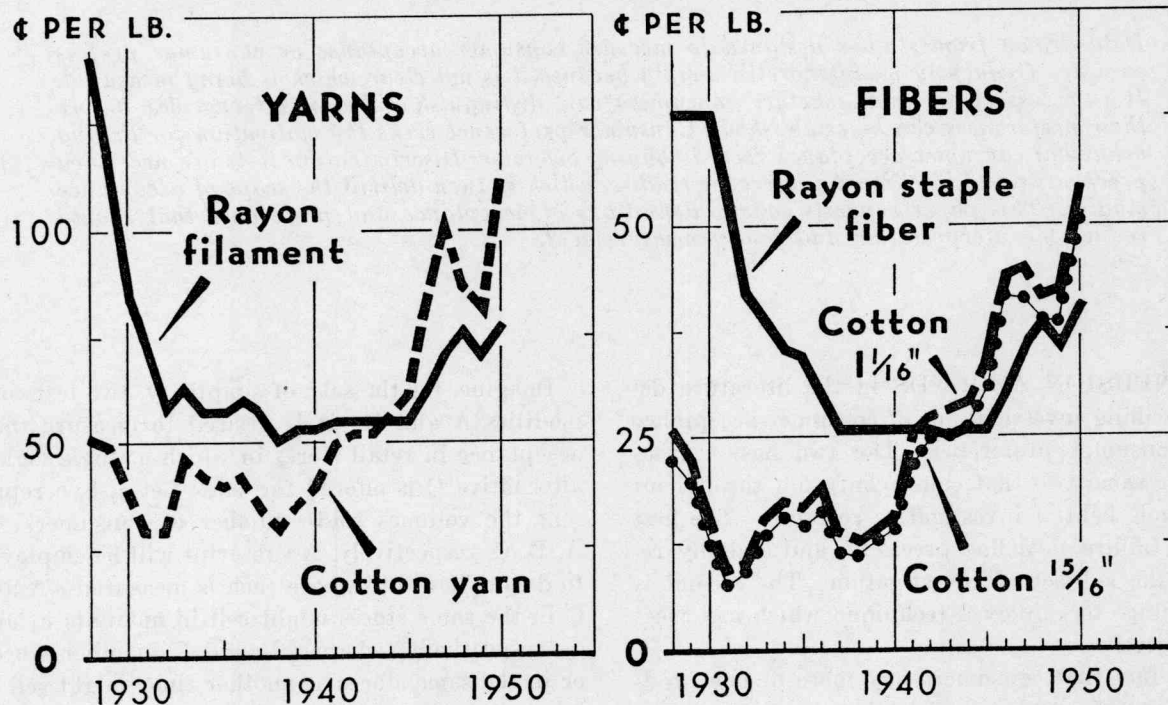
The analysis shows that the elasticity of price of cotton consumed by mills is small. Logically, this result is to be expected. The demand for cotton by mills is a derived demand. The demand by mills for raw cotton is determined by the production of grey goods and cotton yarn. The production of grey goods and yarn is determined by the ultimate consumers and industrial users for end products made of cotton. The cost of cotton comprises a rather small proportion of the cost of cotton end products to these users. For example, in 1939, the cost of cotton accounted for about 10 percent of the retail price of apparel and household goods.¹⁵ Because of this relationship, cotton prices are not a major factor determining the price of end products. If the prices of end products are an important element in determining their demand and, therefore, the demand for raw cotton, the price elasticity of mill consumption of cotton would be small.

Even though the direct effect of cotton prices is small, it should be remembered that these prices are

¹⁴ The measures are average relationships. In any specific year the measures may differ from these data. Approximately the same amount of variation is associated with an analysis that uses an undeflated price variable. However, the individual effect of industrial production, rayon consumption, and price on cotton consumption is to some extent altered.

¹⁵ HOWELL, L. D. MARKETING AND MANUFACTURING MARGINS FOR TEXTILES. U. S. Dept. Agr., Bul. 891; March 1945, p. 6.

PRICES OF RAW COTTON, COTTON YARN, RAYON STAPLE FIBER, AND RAYON YARN



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FIGURE 3.

still one of the contributing causes for the substitution of synthetic fibers for cotton. This substitution stated in percentage appears small. In 1950, an increase of 1 percent in consumption of rayon per capita would have been 0.09 pounds. This would have been associated with a decrease of 0.16 percent in consumption of cotton per capita, approximately 0.05 pounds. Therefore, a small cross elasticity in percentage terms results in a decrease of about $\frac{1}{2}$ pound in cotton consumption for approximately each pound increase in rayon consumption. This absolute measure is equally sig-

nificant for judging the effect of increasing rayon consumption on cotton as the regression in percentage terms. The percentage relationship is small because pounds of cotton consumed per capita are so much greater than the pounds of rayon—in 1950, 30.7 pounds of cotton to 8.85 pounds of rayon. Attention should also be called to the fact that the average per capita consumption of cotton has fluctuated from 24.0 pounds in 1921 to 30.7 in 1950. This was caused by increases in the Index of Industrial Production from .6 per million population in 1921 to 1.1 in 1950.