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U.S. TEXTILE FIBER DEMAND: PRICE ELASTICITIES IN MAJOR END-USE MARKETS

DUDLEY, G.E.

1 OF 1

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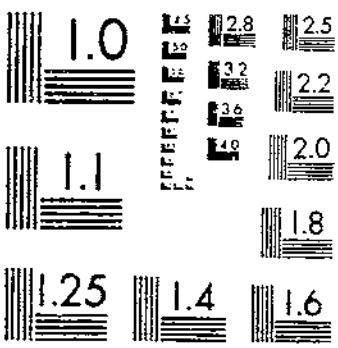


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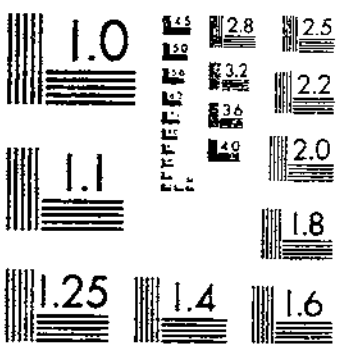


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

# U.S. TEXTILE FIBER DEMAND

## PRICE ELASTICITIES IN MAJOR END-USE MARKETS

U.S. DEPARTMENT OF AGRICULTURE ECONOMIC RESEARCH SERVICE

Technical Bulletin No. 1500

ABSTRACT

Extrapolation from past trends and relationships indicates that domestic use of all fibers will continue to rise, reaching about 82-90 raw fiber-equivalent pounds per person in 1985. But fuel and petrochemical shortages could cause increases to be smaller.

Variables affecting fiber demand were examined. The response of four types of fibers--cotton, wool, cellulosics, and noncellulosics--to prices was measured. Cotton was inelastic in the five end-use markets tested. Noncellulosic fibers were also price inelastic, except in the household furnishings market. Despite the price inelasticities, fiber consumption does respond to price changes.

Keywords: Cotton, fiber demand, domestic use, interfiber competition, price elasticity, noncellulosic fibers, cellulosic fibers, wool.

Washington, D. C. 20250

September 1974

## PREFACE

Fiber competition intensified in the 1960's as abundant supplies of manmade fibers became available and as the technology of blending was developed. This report analyzes trends and projects textile fiber consumption in the United States. The effect of competitive fiber prices on consumption in major end-use products is estimated.

Variables affecting fiber demand are examined. Information in the projections section should aid fiber producers in decision-making. The end-use analysis results should be of interest to planners seeking the most efficient use of research and promotion inputs.

The author is greatly indebted to many colleagues in the U.S. Department of Agriculture for information and assistance. Special acknowledgment is made to James R. Donald and Russell G. Barlowe of the Economic Research Service, who contributed vital assistance on both methodology and presentation as well as data interpretation. Charles H. Wittmann, formerly of the Economic Research Service, gave valuable aid in outlining the structure of the fiber industry, in data interpretation, and in clarifying many technicalities.

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## HIGHLIGHTS

Fiber use will continue to rise to 1985, but probably slower than the sharp increases during the 1960's. Both the rate of increase and the level of demand will depend largely on the availability of fuel and petrochemicals. Extrapolation from past trends and relationships indicates 1985 domestic consumption of all fibers will be about 82-90 raw fiber-equivalent pounds per person. Consumption per capita will be about 14-18 pounds of cotton, 1 pound of wool, 7-8 pounds of cellulosics, and 60-63 pounds of noncellulosics.

Fuel and petrochemical shortages could result in a more moderate increase in total use and a change in the mix of the total. For example, if shortages are severe, increases in noncellulosic use are likely to be smaller than otherwise indicated. The response of fiber to prices was measured in major end uses. A ratio of cotton price to noncellulosic price was used in an attempt to measure competition head-on between cotton and noncellulosic fibers. This permitted a comparison of both cotton price elasticities and competitive relationships. Cotton was price inelastic in all markets, ranging from an elasticity of 0.1 in men's apparel to 0.6 in industrial uses. Thus, cotton would seem most competitive in men's apparel, where it responds most slowly to changes in its own price or the price relationship between cotton and noncellulosic fiber. Noncellulosic fibers were also price inelastic except in the household furnishings market, where prices were slightly elastic.

Despite the price inelasticities, fiber consumption does respond to price changes. Although the changes are small, they are usually statistically significant.

# U.S. TEXTILE FIBER DEMAND

## PRICE ELASTICITIES IN MAJOR END-USE MARKETS

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### INTRODUCTION

The market for textile fibers in the United States is extensive. Textiles are an integral part of almost every facet of our everyday life--tires for our automobiles, clothing for our bodies, parachutes and body armor for our military forces, and towels and bedsheets for our homes. Because textile products appear in a wide variety of forms for so many different uses, fiber demand changes constantly. Interaction of various demographic, economic, and technological demand shifters causes both shortrun and longrun changes. Shortrun variations span a relatively brief time but may occur frequently and cyclically. They may even cause secondary structural changes which linger long after the particular disruption is gone. Longrun changes, on the other hand, occur more gradually. Either longrun or shortrun changes may affect the nature of demand itself or alter the structure of the industry.

Economic forces dominate fiber demand, particularly in the aggregate. Such factors as income and prices influence demand and apportion aggregate demand among various segments of the market, such as industrial, household, or apparel. In addition, demand for fibers in each segment of the market is apportioned among natural and manmade fibers. While economic considerations affect apportionment within and among segments, demographical and technological forces are most important in allocating fibers within each segment.

So the structure of fiber demand is comprised of three fairly distinct levels--the aggregate, the market segment, and the individual fiber level (fig. 1). Demand is determined at the aggregate level by interaction of traditional macro demand shifters such as income, prices, and other parameters peculiar to fibers. At the secondary and tertiary levels, the aggregate is apportioned primarily by micro parameters, such as comparative prices. The importance of demand-influencing parameters will be discussed at greater

# DETERMINATION OF FIBER DEMAND

| | | |
|---|---|---|
| Aggregate fiber demand | = f | Income<br>Price of fiber products<br>Price of nonfiber products<br>Tastes and preferences<br>Consumer stocks of fiber products<br>Technology |
| Demand for fibers in end-use markets | = f | Income<br>Price of fiber products<br>Price of fiber products in other end-use markets<br>Price of nonfiber products<br>Technology<br>Consumer stocks of fiber products in each end-use market<br>Tastes and preferences |
| Demand for individual fibers in each end-use market | = f | Individual fiber prices<br>Other fiber prices<br>Technology<br>Demand for fibers in each end-use market<br>Tastes and preferences |

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Figure 1

length below.

During the past two decades, the U.S. textile economy has undergone vast changes. Increasing use of manmade fibers, rapidly expanding consumer income, generally high levels of economic activity, and increasing demand for foreign textile products have had great impact. The effect of economic activity and levels of consumer income are discussed specifically in the aggregate fiber demand section. The effect of the changing trade balance is reflected in different trends for mill and domestic consumption. However, the advent of manmade fibers, as it affects the aggregate approach to demand analysis, should be given some attention at this point. Natural and manmade fibers differ markedly in terms of supply but are more closely related in terms of demand, since they possess many common properties and markets. Also, their final products evolve through essentially similar textile manufacturing processes. While this does not imply perfect substitutability, it does imply some aggregate demand for fibers and also implies that demand is indicated at the mill and consumer levels by a preference for certain products or a certain fiber "mix." So initially, aggregate fiber demand must be treated as an entity. Such an approach permits discussion of the major demand shifters which show little significance at the individual fiber level.

However, the aggregate concept raises many problems both in analysis and interpretation. For example, one might seek an aggregate elasticity of fiber demand consisting of some combination of demand elasticities for individual fibers (16).1/ Such an approach is neither easier nor more difficult to justify conceptually than is the aggregate approach. But in summing elasticities, it is difficult to measure a response at aggregate levels to changes in economic factors which result in a change of the product mix while total quantities remain constant. And in any conceptualization, such important factors as nonprice interfiber competition and expansion of the market with improving technology must be treated subjectively.

This study initially tried an aggregate concept to measure elasticities which proved unsuccessful. Attempts to measure aggregate coefficients for total fiber demand and particularly its major components were generally unsatisfactory. However, methods of estimating total fiber demand and demand for each major fiber are presented in the first part of the report. In some instances, the projections are accomplished by nonparametric means and rely heavily on the judgment of commodity specialists. Given price structures in the fiber industry and data limitations, they probably are as good as are available.

The second part of the report measures price elasticities for

---

1/ Underscored numbers in parentheses refer to items in Literature Cited at the end of the report.

fibers in major end uses and pinpoints where price changes have the greatest effect on demand.

The findings of this report should help explain past trends and indicate what lies ahead for fibers. Thus, it should help economists, industry planners, consumers, and farmers make rational decisions.

While this report does not analyze fiber supplies, the following discussion of supply is necessary to set the stage for demand analysis.

## Several Sources of Textile Raw Materials for U.S. Consumption

Consumption of raw fiber at the mill is the initial step in the complex production and marketing process through which textile products travel to the ultimate consumer. This involved process can best be shown by a diagram which indicates major outlets and supply sources in the product flow (fig. 2). The diagram is applicable to the fibers taken together or separately, although no attempt is made to indicate the relative importance of any outlet or source. Arrows indicate the direction of product flow.

While mill consumption of fibers ($C_t^m$) is defined somewhat differently for the various fibers, 2/ it is basically an estimate of the fiber use or input of mills in the manufacture of yarn and cloth. Work in process ($W_t$) includes all goods held in inventory or in process between the mill and the fabricator, or goods which require further processing before they can be sold to the ultimate consumer. The production system thus includes the various manufacturing processes from fiber preparation and spinning through dyeing and fabrication of the final product. Imports ($I_t^s$) and

---

2/ Mill consumption for the various fibers is defined as follows: (1) Mill consumption of cotton as reported by the Bureau of the Census. The number of bales of cotton opened and put into process by the mills. (2) Mill consumption of wool as reported by the Bureau of the Census. Wool is considered as consumed (a) on the woolen system when laid in mixes and (b) on the worsted system when entering scouring bowls. Consumption on the worsted system is taken as the sum of top and noil production. (3) Mill consumption of manmade fibers as defined by the Textile Organon, published by the Textile Economics Bureau, Inc. For rayon and acetate, mill consumption includes U.S. producers' domestic shipments of filament and staple fibers. For noncellulosic fibers, mill consumption includes U.S. production of filament and staple fibers less exports, plus imports for consumption of filament and staple fibers.

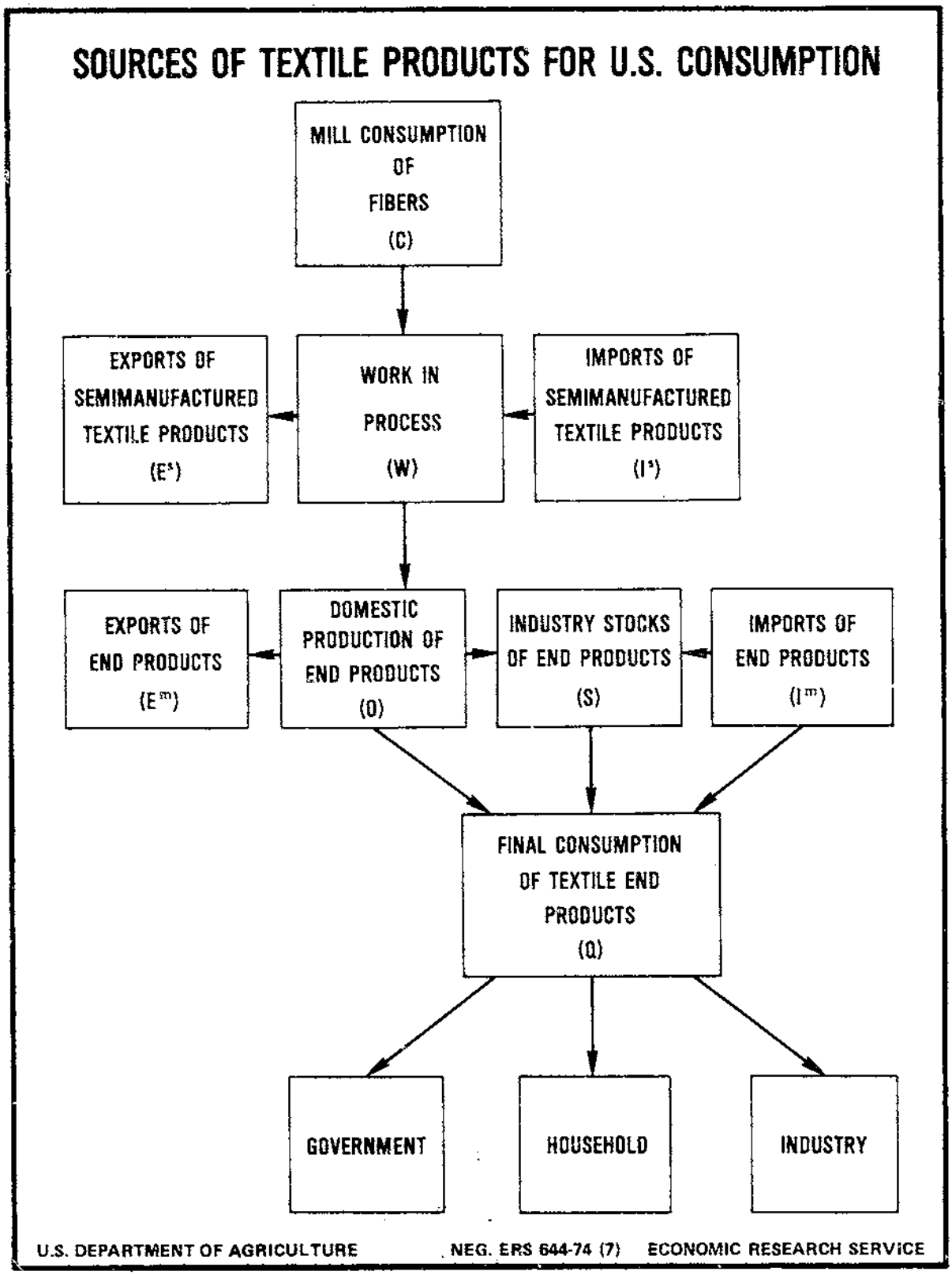
SOURCES OF TEXTILE PRODUCTS FOR U.S. CONSUMPTION
MILL CONSUMPTION OF FIBERS (C)
EXPORTS OF SEMIMANUFACTURED TEXTILE PRODUCTS ($E^s$)
WORK IN PROCESS (W)
IMPORTS OF SEMIMANUFACTURED TEXTILE PRODUCTS ($I^s$)
EXPORTS OF END PRODUCTS ($E^m$)
DOMESTIC PRODUCTION OF END PRODUCTS (O)
INDUSTRY STOCKS OF END PRODUCTS (S)
IMPORTS OF END PRODUCTS ($I^m$)
FINAL CONSUMPTION OF TEXTILE END PRODUCTS (Q)
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Figure 2

exports ($E_t^s$) of semimanufactured textile products cover the same items included in work in process. Domestic production ($D_t$), stocks ($S_t$), imports ($I_t^m$), and exports ($E_t^m$) of end products refer to items which require no further processing prior to use by the consumer. Stocks of end products thus include those held by fabricators, wholesalers, and retailers. The final consumption ($Q_t$) of textile end products reflects sales to ultimate consumers. Further breakdown of the specific levels of production and distribution will be introduced as necessary.

The relationships discussed above and shown in figure 2 may be algebraically expressed as follows:

$$(1)\quad W_t = W_{t-1} + C_t + I_t^s - E_t^s - O_t$$

$$(2)\quad S_t = S_{t-1} + O_t + I_t^m - E_t^m - Q_t$$

$$(3)\quad Q_t = C_t + I_t - E_t - (S_t - S_t\text{-}1) - (W_t - W_{t-1})$$

when $\quad I = I^s + I^m$

$\quad\quad E = E^s + E^m$

and the subscript "t" refers to the current time period, while "t-1" refers to the previous time period.

Equation (3), an algebraic transformation of equations (1) and (2), shows that final consumption of textile products will be equivalent to mill consumption only if net trade in textile products and changes in stocks of end products and work in process offset each other, which is very improbable.

Further consideration is given in a later section to information available about the variables in figure 1 and, to the extent possible, their relative importance is indicated. An economic model presented in (6) served as the point of departure for many of the considerations initially developed in this study.

## DOMESTIC FIBER CONSUMPTION REFLECTS TRADE BALANCE

Mill demand is the major outlet for textile fibers in the United States and, until a decade ago, best indicated final demand. However, mill consumption and final domestic consumption of total fibers may differ as import or export balances of manufactured or semimanufactured textile products change. Raw fiber equivalence of U.S. imports and exports of manufactured and semimanufactured textile products is estimated by the U.S. Department of Agriculture (USDA). Using these estimates, mill consumption is adjusted to

reflect the net import or export trade balance of textile products and achieve a realistic approximation of final domestic consumption of textile fibers.

In addition, aggregate domestic consumption of textile fibers is adjusted to a cotton-equivalent basis to obtain a common denominator for measuring fiber consumption, as there are substantial utility differences among various fibers. The resulting series show aggregate fiber consumption growing at an even faster rate than domestic consumption, primarily because of the incidence of manmade fibers with higher utility factors.

Estimates of domestic fiber consumption will be discussed below, first for aggregate consumption, and then for each individual fiber.

## Aggregate Fiber Consumption Trending Up

U.S. exports of textile products exceeded imports each year prior to 1959. The trade balance then shifted to imports as domestic consumption surpassed mill use. Exports have remained relatively high since the late 1940's. However, imports, which were below 100 million pounds in the late 1940's, climbed sharply in the 1950's and 1960's.

Consequently, although mill consumption and domestic consumption of fibers trended in the same direction, they did so at significantly different rates. Mill consumption in the late 1940's was about a tenth larger than domestic consumption. By the late 1960's, the relative positions were reversed--reflecting changes in the trade balance--and domestic consumption exceeded mill consumption by 5 percent. The level of the net trade balance switched from about a half-billion-pound export balance to nearly a half-billion-pound import balance during the two decades (see table 1).

## Cotton Consumption Declining Since Late 1960's

Until the late 1960's, cotton was the principal fiber consumed by U.S. textile mills. In 1967, however, cotton's share of the total fiber market fell below 50 percent and by the early 1970's dropped to nearly a third. This compares with almost three-fourths of the market in the late 1940's. Cotton use fell by more than 2 million pounds from the late 1940's to the early 1970's. Accelerating shifts to manmade fibers were responsible for much of the decline in mill consumption of cotton. However, increasing import trade balances precipitated at least part of the decline. The net cotton export balance dropped sharply during the 1950's and was reversed to a net import trade balance in 1960. The cotton net import balance trended upward, peaked at 321 million pounds in 1966, and has remained relatively near that level.

Table 1--Total domestic fiber consumption, 1948-72 1/

| Year | Mill consumption | Textile products | | | Domestic consumption |
|---|---|---|---|---|---|
| | | Exports | Imports | Trade balance | |
| | Million Pounds | | | | |
| 1948 | 6,396.3 | 568.4 | 59.5 | 508.9 | 5,887.4 |
| 1949 | 5,441.4 | 502.6 | 63.9 | 438.7 | 5,002.7 |
| 1950 | 6,836.0 | 347.6 | 108.2 | 239.4 | 6,596.6 |
| 1951 | 6,831.2 | 488.9 | 94.5 | 394.4 | 6,436.9 |
| 1952 | 6,427.3 | 439.0 | 123.6 | 315.4 | 6,111.4 |
| 1953 | 6,473.7 | 392.3 | 111.2 | 281.1 | 6,192.5 |
| 1954 | 6,019.7 | 392.1 | 114.5 | 277.6 | 5,742.0 |
| 1955 | 6,698.6 | 356.0 | 175.3 | 180.7 | 6,517.8 |
| 1956 | 6,530.6 | 352.6 | 207.9 | 144.7 | 6,386.0 |
| 1957 | 6,221.7 | 380.2 | 190.2 | 190.0 | 6,031.7 |
| 1958 | 5,962.1 | 329.3 | 215.6 | 113.7 | 5,843.5 |
| 1959 | 6,834.5 | 320.2 | 333.5 | -13.3 | 2/6,851.2 |
| 1960 | 6,476.7 | 328.7 | 415.7 | -87.0 | 2/6,586.4 |
| 1961 | 6,548.2 | 330.1 | 339.8 | -9.8 | 2/6,575.3 |
| 1962 | 7,029.9 | 315.1 | 486.0 | -170.9 | 7,200.8 |
| 1963 | 7,226.9 | 310.5 | 493.1 | -182.6 | 7,409.6 |
| 1964 | 7,763.3 | 328.7 | 491.3 | -162.6 | 7,925.9 |
| 1965 | 8,478.6 | 315.4 | 596.4 | -281.0 | 8,759.6 |
| 1966 | 8,990.8 | 339.6 | 777.6 | -438.0 | 9,428.8 |
| 1967 | 8,980.8 | 330.0 | 705.6 | -375.6 | 9,356.4 |
| 1968 | 9,781.7 | 326.5 | 813.1 | -486.6 | 10,268.8 |
| 1969 | 9,798.0 | 387.2 | 875.0 | -487.8 | 10,285.9 |
| 1970 | 9,557.2 | 353.7 | 909.0 | -555.3 | 10,112.5 |
| 1971 | 10,667.9 | 385.0 | 1,033.4 | -684.3 | 11,316.2 |
| 1972 | 11,622.9 | 501.4 | 1,186.5 | -685.2 | 12,308.2 |

1/ Total mill consumption of cotton, wool, and manmade fibers adjusted for imports and exports of cotton, wool, and manmade fiber products.

2/ Includes 3.4 million pounds raw cotton equivalent of picker laps and processed waste in 1959, 22.8 million in 1960, and 17.1 million in 1961.

Source: See appendix.

As with total fiber, changes in cotton's trade balance resulted in different trends for mill and domestic use in recent years. The differential was even more pronounced for cotton than for total fiber (see table 2).

## Manmade Fiber Consumption Rising Steadily

Exports of manmade fiber textile products exceeded imports in each postwar year until 1967. The export balance ranged from about 16 million pounds to over 100 million. It trended downward in the mid-1960's, reversed in 1967, and has trended upward since.

In marked contrast to other fibers, domestic and mill consumption of manmade fibers rose steadily after World War II. As with other fibers, domestic consumption increased faster than mill consumption, although the trends were not vastly different--domestic consumption increased nearly five times from the late 1940's to the late 1960's, while mill consumption increased over four times. During the same period, manmade fiber's share of the domestic fiber market increased sharply, from about one-fifth to over one-half (see table 3).

Manmade fibers may be divided into two broad groups--cellulosic and noncellulosic. Cellulosic fibers are produced from cellulose, the fibrous substance of all forms of plant life, which is regenerated into fiber form. Noncellulosic fibers are synthesized exclusively from chemicals, generally having as a base some long chain synthetic polymer (11, p. 3). The most dramatic penetration of the fiber market has been by noncellulosic fibers. While cellulosics have generally retained about 15 to 20 percent of the market, noncellulosics leaped from less than 1 percent in 1947 to over 40 percent by 1970. The increase has been largely at the expense of natural fibers.

Consumption of noncellulosics on a poundage basis has also increased dramatically, rising about fivefold from the late 1940's to the early 1970's. While noncellulosic consumption trended upward steadily from immediately after the War until the middle 1950's, the advent of blended fabrics--especially polyester-cotton blends--around 1962 provided added impetus, and consumption more than tripled by 1968.

## Wool Consumption Falling Since World War II

Both domestic and mill consumption of wool trended downward after World War II. Domestic consumption fell from over one-half billion pounds in the late 1940's to below 300 million by the early 1970's. Mill consumption during the same period trended downward even more sharply, as the long-prevalent import trade balance increased. The import trade balance trended upward during the 1950's.

Table 2 --Domestic cotton consumption, 1948-72 1/

| Year | Mill consumption | Textiles | | | Domestic consumption |
|---|---|---|---|---|---|
| | | Exports | Imports | Trade balance | |
| | Million pounds | | | | |
| 1948---- | 4,463.5 | 453.8 | 16.0 | 437.8 | 4,025.7 |
| 1949---- | 3,839.1 | 384.0 | 18.5 | 366.5 | 3,472.6 |
| 1950---- | 4,682.7 | 258.7 | 40.1 | 218.6 | 4,464.1 |
| 1951---- | 4,868.6 | 388.6 | 33.9 | 354.7 | 4,513.9 |
| 1952---- | 4,470.9 | 337.9 | 32.4 | 305.5 | 4,165.4 |
| 1953---- | 4,456.1 | 291.2 | 44.6 | 246.7 | 4,209.4 |
| 1954---- | 4,127.3 | 290.2 | 48.5 | 241.7 | 3,885.6 |
| 1955---- | 4,382.4 | 262.8 | 87.0 | 175.8 | 4,206.6 |
| 1956---- | 4,362.6 | 254.6 | 108.0 | 146.6 | 4,216.0 |
| 1957---- | 4,060.4 | 278.0 | 95.6 | 182.4 | 3,878.0 |
| 1958---- | 3,866.9 | 250.1 | 112.2 | 137.9 | 3,729.0 |
| 1959---- | 4,334.5 | 236.4 | 172.9 | 63.5 | 2/4,274.4 |
| 1960---- | 4,109.9 | 233.3 | 252.3 | -19.0 | 2/4,232.8 |
| 1961---- | 4,081.5 | 239.2 | 188.9 | 50.3 | 2/4,048.5 |
| 1962---- | 4,188.0 | 220.3 | 309.8 | -89.5 | 4,277.5 |
| 1963---- | 4,040.2 | 207.8 | 304.3 | -96.5 | 4,136.7 |
| 1964---- | 4,244.4 | 213.2 | 300.2 | -86.9 | 4,331.3 |
| 1965---- | 4,477.5 | 173.7 | 360.7 | -187.0 | 4,664.4 |
| 1966---- | 4,630.5 | 189.5 | 510.3 | -320.8 | 4,951.3 |
| 1967---- | 4,423.0 | 188.4 | 443.4 | -255.0 | 4,678.0 |
| 1968---- | 4,416.5 | 188.2 | 473.8 | -285.6 | 4,432.2 |
| 1969---- | 3,933.0 | 232.1 | 487.9 | -255.8 | 4,188.9 |
| 1970---- | 3,815.6 | 199.2 | 463.2 | -264.0 | 4,079.6 |
| 1971---- | 3,946.3 | 226.3 | 492.6 | -266.3 | 4,212.6 |
| 1972---- | 3,841.3 | 290.4 | 610.7 | -320.3 | 4,161.5 |

1/ Total mill consumption of cotton, wool, and manmade fibers adjusted for imports and exports of cotton, wool, and manmade fiber products.

2/ Includes 3.4 million pounds raw cotton equivalent of picker laps and processed waste in 1959, 22.8 million in 1960, and 17.1 million in 1961.

Source: See appendix.

Table 3--Domestic manmade fiber consumption, 1948-72 1/

| Year | Mill consumption | Manmade fiber products | | | Domestic consumption |
|---|---|---|---|---|---|
| | | Exports | Imports | Trade balance | |
| | | Million pounds | | | |
| 1948---- | 1,239.7 | 93.9 | 1.2 | 92.7 | 1,147.0 |
| 1949---- | 1,101.9 | 107.3 | 2.1 | 105.3 | 996.6 |
| 1950---- | 1,518.5 | 81.4 | 4.3 | 77.1 | 1,441.4 |
| 1951---- | 1,478.5 | 92.1 | 4.2 | 87.9 | 1,390.6 |
| 1952---- | 1,490.1 | 95.0 | 3.2 | 91.8 | 1,398.2 |
| 1953---- | 1,523.6 | 96.0 | 4.6 | 91.4 | 1,432.1 |
| 1954---- | 1,508.3 | 96.3 | 4.9 | 91.4 | 1,416.8 |
| 1955---- | 1,902.4 | 87.7 | 7.0 | 80.8 | 1,821.5 |
| 1956---- | 1,727.3 | 92.4 | 8.8 | 83.6 | 1,643.8 |
| 1957---- | 1,792.5 | 97.7 | 9.5 | 88.2 | 1,704.3 |
| 1958---- | 1,764.2 | 74.6 | 13.2 | 61.4 | 1,702.8 |
| 1959---- | 2,064.7 | 78.8 | 33.6 | 45.2 | 2,019.5 |
| 1960---- | 1,874.7 | 90.8 | 31.3 | 59.4 | 1,815.2 |
| 1961---- | 2,054.6 | 86.4 | 23.5 | 62.9 | 1,991.7 |
| 1962---- | 2,412.8 | 90.5 | 30.6 | 59.9 | 2,352.9 |
| 1963---- | 2,775.0 | 97.1 | 36.2 | 60.9 | 2,714.2 |
| 1964---- | 3,162.2 | 108.5 | 50.0 | 58.5 | 3,103.7 |
| 1965---- | 3,614.1 | 129.1 | 79.0 | 50.0 | 3,564.1 |
| 1966---- | 3,990.1 | 140.0 | 123.1 | 16.9 | 3,973.2 |
| 1967---- | 4,245.3 | 133.0 | 138.8 | -5.8 | 4,251.1 |
| 1968---- | 5,305.5 | 129.0 | 193.3 | -64.3 | 5,369.8 |
| 1969---- | 5,552.2 | 146.2 | 257.5 | -111.2 | 5,663.5 |
| 1970---- | 5,501.3 | 147.1 | 329.3 | -182.2 | 5,683.5 |
| 1971---- | 6,534.0 | 146.7 | 451.1 | -304.4 | 6,838.4 |
| 1972---- | 7,570.2 | 177.6 | 480.5 | -302.9 | 7,873.1 |

1/ U.S. mill consumption of manmade fibers adjusted for manmade fiber equivalent of trade balance in manmade fiber textile products.

Source: See appendix.

It was rather stable in the 1960's, so trends for domestic and mill consumption of wool were similar (see table 4).

Wool's losses may be best illustrated by examining its decreasing share of the total fiber market. In the late 1940's, domestic consumption of wool accounted for over a tenth of the total fiber market, but by the 1970's it slipped to just over 2 percent. Mill consumption reflected the relatively stable import situation of the 1960's, falling from about one-tenth of the total to just under 2 percent during the decade.

As substantial differentials exist between wool used for apparel and wool used for carpeting, separate breakdowns are shown on the tables for each. However, as wool has in recent years accounted for less than 5 percent of the total fiber market, no extensive analysis of wool demand is made.

## TRENDS VARY FOR PER CAPITA FIBER USE

To facilitate interfiber comparisons, per capita mill, domestic, and cotton-equivalent consumption are expressed in this section as percentage rates of growth. Glover trends 3/ were fit to the three series for 1950-60 and 1961-71 to make these comparisons (see table 5 and figures 3-5 for comparative growth rates).

On a per capita basis, mill and domestic consumption of total fibers trended downward during the middle 1950's, reflecting greater increases in population than in consumption. In contrast, cotton-equivalent domestic fiber consumption increased slightly, reflecting increased penetration by higher-utility manmade fibers. 4/

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3/ The Glover trend is an exponential trend by which increases or decreases of a variable can be described, independent of units, in terms of a single factor--average annual rate of growth. The formulation is:

$$Y = ar^x$$

Where r is a constant rate of change and x is time.

For a discussion of the Glover trend and other nonlinear trends, see (4, p. 240).

4/ Fibers are converted to a cotton-equivalent basis by taking into account differences in processing waste and the coverage or the amount of yarn obtainable from a pound of fiber. Manmade fibers yield more yarn per pound of raw fiber than either cotton or wool. See (6, p. 126) for a complete discussion of fiber utility differentials.

Table 4--Domestic wool consumption, 1948-72 1/

| Year | Mill consumption | | | Trade balance | | | Domestic consumption | | |
|---|---|---|---|---|---|---|---|---|---|
| | Apparel wool | Carpet wool | Total | Apparel wool | Carpet wool | Total | Apparel wool | Carpet wool | Total |
| | Million pounds | | | | | | | | |
| 1948----- | 485.2 | 207.9 | 693.1 | 14.5 | 7.1 | 21.6 | 499.8 | 215.0 | 714.7 |
| 1949----- | 339.0 | 161.4 | 500.4 | 26.6 | 6.5 | 33.1 | 365.6 | 167.9 | 533.5 |
| 1950----- | 436.9 | 197.9 | 634.8 | 46.4 | 9.9 | 56.3 | 483.3 | 207.8 | 691.1 |
| 1951----- | 382.1 | 102.0 | 484.2 | 40.4 | 7.9 | 48.2 | 422.5 | 109.9 | 532.3 |
| 1952----- | 346.8 | 119.6 | 466.4 | 74.0 | 8.0 | 81.9 | 420.7 | 127.5 | 548.3 |
| 1953----- | 358.0 | 135.9 | 494.0 | 47.5 | 9.4 | 56.9 | 405.5 | 145.4 | 550.8 |
| 1954----- | 269.6 | 114.5 | 384.1 | 46.8 | 8.7 | 55.4 | 316.3 | 123.2 | 439.5 |
| 1955----- | 281.2 | 132.6 | 413.8 | 64.0 | 11.9 | 75.9 | 345.1 | 144.5 | 489.7 |
| 1956----- | 296.7 | 144.1 | 440.8 | 72.0 | 13.4 | 85.4 | 368.7 | 157.5 | 526.2 |
| 1957----- | 240.9 | 127.9 | 368.8 | 67.0 | 13.6 | 80.6 | 307.9 | 141.5 | 449.4 |
| 1958----- | 212.0 | 119.1 | 331.1 | 70.5 | 15.1 | 85.6 | 282.5 | 134.2 | 416.7 |
| 1959----- | 264.9 | 170.4 | 435.3 | 96.9 | 25.1 | 122.0 | 361.8 | 195.5 | 557.3 |
| 1960----- | 246.4 | 164.6 | 411.0 | 98.9 | 28.5 | 127.4 | 345.3 | 193.2 | 538.5 |
| 1961----- | 263.1 | 149.1 | 412.1 | 95.2 | 27.7 | 122.9 | 358.3 | 176.8 | 535.0 |
| 1962----- | 280.2 | 148.9 | 429.1 | 112.3 | 29.0 | 141.3 | 392.5 | 177.8 | 570.4 |
| 1963----- | 251.3 | 160.4 | 411.7 | 125.4 | 21.5 | 147.0 | 376.8 | 181.9 | 558.7 |
| 1964----- | 233.9 | 122.7 | 356.7 | 107.1 | 27.0 | 134.1 | 341.1 | 149.8 | 490.8 |
| 1965----- | 274.7 | 112.3 | 387.0 | 122.6 | 21.4 | 144.0 | 397.3 | 133.7 | 531.1 |
| 1966----- | 266.6 | 103.6 | 370.2 | 117.9 | 16.2 | 134.2 | 384.5 | 119.8 | 504.3 |
| 1967----- | 228.7 | 83.9 | 312.5 | 105.4 | 9.4 | 114.8 | 334.1 | 92.2 | 427.3 |
| 1968----- | 238.3 | 91.4 | 329.7 | 128.1 | 8.5 | 136.6 | 366.4 | 99.9 | 466.3 |
| 1969----- | 219.0 | 93.8 | 312.8 | 112.6 | 8.1 | 120.8 | 331.7 | 101.9 | 433.6 |
| 1970----- | 163.7 | 76.6 | 240.3 | 102.2 | 6.9 | 109.1 | 265.9 | 83.5 | 349.4 |
| 1971----- | 116.3 | 75.2 | 191.5 | 69.7 | 8.0 | 77.7 | 186.0 | 83.1 | 269.1 |
| 1972----- | 142.2 | 76.4 | 218.6 | 50.8 | 11.2 | 62.0 | 193.0 | 87.6 | 280.6 |

1/ Mill consumption of wool adjusted for imports and exports of wool manufactures.

Source: See appendix.

Table 5--Comparative growth rates: 1/ Cotton, wool, cellulosic, noncellulosic, and total fiber consumption, averages 1950-60 and 1961-71

| Item and period | Cotton | Wool | Cellu-losic | Noncellu-losic | Total |
|---|---|---|---|---|---|
| | Average annual percentage change | | | | |
| Domestic consumption | | | | | |
| 1950-60 | -2.6 | -3.9 | -2.1 | +15.4 | -1.6 |
| 1961-71 | -1.0 | -1.9 | +1.4 | +17.7 | +4.0 |
| Domestic consumption 2/ | | | | | |
| 1950-60 | -2.6 | -4.1 | -2.5 | +16.5 | -0.8 |
| 1961-71 | -1.0 | -6.3 | +1.1 | +16.8 | +5.8 |
| Mill consumption | | | | | |
| 1950-60 | -3.2 | -5.5 | -3.1 | +14.7 | -2.2 |
| 1961-71 | -1.7 | -7.1 | +0.9 | +16.8 | +3.5 |

1/ Average annual rates of growth computed by Glover trends fit to per capita data.

2/ Cotton-equivalent pounds.

In the 1960's all total fiber series trended upward. The difference in growth rates for mill and domestic consumption reflects changing trade balances. Differences between trends for domestic and cotton-equivalent domestic consumption illustrate the great impact of manmade fibers in the total fiber market.

Declining fiber use in the 1950's was reversed in the 1960's. Rates of growth for domestic and cotton-equivalent domestic consumption were smaller than for mill consumption in the 1950's, reflecting small manmade fiber use and--particularly in the case of domestic consumption--a net export trade balance for most of the decade. In the 1960's, the relationships were quite different. Domestic consumption grew in relation to mill consumption, reflecting a growing net import balance. The upward shift in the trend of cotton-equivalent domestic consumption relative to the other two series shows sharply increasing use of higher-utility manmade fibers.

All series for cotton consumption trended downward during both decades. A net export trade balance reversed in the 1950's, so the

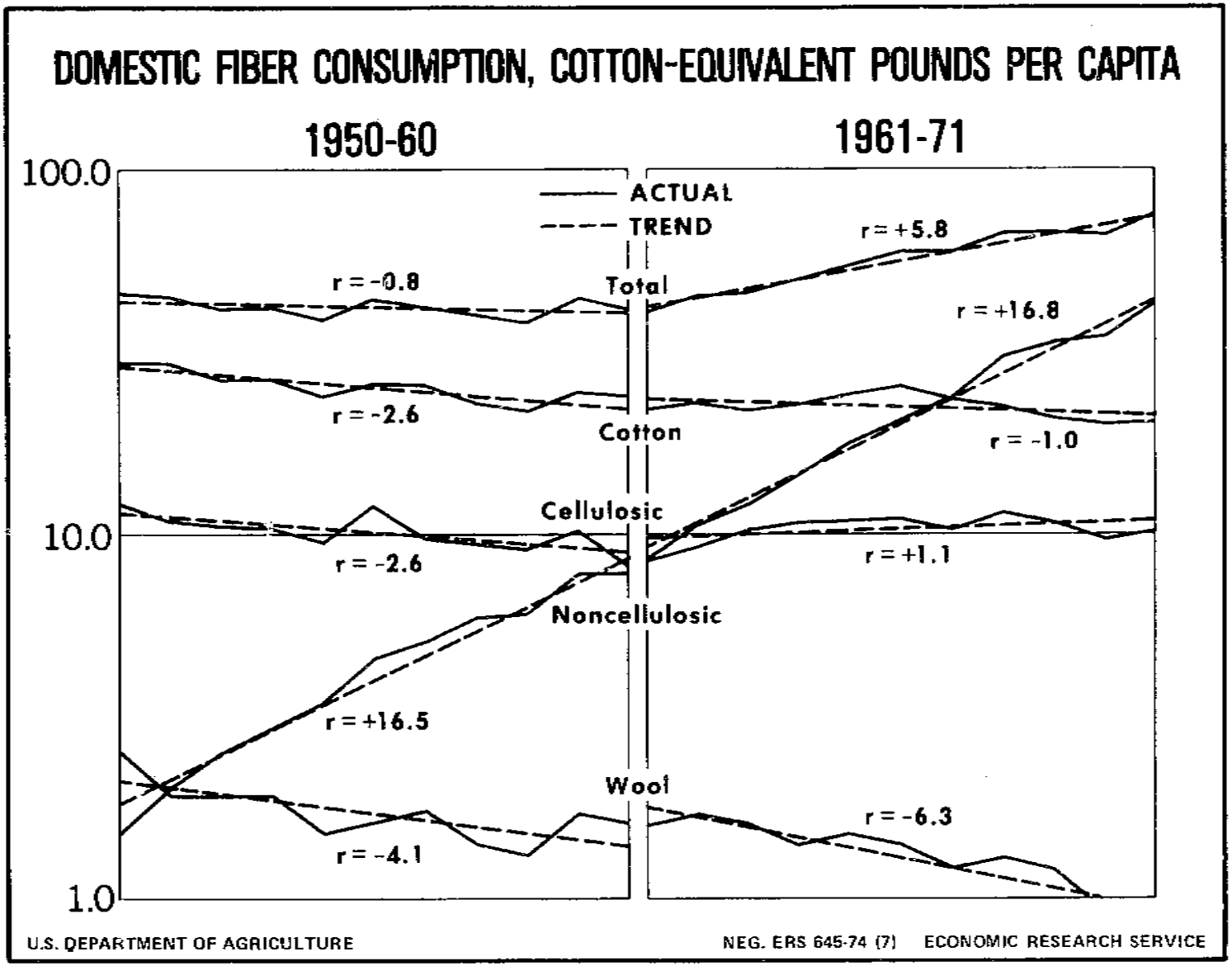
DOMESTIC FIBER CONSUMPTION, COTTON-EQUIVALENT POUNDS PER CAPITA
1950-60
1961-71
100.0
10.0
1.0
ACTUAL
TREND
r = -0.8
Total
r = +5.8
r = -2.6
Cotton
r = +16.8
r = -1.0
Cellulosic
r = -2.6
r = +1.1
Noncellulosic
r = +16.5
Wool
r = -4.1
r = -6.3
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Figure 3

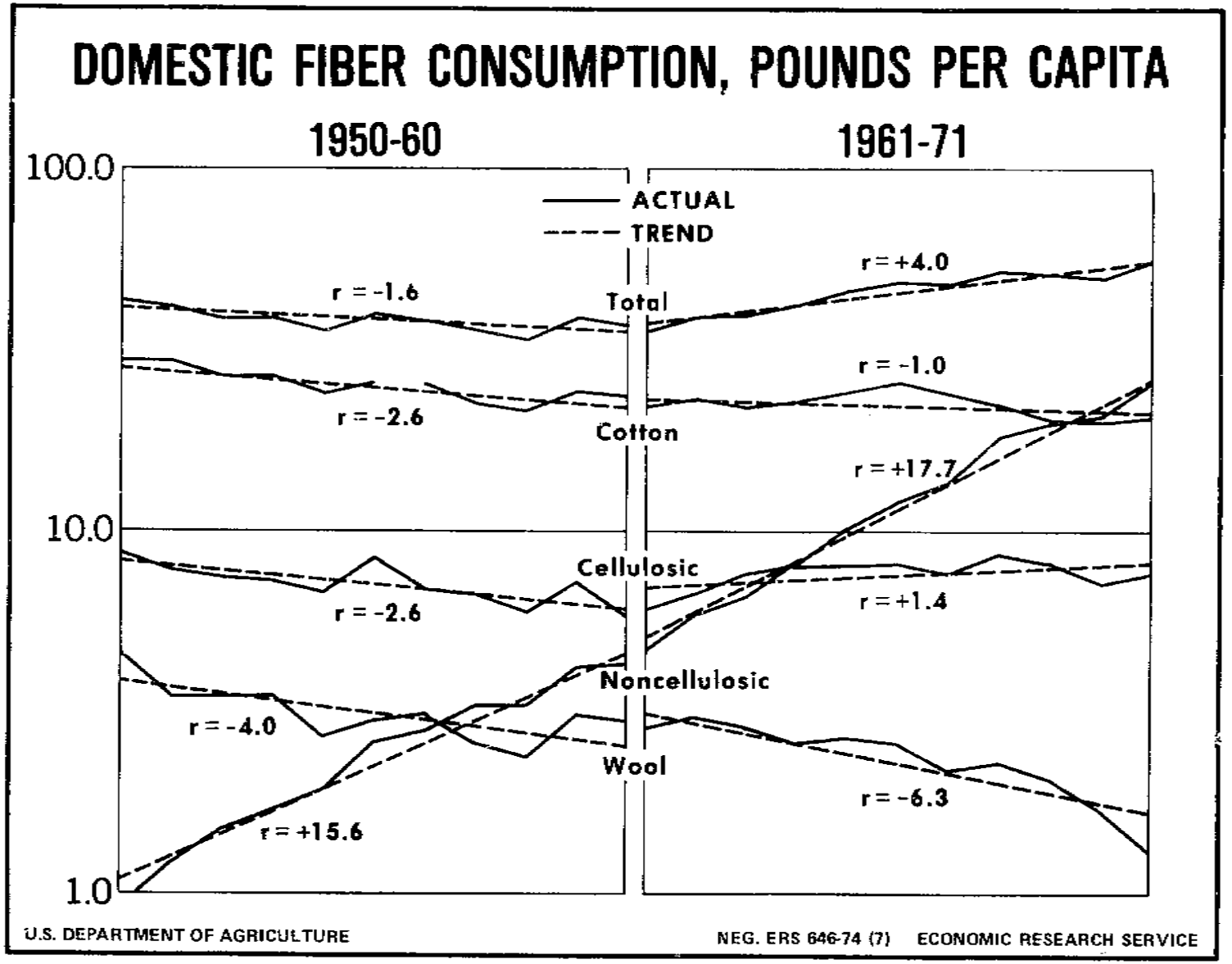
DOMESTIC FIBER CONSUMPTION, POUNDS PER CAPITA
1950-60
1961-71
100.0
10.0
1.0
ACTUAL
TREND
r = -1.6
Total
r = +4.0
r = -2.6
Cotton
r = -1.0
r = +17.7
Cellulosic
r = -2.6
r = +1.4
Noncellulosic
r = -4.0
Wool
r = -6.3
r = +15.6
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 646-74 (7) ECONOMIC RESEARCH SERVICE

Figure 4

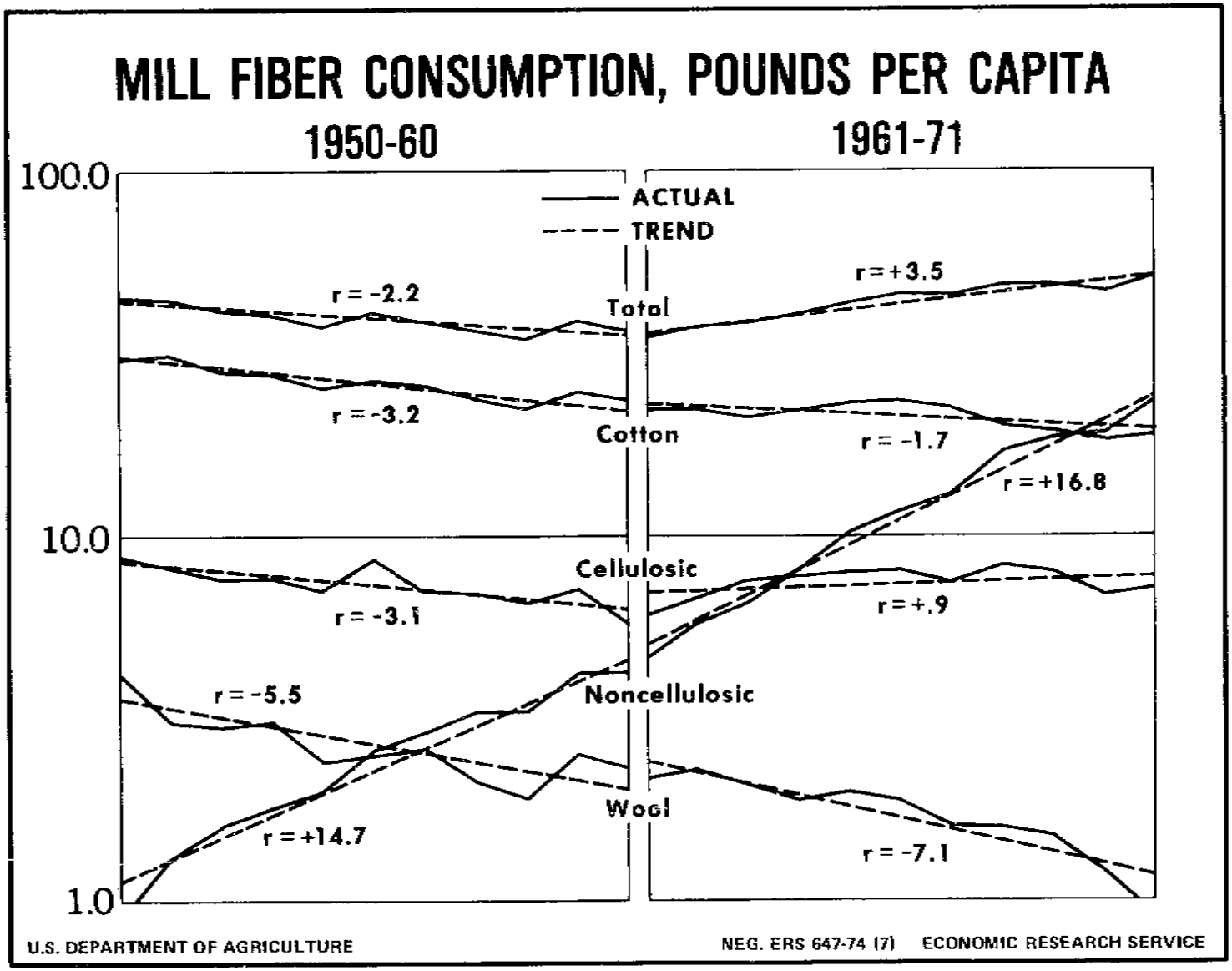
MILL FIBER CONSUMPTION, POUNDS PER CAPITA
1950-60
1961-71
100.0
10.0
1.0
ACTUAL
TREND
r = -2.2
Total
r = +3.5
r = -3.2
Cotton
r = -1.7
r = +16.8
Cellulosic
r = -3.1
r = +.9
r = -5.5
Noncellulosic
Wool
r = +14.7
r = -7.1
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 647-74 (7) ECONOMIC RESEARCH SERVICE

Figure 5

rate of downtrend was slightly higher in the 1960's for mill than for domestic consumption, as textile imports increased. Both series' downtrend was moderated in the 1960's as domestic use declined at a yearly rate of only 1 percent. No adjustment is made on cotton to account for utility differentials, as other fibers are placed on a cotton-equivalent base.

Noncellulosic fiber consumption has shown a slight import trade balance in each decade. In the 1950's, it was the only series which increased. Noncellulosic annual growth has been phenomenal, registering average gains of at least 15 percent for each series. Cellulosic consumption grew slightly in the 1960's in contrast to the downtrend of the 1950's.

Each series for wool consumption trended downward in each decade, reflecting shifts to other fibers and blends. The net import trade balance changed little.

In summary, total per capita mill consumption of raw textile fibers trended downward during the early post-World War II period. However, the volume of fiber available for domestic consumption did not show a similar downward trend. The difference in early postwar trend rates between mill and domestic consumption developed in response to two factors: (1) Sharply declining exports of textile products which reduced mill consumption of raw fibers; and (2) rapidly increasing imports of textile products which tended to reduce mill consumption while increasing domestic consumption. Domestic fiber consumption, which is mill consumption adjusted for imports and exports of textile products, showed a much less pronounced downward trend in the early postwar period than did mill consumption of raw fibers. Another factor tending to reduce both mill and domestic consumption of fiber during this postwar period was the changing composition of the fiber package associated with increasing use of manmade fibers. The conversion of fiber consumption to a cotton-equivalent base increased manmade fiber's percentage of total fiber consumption. And in the last decade, while imports of textile fibers were still tending to increase domestic consumption and dampen mill consumption, increasing use of fibers--primarily noncellulosics--was of paramount significance.

## MANY FACTORS AFFECT FIBER DEMAND

Figure 1 indicates broadly those factors to be considered in studying fiber demand variation over time. However, it does not specify the interplay of economic and other relationships which determine demand at a given time. These relationships are more fully discussed in the economic model presented in (6, p. 112).

The quantity of fiber consumed by mills ultimately reflects final consumer textile demand. Over periods of time long enough

to dampen the effect of stock changes, consumer purchases should about equal mill consumption, if trade balances are discounted. However, in shorter periods, this does not occur, because inventories are held at each level of the production and distribution process to offset anticipated changes in demand.

Four primary levels of demand comprise the textile industry--consumer, retailer, fabricator, and mill. Ideally, all economic relationships affecting each component of each level should, in an economic model, be allowed to interact simultaneously. Thus, purchases by consumers, changes in inventories, work in process at each level, fabric or production output, and mill consumption could be simultaneously determined, along with prices, margins, and inventory imbalances at each level compatible with quantities. Unfortunately, data to complete such a model are not available. Available data are limited to the aggregate data discussed above and some data on consumer consumption.

## Four Sources of Final Domestic Demand

Domestic demand for fibers has been discussed above without reference to final consumption of textile products. There are four sources of final demand for consumer products--foreign, government, industry, and household (fig. 2). As demand for textile fibers is derived from final demand for textile products, some understanding of the relative importance of demand from each of these sources and the nature of products or fiber demanded by each is necessary for analyzing aggregate domestic demand. While data on the composition of each source of demand are not complete, the data available give some insight into final product demand.

End-use data on all fibers are published by the Textile Economics Bureau, Incorporated. The National Cotton Council also publishes estimates of end-use data for cotton. 5/ The Textile Economics Bureau data, which were used in the end-use portion of this study, are available for 1937 and for 1949-70. The estimates break down total fiber use into quantities used to produce textile products in the United States for the following end uses: Men's and boys' wear; women's, misses', infants', and children's wear; household furnishings; other consumer products; industrial uses; and exports of domestically produced products.

Before discussing the end-use data as estimates of final domestic demand, several limitations must be noted. First, as the data are basically production data, they are several steps removed from final consumption. In apparel classes, for example, the estimate of the end-use consumption of fiber is based on cutting, not

5/ Cotton Counts its Customers. The data are available for 1939-70.

consumer purchases. The attempt was "to measure the poundage end use of fibers...at the point nearest the final consumer, at least at the first point where the true end use is determined or determinable." (13, p. 158). Second, the estimates are not adjusted to reflect import or export trade balances of finished textile products, and so may overstate or understate final domestic demand by the magnitude of the trade balance. Third, Government uses are not separated out. Government demand ordinarily would not be important but military use was quite significant during the Korean and Vietnamese wars. Also, the relative importance of military use is probably not evenly distributed among the several categories.

The relative importance of end-use markets is examined at some length later in the report. But at this point, as fiber demand is being traced directly to the consumer, examination of the "chain of demand" is relevant.

Each fiber product is used either by consumers or industry. The primary source of demand is in the apparel and household furnishings categories, which account for over two-thirds of total fiber use. In general, items in these classes are readily identifiable by consumers as textile products. The chain of demand from mill to consumer is long but direct.

"Other consumer products" is a second category. It consists of goods which are also identifiable as textile products but which, between mill and consumer, must go through a nontextile fabricator. Thus, the chain of demand is more indirect than for apparel or household items. This category includes products in which fibers play a secondary role, such as luggage. The demand elasticities would be expected to differ from elasticities for products for which fiber is the principal raw material.

Demand for textiles for industrial uses follows an even less direct route from the mill to the consumer. Some industrial products, such as cables or conveyor belts, are capital goods for industry. Demand for them would be determined by anticipated consumer demand for the particular industry's goods or services. As with the "other consumer products" category, the industrial segment contains some textile items which form part of other consumer goods, such as tire cord. Such products would also be expected to have different demand elasticities than purely textile products.

Ideally, to analyze aggregate fiber demand, one should attempt to isolate and analyze each of the major categories in each end use, thus developing elasticities and cross elasticities for each category. This would call for a distinction between capital and noncapital goods as well as between textile products and products in which fibers play a secondary role, or where demand has little relation to textile content. However, data necessary to perform such an operation are not available.

It is almost impossible to quantify the importance of the above

market breakdowns over time. While the Textile Economics Bureau data give breakdowns of broad end-use categories, many of the end uses themselves could be in textile, nontextile, and industrial uses. Each of these three divisions could be further broken down into capital and consumer goods. The Donald study, making admittedly crude estimates, indicated that about three-fourths of total textile end-use consumption was in textile consumer goods in 1960, with the remainder distributed between nontextile consumer goods and nontextile and textile capital goods (6). An examination of current data, also using crude assumptions, indicates these portions have not changed significantly.

With sources of supply and final demand for fiber delineated, an examination of the history of U.S. fiber use is necessary to gain the perspective necessary for demand analysis.

## Interfiber Competition Based on Price and Nonprice Factors

Cotton and manmade fibers compete for markets on the basis of both price and nonprice factors. Nonprice factors have probably dominated in the past. However, price competition and nonprice competition are often hopelessly interrelated, due to extensive advertising and promotion campaigns by fiber producers, particularly manmade fiber manufacturers and marketers. These campaigns often are tied to fiber prices, and substantial discounts may be given purchasers at all levels between producer and retailer in consideration for joint advertising of a specified brand of fiber.

Price competition implies a drive for profit maximization, but the profit maximization motive itself provides drawbacks to direct interfiber price competition. For two products to compete directly on the basis of price, (1) they must be near or perfect substitutes for one another--that is, the marginal rates of substitution between the two products must approximately equal one, and (2) shifts back and forth between them must be easily made at all levels between producer and consumer. While cotton and manmade fibers may meet the first criterion (with certain very broad reservations), the second provides a much greater obstacle, particularly in the short run. While such substitution can be made without particular difficulty for many products and at many levels, at the mill level it is difficult and time-consuming to change from production of 100 percent manmade fiber to production of 100 percent cotton fiber, or vice versa. Major difficulties may even be encountered in shifting from production of manmade fiber-cotton blends to production of 100 percent cotton fabrics. All of one fiber must be run out of the machines which are changing fiber and the machines must be thoroughly cleaned. This is a major undertaking and naturally quite time-consuming. During the change, neither labor nor machines operate at peak efficiency. So once a mill shifts from cotton to manmade fiber in response to an anticipated price or supply movement, it is unlikely that the change will be reversed unless planners at the individual mill level feel they must do so to avert

a severe profit squeeze or in response to strong consumer demand. This explains in part the apparent difficulty cotton experiences when attempting to recover markets in a specific end use once it has been displaced. That is, the change is in response to anticipated longrun factors, and profit maximization drives would tend to counter the shutdown necessary to move back to cotton. This would also explain any lack of direct competitive shortrun responses by cotton and manmade fibers to seasonal price fluctuations.

Cotton suffered its greatest loss to other fibers in 1968; high cotton prices and a short-supply scare in late 1967 precipitated substantial mill-level shifts to manmade fibers. Although supplies proved to be generally adequate and prices fell in subsequent years, cotton did not recover the markets it had lost. And in 1972 and 1973, the pattern was repeated. These observations support the hypothesis, discussed at greater length in a later section, that cotton demand is inelastic in the short run, particularly when cotton prices are declining. In the long run, however, demand would be expected to be less inelastic and may even be elastic with respect to price.

At this point, a short discussion of comparative prices is relevant. Cotton and manmade fiber do not compete on a pound-for-pound basis due to different waste factors, different amounts of raw fiber required for a pound of cloth, and the effect of technological expansion (discussed later in this section) on the total fiber market. However. ignoring the effect of technological expansion, fibers may be converted to a base which reflects final utility--that is, one may estimate the final yardage of cloth which can be obtained from a pound of a specific raw fiber. The actual levels of fiber use may be adjusted or the prices themselves may be adjusted to reflect different utility factors. If one adjusts fiber prices and examines them, it is immediately apparent that the prices of manmade and natural fibers have recently converged(fig.6). In 1960, for example, the price differential between the producer list equivalent price for polyester staple and the mill price of cotton was about 65 cents per pound. By the end of the decade, the differential had narrowed to 16 cents. And if one adjusts the prices to reflect utility differentials, and considers in addition to the adjustments manmade fiber manufacturers' reported discounts in recent years of as much as one-fourth, there is obviously little real difference in fiber prices.

This implies that if cotton could develop such characteristics as a satisfactory durable press and increase its substitutability for manmade fibers, or could achieve greater price stability and favorable price differentials in the long run, demand for cotton and its competitive position could improve.

Natural and manmade fibers also compete widely on the basis of nonprice factors. The manmade fiber-producing industry constantly strives to develop new fibers with characteristics appealing to consumers, or with specific properties applicable to industrial use.

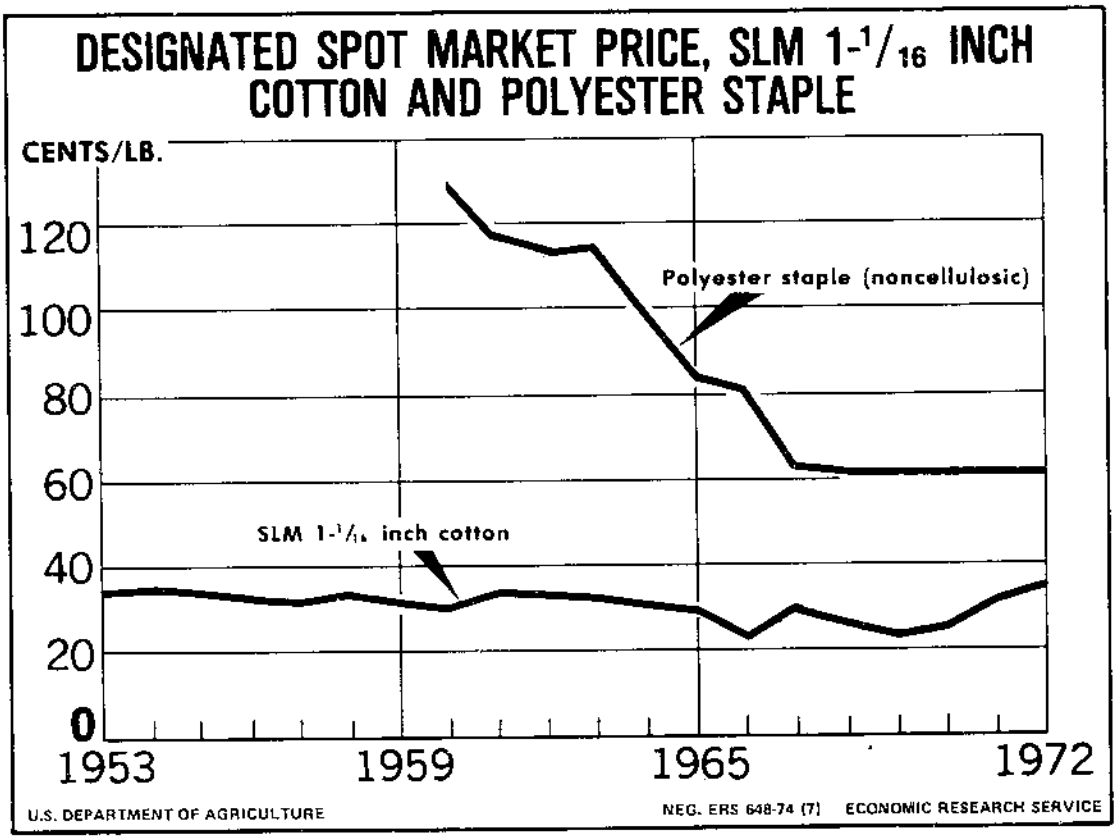


Figure 6

Fast-drying and shape-retaining fabrics have been developed from fibers such as polyester for specific consumer-oriented end uses. Industry has benefited from such products as nylon rope which is reportedly lighter and stronger and longer wearing than cotton or manila. Once such characteristics are developed, they are used in promotion. The value of the fiber properties is vividly demonstrated to consumers, and demand is thus created or augmented.

Research and development expenditures on fibers greatly affect consumption, particularly of manmade fibers. Such expenditures have been sharply greater for manmade than for natural fibers. 6/ But although natural fibers lagged far behind in this respect for many years, the gap may be closing. Researchers are presently trying to increase the percentage of cotton in blends and develop satisfactory washable woolen products. Flame resistance has been imparted to many fibers, both natural and manmade. While some research is privately funded, recent legislation provides substantial sums for natural fiber research and development. Under the auspices of the Cotton Research and Promotion Act of 1966, upland cot-

6/ For example, in a speech before the National Cotton Council in St. Louis in January 1974, the president of Cotton Incorporated stated that Dupont spent $28.5 million on fiber research in 1973.

ton producers are assessed $1 on each bale of cotton they market. The money is earmarked for research and promotion. In addition, the Consumer and Protection Act of 1973 authorizes the Secretary of Agriculture, at his discretion, to make available up to $10 million more. While cotton faces the handicap of late entry into research, development, and promotion fields, these sums are enhancing its competitive position. Although Government-sponsored money is fractional compared with the reported $250 million spent by the manmade fiber industry in 1968, no single manmade fiber has duplicated all of cotton's inherent desirable characteristics--comfort, absorbency, dimensional stability, and appearance, to name but a few. These factors may begin to be of increasing importance in maintaining demand for cotton, especially in an informal and leisure-oriented society. This idea is supported by the recent strong demand for cotton jeans and similar clothing.

Closely allied with research and development is promotion. In the past, producers of manmade fibers extensively promoted their special characteristics, spending perhaps 20 to 30 times as much as natural fiber producers. Such expenditures may have reached or exceeded $100 million in 1968, according to the Cotton Producers' Institute (3, p. 18). Promotion has stressed manmade fibers as new products with glamorous properties. However, under the above-mentioned Government programs, promotion of natural fibers is expected to increase. This promotion may stress primarily those inherent characteristics of natural fibers that manmade fibers have found difficult to imitate. In addition, for cotton, fashion is currently heavily emphasized.

The availability and quality of supply is important in determining fiber demand, particularly at the mill level. Generally, this has been an advantage for manmade fiber in competition with natural fibers. Prior to the energy shortage, mills were generally assured of a predictable supply of manmade fiber of a constant quality and at relatively stable, predictable prices. However, production and quality of cotton is less dependable. Such factors as weather, insects, and Government programs, none of which can be predicted with certainty, affect quality, quantity, and prices of cotton (7).

Blending two or more fibers allows certain desirable properties of each to be retained. As a result, a fiber may lose part of an end-use category earlier considered its exclusive domain. An often-cited example of this is the bedsheeting end use. This outlet traditionally accounted for over 500,000 bales of cotton. It has been shifting toward blends, apparently because they retain most of the feel of cotton while the polyester supports a durable press finish. In 1968 alone, although blends used in bedsheeting contained about 50 percent cotton, the shift to blends caused total cotton used in bedsheeting to fall over 6 percent (1, 5).

Finally, as in any market operation, psychology plays a major role in determining cotton demand in relation to demand for manmade

fibers. This psychology may operate at the mill, wholesale, and retail levels. Traditionally, mills have shifted to manmade fibers when they anticipated problems with cotton supplies, longrun higher prices, or shifts in consumer demand. Currently, mills may shift back to cotton in anticipation of longrun shortages of petrochemicals. Once such a shift is made, the profit motive discussed above moderates a reversal, even if the anticipated structural change fails to materialize. At the wholesale level, anticipation of consumer preference affects buying patterns. At the consumer level, certain promotional undertakings affect the substitutability of various fabrics or fibers. Of all nonprice variables, market psychology is the most difficult to measure. One can only note that cotton buying by the U.S. consumer has not increased proportionately to purchasing power.

Although the actual effect of consumption of one fiber on another or on the aggregate cannot be statistically measured, some comments are in order. Tastes and preferences at the consumer level, shaped largely by promotion at the producer or retailer level, are often important in determining demand for a particular product. Another facet of interfiber competition has received insufficient attention--the fact that markets may be expanded by the effect of technological advances. This may, in many instances, provide a great stimulus to demand, especially in a technologically advanced, high consumption economy.

Technological market expansion, for the purposes of this study, refers to expansion of a particular market which is elicited solely by advances in the technology of production or distribution of a product. Any market expansion is, of course, affected by such traditional demand variables as income, population, and price. The technological market expansion could be conceived of as adding to the effect of these variables. This is conceptually near the idea of created demand proposed by Galbraith (8). It can be characterized as an improved or substitute production which enlarges a traditional market with rather sharply delineated boundaries, rather than a product which is created and for which a market is achieved through promotion.

One of the best examples of technological market expansion is provided by recent textile demand. Traditionally, the fiber market was the exclusive domain of natural fibers. Cellulosic fibers were created. They competed somewhat with natural fibers, largely on the basis of price. Then noncellulosic fibers were developed, which were suitable for a great variety of end uses and for some uses were superior to natural or cellulosic fibers. As noncellulosics came into greater use, total fiber use began to increase very rapidly, exceeding any earlier responses elicited by the traditional demand factors. It seems logical that some of this increase resulted from the manmade fiber technology itself. Use of carpeting, as a general example, leaped as manmade fiber technological advances provided a fiber well suited for carpets in abundant supply at attractive prices. Income, availability, and price were

somewhat important in the increasing use of carpeting, but perhaps more important was the suitability of the noncellulosics for this end use.

In past discussions of interfiber competition, reference was often made to the displacement of cotton in its traditional markets, or of cotton's failure to expand as fiber markets expand. This displacement was then "proved" by citation of data on fiber consumption which show that cotton, as a percentage of specified end uses, is declining or failing to expand with the market. This was attributed directly to manmade fiber's penetration of cotton's markets. Although it is true that substantial amounts of cotton were displaced by manmade fibers in each major category of end uses, such an argument is now at least open to some question. Certainly, it overstates the effect of manmade fibers on cotton demand, if we assume that manmade fiber technology has caused fiber use increases beyond what could have been realized in its absence. It is impossible to determine how much a specific market has been increased, but it seems unlikely that all markets have been similarly affected.

## AGGREGATE FIBER DEMAND ANALYZED

As indicated earlier, domestic consumption of all fibers varied widely over the past three decades. Consumption rose sharply in the 1940's, largely reflecting purchases by the military during World War II. Consumption declined slightly after the war, rose during the Korean War, and fell slightly in the mid-1950's. Then, in the early 1960's, fiber use snowballed, surpassing all prior per capita records. These fluctuations and the subsequent uptrend reflected, among other things: changes in fiber price relationships, changes in tastes and preferences, varying levels of military activity, and the advent of new and improved products made possible by fiber research, particularly by the manmade fiber producing industry.

A close examination of fiber use data reveals both longrun and shortrun fluctuations in fiber demand over the past two decades. Longrun variation is indicated by the direction of change over time, while shortrun variation may be seen in deviations from trends. Changing levels of consumer income and prices or fashions may precipitate shortrun or year-to-year fluctuation in fiber demand. Longrun shifts in demand are generally associated with such factors as the level of disposable income and shifts in tastes and preferences usually due to changes in the composition of the population. Unfortunately, not all of these factors can be measured. Industrial activity, consumer income, and population may be accurately reflected, while climate, fashion changes, new products, and increasing leisure time may not, although they may be as important as those factors for which data exist. An additional factor is a reported trend toward wearing of lighter-weight garments, which

tends to reduce fiber use. The prevalence of factors which cannot be measured suggests that statistical evaluation should be approached through some type of dynamic model which specifies consumer behavior in one period as depending both on economic factors and past behavior.

Purchases by final consumers ultimately determine final fiber consumption. Thus, changes in final purchases will be reflected at each stage of the marketing-production chain. In analyzing final demand it would be desirable, because of the implicit interrelationships involved in and between each stage in this chain, to statistically fit a model which would allow for interaction of the variables at each successive fabricating, marketing, or distribution level. The model would thus simultaneously reflect quantity purchased by final consumers, changes in inventory levels and work in process, fabric and product output, and quantity of fabric consumed by mills. However, data limitations preclude such an approach.

In traditional demand analysis, personal disposable income is generally used as the demand shifter. In analysis of a major component of consumer purchases, such as fiber, one might expect the level of real disposable income to be the factor with the greatest bearing on aggregate demand. History bears this out, to some extent. Substantial growth in per capita disposable income in the 1960's closely paralleled substantial increases in fiber consumption. The high correlation between income and total fiber consumption may be seen in figure 7. The dot chart implies a major structural change in the early 1960's.

Implicit in changing income is change in the sociological and demographic composition of the population. Metropolitan-area residents earn more than nonmetropolitan-area residents. During the 1960's, the total population of the United States increased 12 percent while population within metropolitan areas increased 15 percent. During the same period, unemployment rates were cut by about one-half. Also, from 1959 to 1968, the proportion of the population below the poverty level dropped from 22 to 13 percent (15). Although the rise in per capita income was partially dependent on these population shifts, the shifts themselves are not inherent in increased per capita income levels. That is, as income distribution becomes more equal throughout the economy, consumption of most items would be expected to rise. Although the effects of these shifts cannot be precisely measured, they would have affected fiber demand positively. This implies that if the projected increases in income transpire and more people move above the poverty level, on an aggregate basis the effect of any diminishing marginal utility for fibers with respect to income may be postponed. For example, a guaranteed annual wage or a negative income tax would be likely to increase fiber use.

Another important demographic factor is population and its age-sex composition. Growth in aggregate population, of course, portends growth in demand for products, goods, and services. A

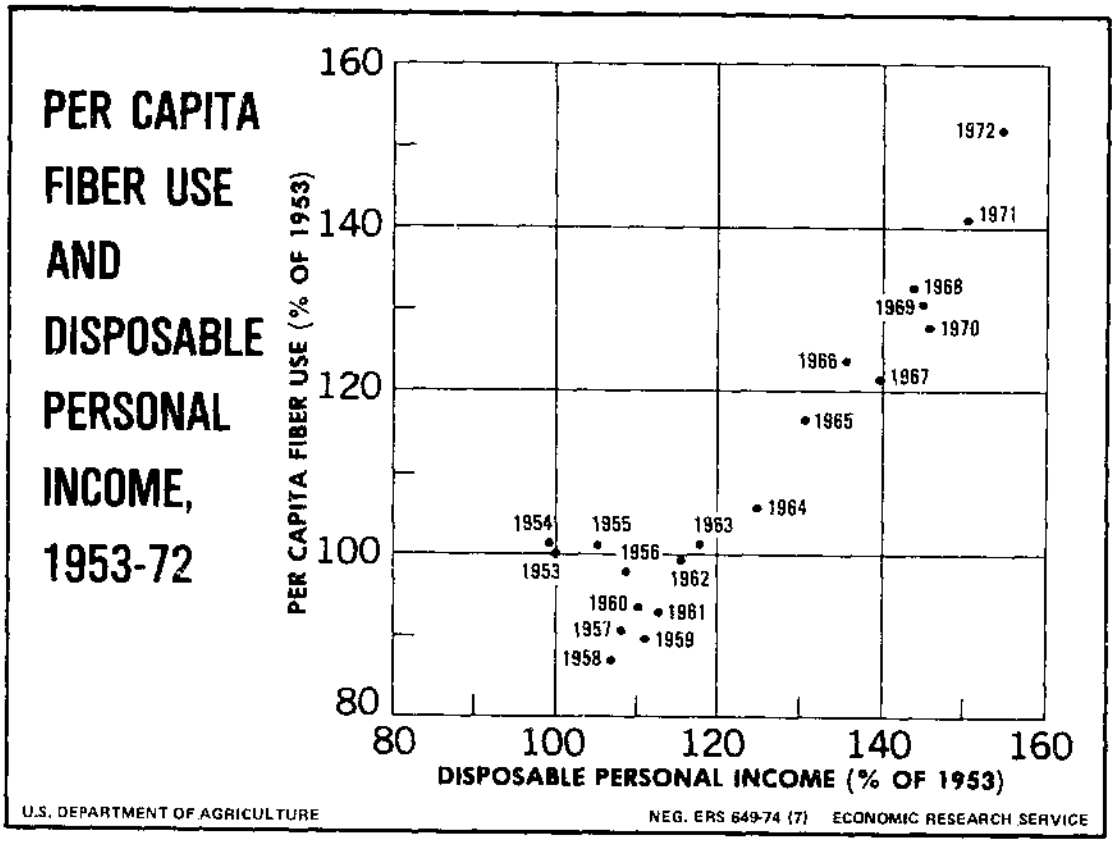


Figure 7

growing population stimulates economic growth, which leads to higher income levels. The effect of population level is accounted for by adjusting income to a per capita basis. The age-sex composition of the population also affects fiber demand, since certain segments spend more of their income on apparel or other textile products. For example, the movement of large numbers of postwar babies into high consuming, family-starting groups contributed to accelerating fiber use in the 1960's.

Year-to-year changes in income probably influence shortrun demand for fiber. As income rises or falls from year to year, consumers would be expected to increase or decrease purchases of durable or semidurable goods. They might maintain inventories, living from them as income falls or prices rise and replenishing them as income increases or prices fall.

Price levels generally affect demand. Theoretically, increased fiber prices cause purchases to be postponed or foregone. Donald used actual prices to obtain a total weighted fiber price (6). Ward computed indexes using BLS (Bureau of Labor Statistics) indexes. But in general, attempts to measure direct price elasticities have been disappointing.

Aggregate fiber demand may not respond to price changes for specific fibers, for several reasons. First, certain textile products complement industrial goods. For example, the price of automobiles may influence tire cord demand more than the price of nylon. Second, among other end uses such as apparel, substitution of less expensive for more expensive fibers may occur. In addition, consumers may shift to lower quality products as prices rise rather than reduce quantities and lower final consumption levels. Third, in a period of economic expansion, such as that experienced in the United States during the past decade, demand for all products increases. And finally, manmade fiber producers frequently sell fiber at substantial discounts, so list prices do not accurately represent costs of fibers.

Thus, it is difficult to develop a weighted price index which reflects the actual relationship among fibers and other goods. If an index is computed, it depicts a rise in fiber prices during the 1960's due to continuing shifts from generally lower priced cotton and rayon-acetate to higher priced noncellulosic fiber. Such a trend practically assures that in regression analysis, the coefficients obtained from a price-level variable will be small, statistically insignificant, and may even have the positive sign. Initially, this might suggest that fiber prices play a small role in determining aggregate demand and thus should be excluded from analysis. However, such results may only mask the cross-price elasticity between fibers and other products, not render the own-price elasticity for fibers insignificant.

Inventory imbalance at the mill level affects fiber demand. As the textile industry is essentially a forward-ordering industry, stocks of products are held at the various levels of fabrication and distribution. When mill stocks are increased or decreased in relation to anticipated changes in consumer demand, an inventory imbalance develops, which causes mills to decrease or increase output until balance is restored. 7/ The available stocks-to-unfilled orders ratio is for broadwoven goods. As the relative importance of broadwoven goods as a component of total fiber demand declines, as it did in the 1960's, the importance of the stocks-to-unfilled orders indicator lessens.

Donald, Lowenstein, and Simon (6, p. 55), in attempting to derive price elasticities for fiber and project domestic use, explained 96 percent of the variation in total fiber consumption during 1927-60 by relating total domestic fiber consumption in cotton-equivalent pounds to per capita disposable real income, year-to-year change in income, the ratio of stocks-to-unfilled orders of cotton broadwoven cloth, a weighted fiber price index, and time beginning in 1950. Unfortunately, when current data were added, the equation was no longer satisfactory.

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7/ For a more complete discussion, see (6, p. 62).

The price and time variables were insignificant in the updated analysis although the coefficients of all variables were roughly the same as in the earlier equation. The size of the coefficient for year-to-year change in income declined slightly. This may partially reflect declining importance of consumer inventories in the 1960's. While the stocks-to-unfilled orders variable was still significant, cotton broadwoven goods have declined in importance until they currently represent substantially less than half the total fiber market. It is thus very hard to interpret the coefficient for the stocks-to-unfilled orders variable, particularly since the size increased slightly. Additionally, the Durbin-Watson test was unsatisfactory. The insignificance of the price and time variables, the questionable value of the inventory imbalance variable, and the presence of strong serial correlation in the unexplained variation pointed out the need for additional analysis.

There seems little justification for grouping pre- and post-World War II factors, especially in light of developments in the 1960's. Since the Korean war caused distortions which would probably bias estimates, the period of primary consideration became 1953-70. A new price index ($P^{TF}$) was computed and deflated. It is the same as the one described above but uses the price of polyester staple as representative of noncellulosic staple fiber rather than nylon after 1958, as polyester has declined in price and become more significant in the total fiber consumption picture than nylon staple. This price series was run in a regression with the deflated level of personal disposable income ($Y_d$) related to total domestic cotton-equivalent consumption ($C_t^{TF}$). Figures in parentheses are computed t values for the regression coefficients.

$$\underset{}{\text{Log } C_t^{TF}} = \underset{}{0.88} + \underset{(10.38)}{0.86} \text{ Log } Y_d + \underset{(1.46)}{0.51} \text{ Log } P_{t-1}^{TF}$$

$R^2 = 0.91$
s.e.e. = 0.03
d.w. = 1.29

This formulation explains over nine-tenths of the variation in total fiber consumption from 1953 to 1970. However, it is both statistically and economically unacceptable. The Durbin-Watson statistic indicates that serial correlation may be present in the residuals. The price coefficient is positive. The sign of the income coefficient is correct, and the coefficient itself appears reasonable--an indicated 8.6-percent increase in consumption is elicited by a 10-percent increase in income. But correlation of income with fiber consumption during the 1960's is of scant value. Both are about as highly related to time as to each other.

It has been hypothesized that the cross-price elasticity between aggregate fibers and all other commodities was overshadowed in regression analysis by factors such as income. The positive sign of the price coefficient reinforces this hypothesis. Thus, attempts to develop coefficients which meaningfully measure struc-

tural relationships for total fiber demand by regression analysis failed. But a second consideration of this study was to develop methods to project future demand. To effectuate the best possible estimating equation, the errors of the estimates must be minimized. If this is to be done, a variable of such theoretical importance as price cannot logically be omitted. So to achieve the best possible estimates of fiber consumption, a real-price approach was selected. The justification for such an approach lies in indifference theory. Obviously, if elasticities of substitution between two product groups are low, an increase in income or a decrease in price effectively lowers the real cost, or cost as a percentage of income, to the consumer. For example, he may be as well off with a 10-percent decrease in price of an important commodity as with a 1-percent increase in income. Any change in either price or income not matched by a proportionate change in the other would alter the consumer's purchasing powers and be translated into changes in his product consumption "mix."

Thus, to analyze fiber consumption in terms of real price, the total fiber price index described above was deflated by an index of personal disposable income and related to consumption. The resulting equation explained about four-fifths of the variation in total fiber consumption during 1953-70. The residuals from this equation were then plotted against other variables.

Year-to-year changes in income were highly correlated with the unexplained variation in the 1950's, but uncorrelated during the 1960's. This would indicate that consumers respond to changes in income by either increasing buying and thus stocks of textile products when income is rising or by decreasing buying and thus stocks when income falls. It further indicates that in the 1960's, the importance of stocks decreased, as income changes were always in the same direction. Also, during the 1960's, rapidly changing fashions and relative consumer affluence undoubtedly influenced the declining importance of old apparel stocks.

When year-to-year changes in income during 1953-59 were introduced along with the real price, about 85 percent of the variation in demand during 1953-70 was explained. While more variation was explained, the Durbin-Watson test indicated strong serial correlation in the unexplained variation. The residuals themselves manifested a strong uptrend, beginning in the early 1960's. This of course reflects factors contributing to increased fiber use in the 1960's such as the development of permanent press and rapid fashion changes, discussed at length in the earlier section on interfiber competition. So the next formulation included time beginning in 1961, along with the real price variable and year-to-year change in income during 1953-59.

The resulting equation explained 97 percent of the variation in total fiber use during 1953-70. All coefficients were significant at the 5-percent probability level with the expected signs. The real price coefficient indicated that a 10-percent real price

change elicited a 4-percent inverse response in fiber consumption, which appeared fairly reasonable. However, the Durbin-Watson test remained inconclusive.

While the ratio of stocks to unfilled orders of cotton broadwoven goods was discounted as a useful stock change variable, consumer stocks are still of some importance. Consumer purchases of textile products in one year affect purchases in subsequent years. In the equation below the dependent variable, lagged one year, was introduced to reflect consumer stock changes.

$$\text{Log } C_t^{TF} = 1.65 - \underset{(2.53)}{0.38} \text{ Log } P^{TF}/I_{t-1} + \underset{(3.55)}{2.34} \text{ Log } \Delta Y_{d_{53-59}}$$

$$+ \underset{(1.40)}{0.19} \text{ Log } C_{t-1}^{TF} + \underset{(4.70)}{0.15} \text{ Log } T_{61-70}$$

s.e.e. = 0.02
$R^2 = 0.97$
D.W. = 1.61

This equation explained 97 percent of the variation in total domestic fiber consumption for the 1953-70 period. All coefficients except for the lagged dependent variable were significant at the 5-percent level. However, as the coefficient was greater than its standard error, it was retained, since the primary purpose of the equation was projection. This procedure minimizes the estimated variance of the projection (9, p. 7). Inclusion of the lagged dependent variable effectively gives a dynamic equation. Fiber end products are, as stated above, semidurable goods, generally with a life of less than 3 years. Inclusion of the lagged dependent variable reflects the effect of earlier purchases on current purchases.

The equation indicates a 10-percent change in the real price of fibers results in a 3.8-percent inverse change in fiber use.

The statistical fit of the equation is shown in figure 8. The raw data are presented in table A-1.

## FACTORS AFFECTING DEMAND FOR INDIVIDUAL FIBERS

As earlier indicated, this study hypothesizes an aggregate level of demand for fiber. The hypothesis can be justified, despite the myriad fiber types and constructions with resultant wide range of fiber costs to consumers, because of the high degree of substitution among various fibers. Once this aggregate level is determined, it must be apportioned among various fibers by consideration of competitive factors such as prices, utility, and wear-

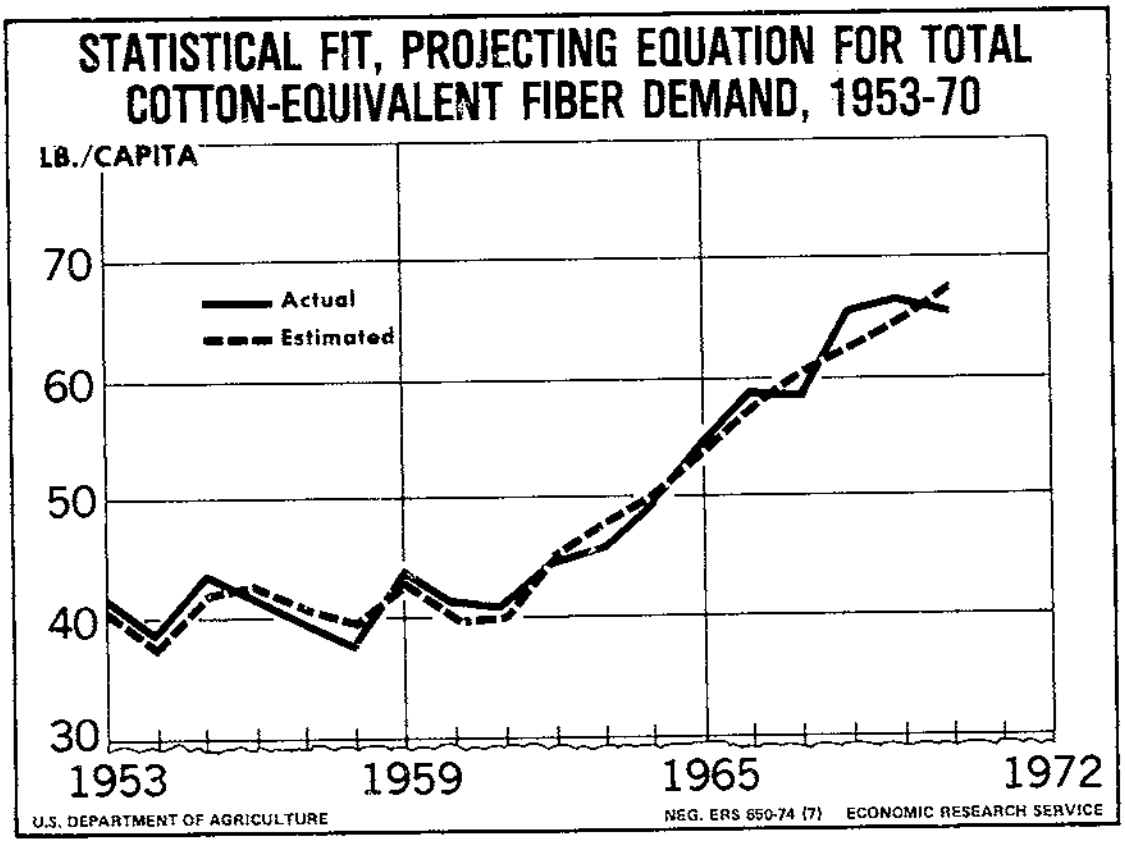


Figure 8

ability. This section will identify the competitive forces to which individual fibers react.

In projecting use of individual fibers, one might relate a fiber to income, the price of the fiber, the price of competing fibers, and other specialized demand variables relevant to the particular fiber. However, regression analysis was unsatisfactory when this approach was followed, so nonregression methods were necessary to achieve projections. The sections below identify factors which theoretically would influence demand, but which cannot be satisfactorily specified or measured.

## Cotton Markets Penetrated by Manmade Fibers

Traditional analyses usually related cotton demand to a long-run demand shifter (income), own-price (deflated by some price index), and other variables peculiar to cotton. This implicitly assumes a demand for cotton per se rather than demand for cotton as an increment of total fiber demand. A decade ago, this was not patently unreasonable. But today, cotton no longer dominates the fiber market. Emphasis today must be placed on competition among or between fibers. Waugh analyzed cotton consumption using a dis-

tributed lag specification for a cotton-rayon price ratio, but stopped short of conceptualizing an aggregate fiber demand (17). In an attempt to achieve a price elasticity of demand for cotton, this analysis of cotton demand began similarly.

As earlier indicated, cotton demand trended slowly downward in the past two decades as total fiber use increased. The downtrend apparently was largely due to substitution of manmade fibers, particularly noncellulosic fibers, for cotton in many end uses (2). Because of this, a ratio of noncellulosic price to cotton price was used to reflect price competition. As the price of noncellulosic fiber declines with respect to cotton, one would expect more cotton to be replaced by noncellulosic fibers. Income was initially introduced as the demand shifter and thereafter, total demand for fibers was used as a variable to reflect aggregate demand and all other unspecified macroeconomic factors affecting cotton use.

Finally, an inventory imbalance variable was used. As a complete explanation of this variable may be found in the Donald study (6), only a few brief comments are necessary here. The textile industry for the most part is a forward-ordering industry. At each level of fabrication and distribution, orders are placed and/or received for delivery of goods in the future. Order backlogs are created and inventory is necessary. However, when inventories of products are being built up at any level of marketing, the increments represent an increase in demand for fabrics, and hence for fibers, over and above current consumption. Inventory imbalances caused by errors in adjusting sales or production to inventory arise at various levels of marketing. They probably originate at the retail level and are magnified at each level back to the producer. Although changes in inventories at the various levels are related to expected prices, prices alone would not be expected to account for effects of inventory imbalances or unplanned changes in inventories on demand for fibers.

As inventory data are not available for statistical analyses at various levels of fabrication and distribution, it is not possible to measure the effect that changes in inventory demand at these various levels have on domestic demand for cotton. However, data are available for inventories of cotton broadwoven goods held by textile mills. These data were used by Donald (6, p.66) and by Lowenstein (10) to explain variation in cotton consumption. The level of inventories and concurrent mill demand for raw fibers were highly correlated.

A ratio between inventories and unfilled orders reflects the degree of imbalance between stocks, output, and demand at the mill level. When the ratio is relatively high, unless an increase in demand is forthcoming, a downward adjustment in mill consumption to reduce stocks is indicated. Conversely, a relatively low ratio would indicate a higher rate of consumption in the near future. The lag was found to be 5 months. Also, some inventory is necessary for mills to function properly and efficiently. The amount

of inventory not considered excessive may vary directly with the volume of business, so that a relatively constant ratio between the two is sought. Whether mill stocks of cotton cloth are too high or too low at a given time probably depends more on the amount of business expected in the near future--reasonably approximated by the level of filled orders--than on past volume. All analysis indicates that the inventory imbalance variable was substantially reliable as a short-term indicator through the 1960's. And the analysis indicated no change in the 5-month lag.

However, efforts to relate domestic cotton consumption to the traditional demand variables failed. This necessitated a nonparametric device for estimating. Barlowe has successfully described trends in mill consumption of cotton in terms of a Gompertz curve (3).

Essentially, the Gompertz curve depicts a trend in which, for our purposes, the increments of decline in the logarithms are declining by a constant percentage. So the natural values of the data show a declining ratio. The logarithmic form of the equation for the Gompertz curve, which is fully explained in Croxton and Cowden (4), is:

$$\log Yc = \log k + (\log a)b^x$$

According to Prescott (12, pp. 471-75), when the growth increments of the trend are positive, or when log a is negative and b is less than 1, the shape of the trend reflects the growth of many industries. He divided the stages of growth into four increments:

(1) Experimentation
(2) Growth into the social fabric
(3) Increasing growth at a diminishing rate
(4) Stability.

However, cotton demand has not been growing, so the above explanation is inappropriate. But where the trend is declining, or when log a is positive and b is less than 1, one might speak in terms of decay, or of penetration of a market by a substitute fiber. The stages might then be as follows:

(1) Experimentation: The substitute product is high in price, limited in supply, and in a state of technological development, although not feasible for present widespread use.

(2) Decay begins as the substitute product moves into markets formerly held by the older product. Here the new product becomes, in terms of supply, price, and technological feasibility, a reasonable alternative to the older product. The rapidity of displacement depends on factors such as the product's acceptance by the consuming public

and the product's inherent characteristics.

(3) Decay continues at a decreasing rate. The substitute product has made substantial displacements of the older product, and the rate of displacement slows. Nevertheless, some substitution continues.

(4) Stability: Generally, feasible displacement has taken place and the older product holds a significantly smaller share of the market than in stage 1, above.

The above stages seem particularly germane to cotton demand. Read "cotton" for "older product" and "noncellulosic fiber" for "new product," and you have a good description of how noncellulosics displaced cotton in consumer markets over the past two decades. The "fit" of the curve to cotton demand is shown in figure 9.

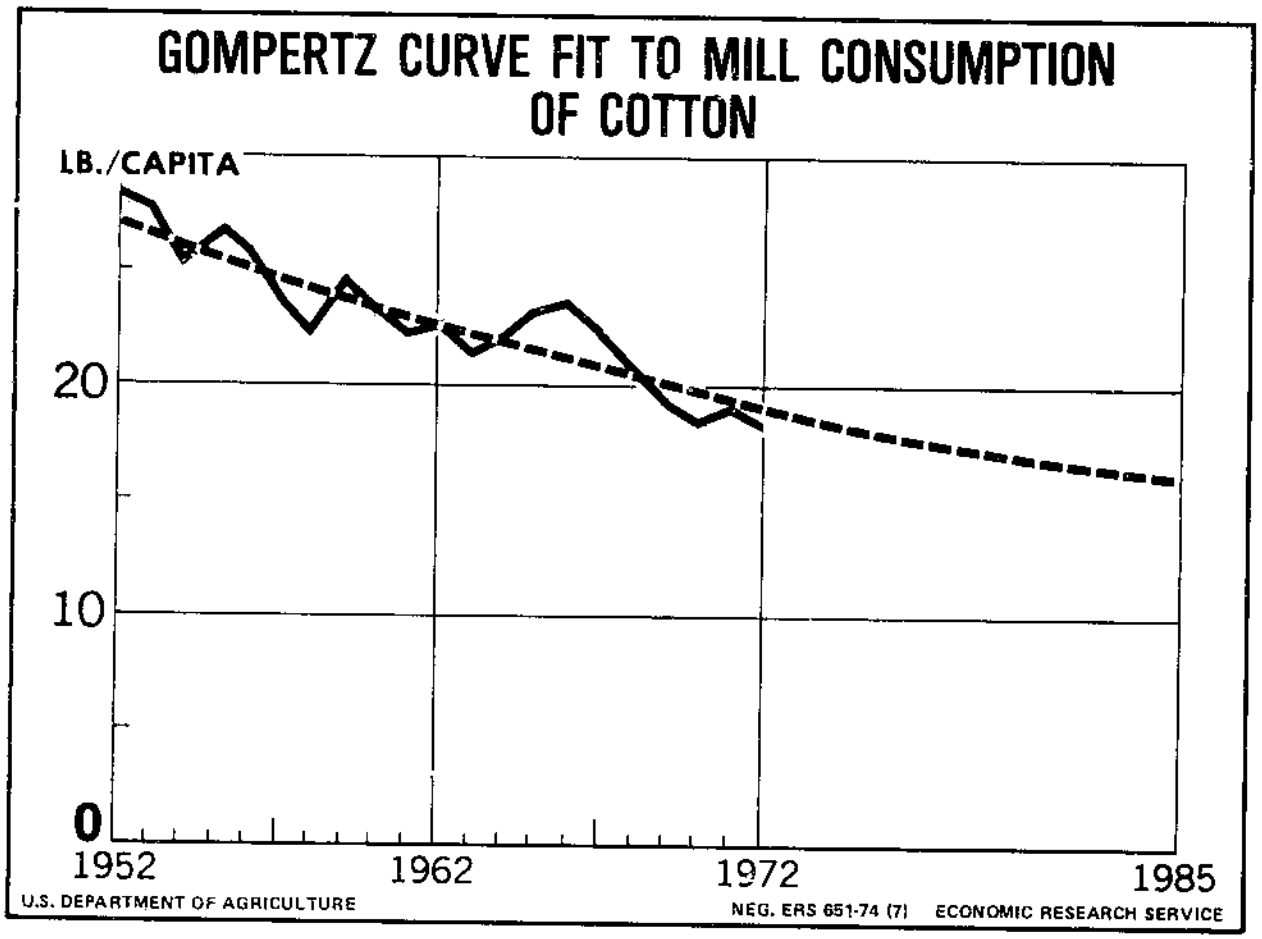


Figure 9

## Noncellulosics Displace Other Fibers

Noncellulosic fibers have grown at a phenomenal rate since their entry into the fiber market in the 1940's. Annual per capita domestic consumption on a cotton-equivalent basis grew from a fraction of a pound in the late 1940's to over 30 pounds in 1972. In the same period, noncellulosic fibers captured about half the total fiber market. All other fibers have lost markets to noncellulosic fibers. For example, cotton has been displaced in such end uses as bedsheeting by polyester, wool has been displaced in apparel markets by acrylic and other noncellulosic fibers, and cellulosics have lost tire markets to nylon.

Regression analysis proved unsatisfactory for noncellulosic fiber, so the projections reflect trend extrapolation and judgment of USDA commodity specialists.

## Cellulosic Use Unchanged in Two Decades

Cellulosic fiber per capita consumption has remained near the 7-8 pound level during the past two decades. On the basis of price levels, cellulosic staple competed with cotton throughout most of the 1950's and 1960's. Due to discounting of rayon staple prices as cotton prices fluctuate, cotton prices may be a better proxy for staple price than producer list prices. At any rate, due to the lack of variation in list prices of cellulosic fiber, no satisfactory forecasting equation was developed for cellulosic fiber demand.

## Wool Demand Declines as Competition From Manmade Fibers Increases

Per capita demand for wool trended down over the past two decades, reflecting increasing competition from manmade fibers. Currently, per capita domestic consumption is slightly less than 2 pounds. No analysis for wool demand was statistically acceptable.

## Fiber Use in 1985 Should Reach 82-90 Pounds Per Person

While this study presents an equation which can be used to estimate future domestic fiber consumption, current uncertainties render any specific estimate for 1985 quite tentative. Income will continue to increase and have a positive influence on fiber use. But despite higher personal incomes, consumption of different fibers and their respective market shares will probably depend largely on petroleum availability. If supplies of petroleum and petrochemicals are severely limited, noncellulosic fiber use will suffer and cotton will benefit.

Nevertheless, when likely combinations of prices and income for 1985 are considered in conjunction with the elasticities of the total fiber demand equation, fiber use in 1985 is indicated at about 82-90 pounds per capita (table 6). This level of use assumes about a 3-percent annual increase in disposable personal income and a 2-percent annual increase in the price index, after accounting for inflation. It also assumes blend technology will play a lesser role in the next decade than in the last.

The estimated price increase reflects higher energy costs and if shortages persist, it may be too low. The income estimate assumes no substantial long-term disruptions in the national economy caused by higher energy costs or scarcities.

Turning to individual fibers, the cotton analysis, based on a Gompertz curve, indicates 1985 mill consumption at about 15 pounds per capita. This implies about 8 million bales mill consumption. If the energy crisis persists and noncellulosic fiber use is curtailed by petrochemical shortages, this estimate could be 0.5-1.5 million bales too low. In addition, cotton textile imports will probably continue to increase. Since the curve is fit to mill consumption, the projection must be adjusted for net cotton textile imports. The import trade balance will probably increase at an annual rate of about 1 percent until 1985. So, adjustment for cotton textile trade indicates domestic use in 1985 at about 16 pounds per capita.

No analysis of aggregate cellulosic use was successful. However, trend extrapolation and subjective considerations would place cellulosic use in 1985 near the current per capita level of 7-8 pounds. So, the projected growth of cellulosic fiber is estimated to be closely tied to population growth.

Wool demand also failed to respond to analysis. Based on past trends, 1985 wool use of about 1 pound per person would appear most likely. While the scarcity of inputs for noncellulosic fiber could benefit wool use somewhat, no substantial per capita consumption increases appear likely.

The balance of domestic consumption, about 60 pounds per capita, would consist of noncellulosic fiber. The estimate for this fiber is probably the most uncertain of all. Growth will probably continue, but the availability of energy and petrochemicals may largely determine the rate of increase. Potentially, noncellulosic fibers could suffer more than any other fiber from the energy crisis. Severe curtailment of noncellulosic fiber use would pull down the estimate for total fiber use.

Projections for cellulosic and noncellulosic fibers are based largely on the judgments of USDA commodity specialists.

Table 6--Domestic fiber use, average 1968-70 and projected 1985

| Fiber | 1968-70 | 1985 |
|---|---|---|
| | Pounds per capita | |
| Cotton | 20.9 | 14-18 |
| Wool | 2.0 | 1 |
| Cellulosic | 8.0 | 7-8 |
| Noncellulosic | 19.5 | 60-63 |
| Total | 50.4 | 82-90 |

## FIBER USE MEASURED IN END USES IN FIVE MARKETS

Demand for fibers in final products has been discussed in earlier sections. In this section, end-use data published by the Textiles Economic Bureau, Incorporated, are analyzed. As stated earlier, these data purport to measure fibers in end uses in the following market categories: Men's and boys' apparel (MA);women's, misses', children's, and infants' apparel (WA); household furnishings (HF); industrial uses (I); and other consumer products (OP).

Throughout this section, the above divisions of fiber consumption will be referred to as "markets." Any further divisions will be denoted "uses," such as men's dress shirts in the men's apparel market. Each of the markets may be relatively heterogeneous. If so, different parameters would be likely to affect demand in different markets, or the effect of parameters on demand might at least differ from market to market. If a specific parameter such as price elicits different changes in demand in separate markets, knowledge of the differences would be of interest, particularly to parties planning inputs for cost research, advertising, and production. For example, if a reduction in the price of cotton in one end use elicits proportionately greater increase in demand than in another, the cotton industry would benefit from orienting its cost-reducing research toward products in the first market.

To measure the differences in these relationships, an attempt was made to relate demand in a specified market to both own-price and the price of substitute products, level of disposable income,

year-to-year change in disposable income, technology, changes in tastes and preferences, and other relevant factors. Next, demand for a specific fiber in the market was related to specific parameters (such as relative prices or relative preferences) which determine final demand for the fiber. This approach is quite similar to the approach used by Ward (16), although different price series are used. As with Ward's work, the results were not entirely satisfactory. Changing technology cannot be quantified and changing tastes and preferences cannot be quantified or specified except by general analysis of consumer purchases, so satisfactory price coefficients could not be obtained. Price coefficients were affected by essentially the same type of factors as affected fiber price coefficients in the projecting model.

A second procedure could be to determine demand for a specified fiber in a market and then aggregate the results into a total fiber demand. This approach would necessitate hypothesizing a specific income effect on individual fibers in the various markets. However, this largely ignores reality, as the sum of all the elasticities would have to be one. The variety of fibers at different costs allows consumers to adjust expenditures for fibers without significantly affecting quantities purchased.

As the above approaches were unsatisfactory, additional considerations were necessary. The primary goal of this study was to measure price responses of individual fibers in each market. Demand shifters obviously affect the quantity of each fiber used. Nevertheless, in the specification, where individual fiber demand is hypothesized as responding to micro relationships such as price rather than macro demand shifters such as income, inclusion of income as a demand shifter seems illogical. While income might affect use in a specific market, the effect on any specific fiber would probably be small.

An analytical approach was finally chosen to alleviate the most serious of the above objections. No attempt was made to measure demand in aggregate markets. Fortunately this does not impair the basic purpose of the analysis, to estimate price coefficients.

Total fiber demand ($D^T$'s.e.u.) in each market was used as the demand shifter in the individual fiber equations. Total demand thus becomes a proxy variable for all macro demand shifters affecting individual fibers, from income to technological advances to changing tastes and preferences. This obviously reduces the standard error of the coefficients derived for price effects, as it is tantamount to including in the analysis all macro demand shifters affecting the market as a whole. Relative prices were included to portray the competitive relationships between individual fibers. Price data are shown in table A-2.

Preliminary regression analysis of the total fiber demand and price variables and examination of the residuals indicated that

fiber consumption shifted upward relatively sharply around 1964. Consequently, time was introduced in the equations in 1964. This primarily reflects penetration of the fiber market by noncellulosic fiber technology. By 1964, noncellulosics were becoming a feasible alternative to other fibers in common end uses, both from a technical and price standpoint. The technology of blending fibers was also coming of age at about this time, pushing up use of noncellulosics and total fiber. The introduction of noncellulosics and blend technology probably caused the fiber market to increase in excess of what the demand parameters would otherwise imply. The trend variables in the equations below reflect these considerations. The changing composition of fiber use in major markets is shown in figures 10 through 12.

## Most Cotton Used in Household Furnishings

In the following analyses of cotton in end-use markets, price competition is reflected by the ratio of cotton prices to noncellulosic prices. Much of the displacement of cotton occurred as noncellulosics became more price-competitive with cotton. The use of a ratio eliminates the intercorrelation present when the separate price levels are incorporated. Total demand for each fiber was used as the demand shifter. A time trend from 1964 to 1970 was used since time reflects considerations such as changing technology and promotion which cannot be quantitatively specified. These factors were combined into the basic equations for cotton demand in each market. The results are shown in table 7.

Men's apparel.--Men's apparel (MA) in recent years has been the second largest outlet for cotton, comprising just over one-fourth of total demand for cotton in 1970. Also, MA is the only market in which cotton provides over half the total fiber used. Nevertheless, after nearly holding its own in the 1950's, cotton suffered severe competitive losses to manmade fiber during the 1960's. Cotton fell from about 75 percent of the total MA market in 1960 to 56 percent in 1970. The largest end use for cotton in this category is utility clothing, which takes about one-third of all cotton used in MA. Underwear, sport shirts, and slacks are other important uses.

The basic cotton equation outlined above explains nearly nine-tenths of the variation in MA. The Durbin-Watson test was satisfactory. Coefficients for time and total demand are significant at the 1-percent level of probability. The time variable coefficient is negative, reflecting improving manmade fiber and blend technology in the 1960's which cut cotton's markets. However, the total demand variable indicates that cotton responds favorably to growth in the MA market. A 10-percent market gain indicates about a 9-percent increase in cotton use. The price

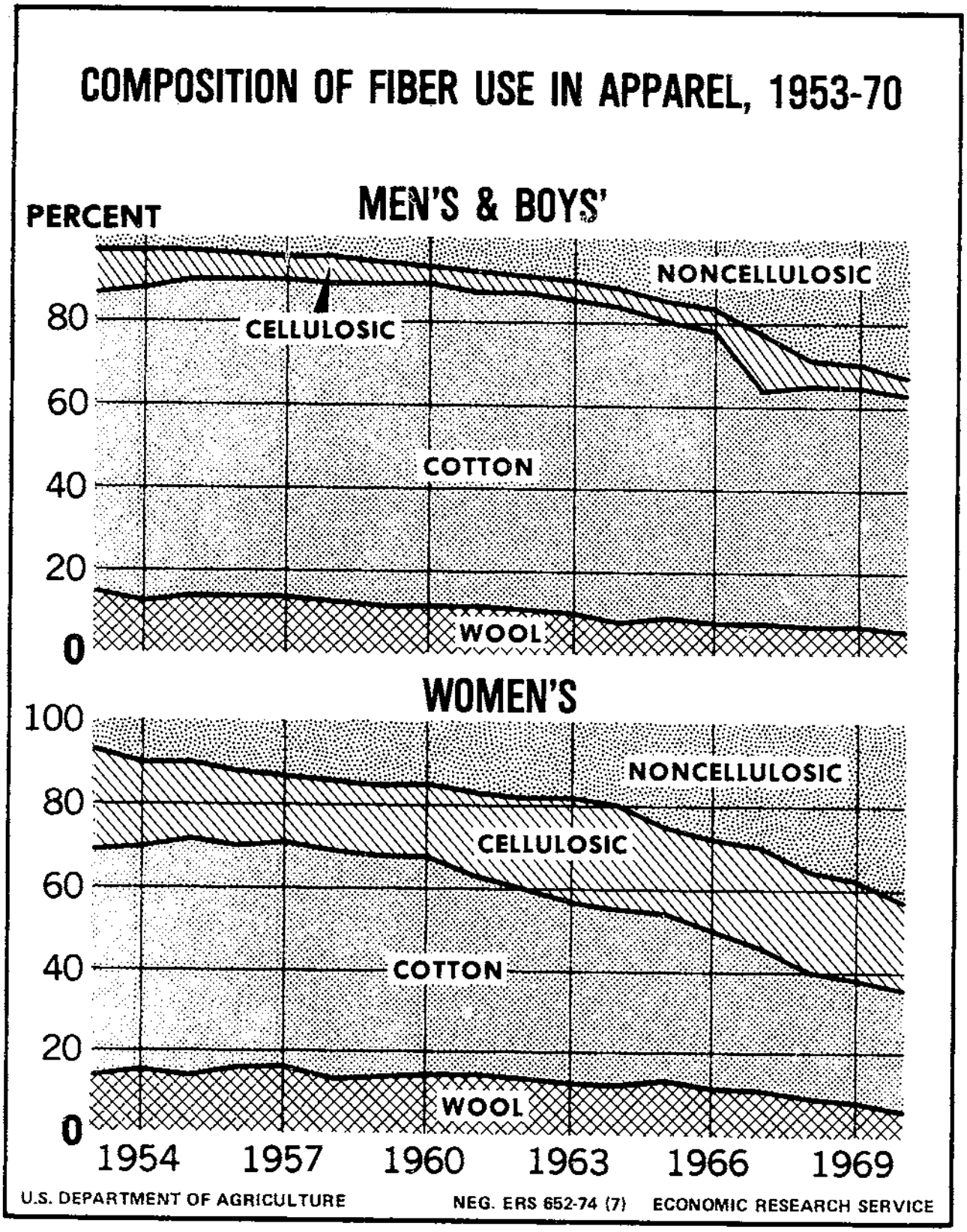
COMPOSITION OF FIBER USE IN APPAREL, 1953-70
MEN'S & BOYS'
PERCENT
NONCELLULOSIC
CELLULOSIC
COTTON
WOOL
80
60
40
20
0
WOMEN'S
100
80
60
40
20
0
NONCELLULOSIC
CELLULOSIC
COTTON
WOOL
1954
1957
1960
1963
1966
1969
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 652-74 (7)
ECONOMIC RESEARCH SERVICE

Figure 10

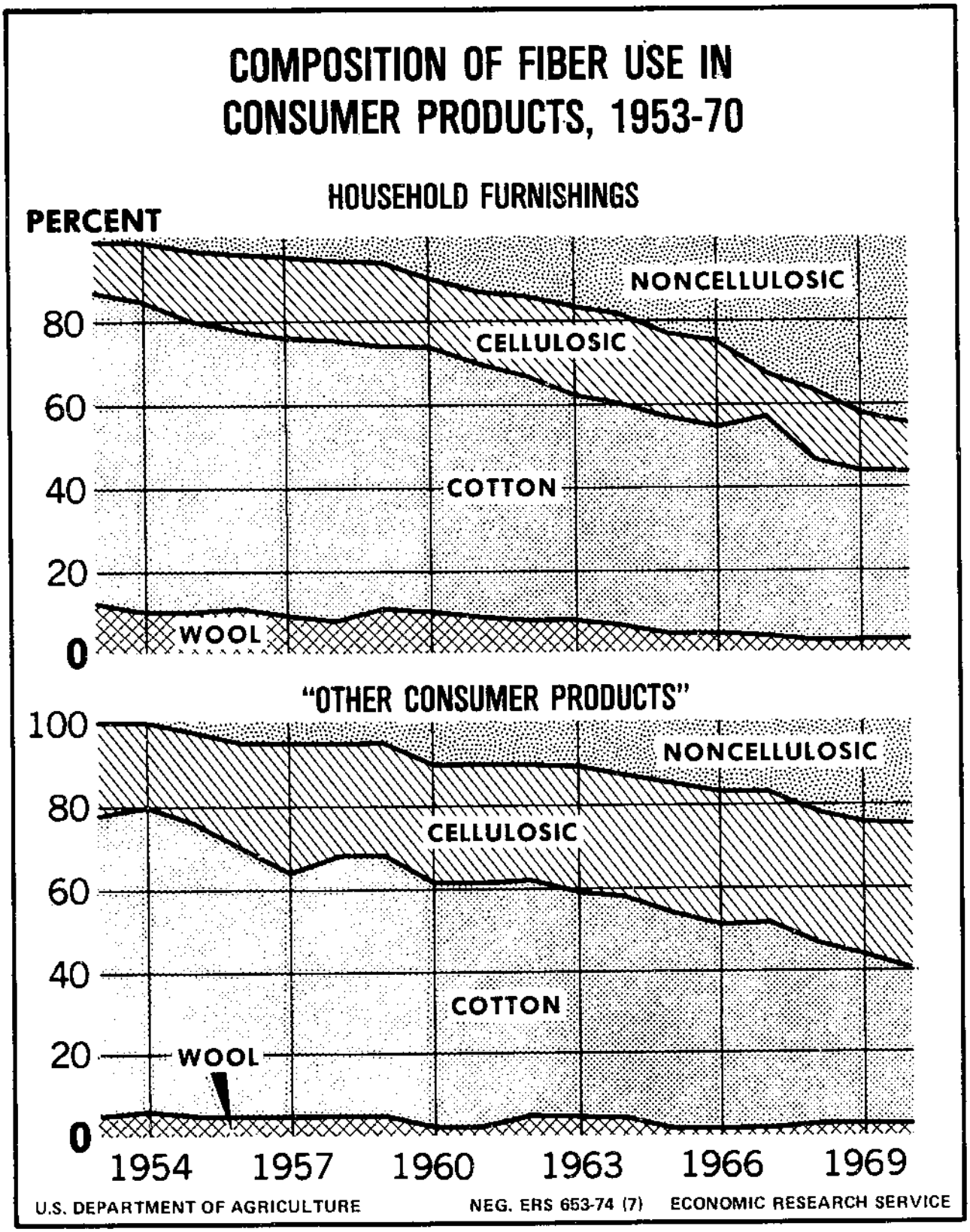
COMPOSITION OF FIBER USE IN CONSUMER PRODUCTS, 1953-70
HOUSEHOLD FURNISHINGS
PERCENT
NONCELLULOSIC
CELLULOSIC
COTTON
WOOL
80
60
40
20
0
"OTHER CONSUMER PRODUCTS"
100
80
60
40
20
0
NONCELLULOSIC
CELLULOSIC
COTTON
WOOL
1954
1957
1960
1963
1966
1969
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 653-74 (7)
ECONOMIC RESEARCH SERVICE

Figure 11

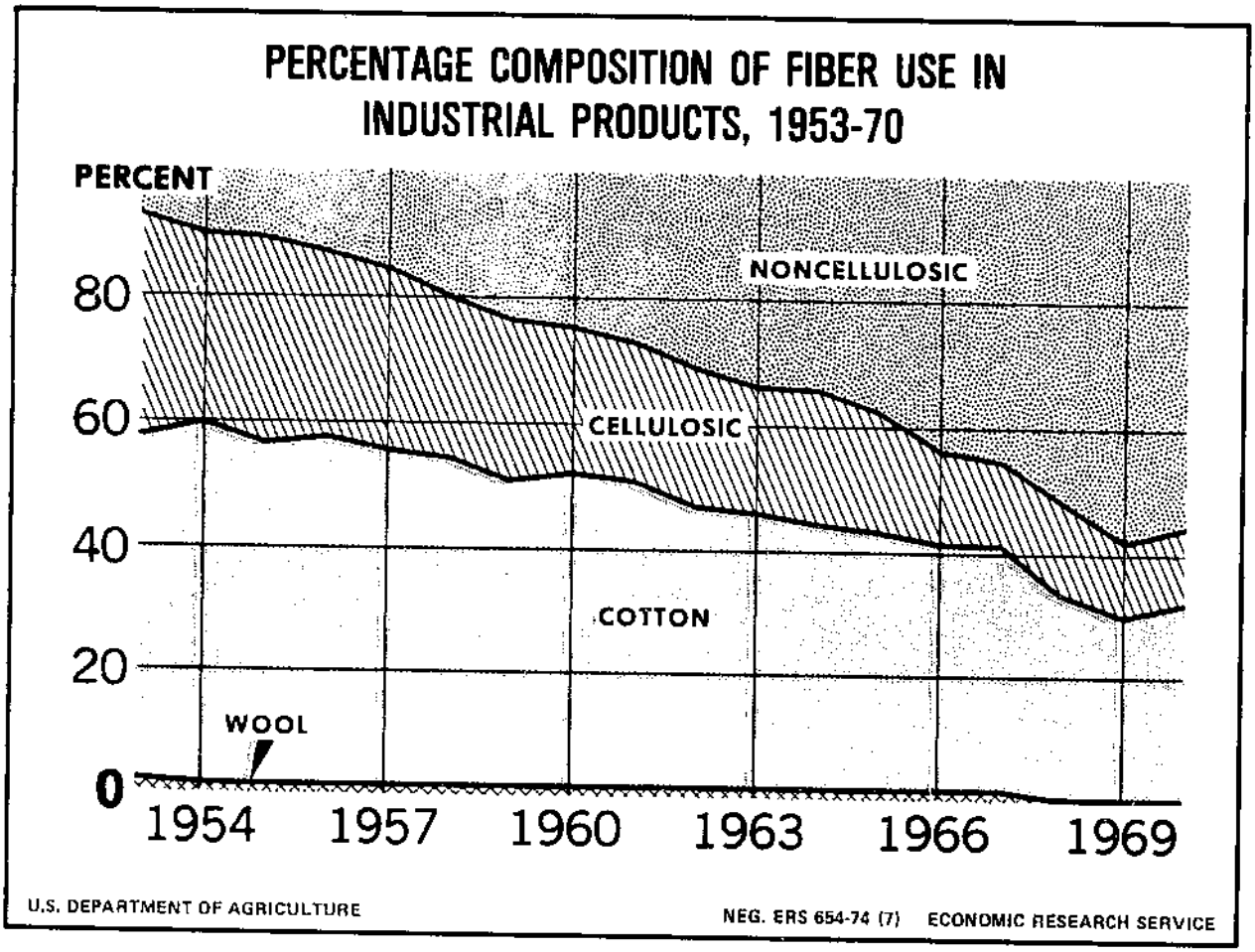


Figure 12

ratio coefficient was not significant, but this is not particularly surprising. Over half this market is in utility-type clothing and underwear. Price would undoubtedly be a minor consideration affecting demand, as these products are relatively low priced. Also, in other end uses, nonprice factors dominate. For example, cotton reportedly wears better than blends or manmade fibers in work clothes. Also, cotton is reportedly more comfortable, which has probably prevented substantial penetration by manmade fibers into end uses such as men's underwear.

Thus, the insignificance of the cotton price ratio in MA is readily justifiable. More importantly, the coefficient carries the expected sign and indicates demand for cotton in MA is highly inelastic with respect to relative prices of cotton and noncellulosic fiber. The statistical fit of the equation for cotton demand in men's apparel is shown in table A-3.

Table 7--Cotton demand in major end uses, 1953-70

| End use | Statistical measures | | | Regression coefficients | | |
|---|---|---|---|---|---|---|
| | $R^2$ | D.W. | S.E. | $P^{cot}/_{P}nc$ | $D^{T}seu$ | $T_{64-70}$ |
| Men's apparel | 0.89 | 1.68 | 0.41 | | | |
| Coefficient | | | | -3.93 | 0.64 | -0.74 |
| T - value | | | | (1.28) | (7.74) | (7.19) |
| $\bar{x}$ - elasticity | | | | -0.9 | +9.1 | --- |
| Women's apparel | 0.94 | 2.30 | 0.28 | | | |
| Coefficient | | | | -5.11 | -0.16 | -0.26 |
| T - value | | | | (1.54) | (2.05) | (3.31) |
| $\bar{x}$ - elasticity | | | | -1.8 | -3.9 | --- |
| Household furnishings | 0.71 | 1.78 | 0.17 | | | |
| Coefficient | | | | -6.13 | 0.12 | -0.10 |
| T - value | | | | (3.65) | (4.09) | (2.07) |
| $\bar{x}$ - elasticity | | | | -2.0 | +2.0 | --- |
| Other consumer products | 0.71 | 2.14 | 0.07 | | | |
| Coefficient | | | | -3.27 | -0.03 | 0.06 |
| T - value | | | | (5.01) | (0.54) | (2.19) |
| $\bar{x}$ - elasticity | | | | -4.4 | -0.4 | --- |
| Industrial uses | 0.98 | 2.23 | 0.09 | | | |
| Coefficient | | | | -6.80 | 0.35 | -0.18 |
| T - value | | | | (13.01) | (8.25) | (10.86) |
| $\bar{x}$ - elasticity | | | | -6.1 | 7.7 | --- |

Women's apparel.--Women's apparel (WA) is the second smallest outlet for cotton, accounting in 1970 for only about 13 percent of total cotton consumption. Cotton about held its own in the 1950's. However, penetration of manmade fiber into the WA market was relatively severe in the 1960's. Cotton fell from over half of the market in 1960 to less than three-tenths in 1970. Cotton use has trended down in the last decade in all major end uses in this category except working clothes. Losses have been particularly noteworthy in dresses, where the total market grew sharply while cotton use fell.

The cotton demand equation explains over nine-tenths of the variation in WA over the period analyzed. The Durbin-Watson test was satisfactory. The time variable coefficient is significant at the 1-percent probability level, while the price coefficient is

only significant at the 10-percent level. The total demand coefficient fell slightly below the significance level desired, but exceeds its standard error. The price ratio coefficient carries the expected sign. No a priori determinations can be made as to the sign of the time and total demand variables. The time variable representing manmade fiber technology carries the negative sign as does the total demand variable. This indicates cotton use in WA declines as the WA market expands; a 10-percent increase in the total category is related to a 4-percent decline in cotton. The price ratio indicates a 10-percent change in the relationship between cotton price and noncellulosic price elicits about a 2-percent change in cotton demand. That is, if noncellulosic prices remain constant and cotton prices rise 10 percent, demand for cotton in WA would fall about 2 percent. The statistical fit of the women's apparel equation for cotton demand is shown in table A-3.

Household furnishings.--Household furnishings (HF) recently moved ahead of men's apparel to become the largest user of cotton of the five markets. In 1970, nearly one-third of all cotton was used in HF end uses. However, cotton's share of the market started declining in the early 1950's. Penetration of manmade fibers in HF uses became more severe in the 1960's as cotton fell from nearly two-thirds of the market in 1960 to two-fifths in 1970. This, however, may not reflect as much competitive displacement of cotton as first seems apparent. Much of the growth in HF has reflected increasing use of fibers in carpets and rugs, uses for which cotton is not as well suited as some other fibers.

Two of cotton's largest uses are in the HF category. The largest is sheets, where four-fifths of the fiber used is cotton. Of particular concern for cotton in this end use is penetration by noncellulosic staple fiber, particularly that used in cotton-polyester blends. In the other major end use--towels--cotton accounts for 98 percent of the fiber used and seemingly faces little competition.

The cotton equation for HF explained only about four-fifths of the variation in cotton use over the period analyzed. The trend variable was negative but small. The aggregate demand variable indicates that as total use increases 10 percent, cotton use increases about 4 percent. The rather low elasticity reflects the high proportion of carpets and rugs in this category. The elasticity for towels and sheets, which comprise nearly two-thirds of cotton demand in HF, is probably near 1.

The price ratio coefficient implies that as the relationship between cotton price and noncellulosic price widens 10 percent, cotton demand falls 2 percent. The time variable coefficient is significant at the 5-percent level of probability. Coefficients for the price ratio and total demand are significant at the 1-percent level. The statistical fit of the equation for cotton demand in household furnishings is shown in table A-3.

Other consumer products.--Other consumer products (OP) include apparel linings, retail piece goods, medical supplies, narrow fabrics, and shoes and slippers. Only 12.5 percent of all cotton consumed in 1970 was in this market, making it the smallest market for cotton. Cotton's share of the OP market fell from about seven-tenths in the early 1950's to only one-third now.

The demand equation explained 70 percent of the variation in cotton demand for the period analyzed. The price ratio coefficient indicated less price inelasticity than in markets previously examined. The price coefficient, significant at the 1-percent level, indicates just over a 4-percent inverse response of demand to a change in the cotton price/noncellulosic price relationship. This indicates rather strong price competition between noncellulosic fiber and cotton in OP.

The time variable is positive, very small, and significant at the 10-percent level. This probably indicates that in this market, where the products are often unspecialized (such as for apparel linings), use depends more on price relationships than on changing technology.

The total demand coefficient was small, negative, and insignificant. As the total demand variable ostensibly reflects general demand shifters, the relationship appears logical. Medical supplies, for example, which account for a significant amount of cotton used in OP, would be likely to respond very little to parameters such as income. The statistical fit of the equation for cotton demand in other consumer products is shown in table A-3.

Industrial uses.--About 13 percent of all cotton is used by industrial markets. Uses include sewing thread, cordage, coated fabrics such as parachutes, and transportation upholstery. Manmade fiber penetration has caused cotton's share of the market to fall from over half in the early 1950's to less than one-third by the early 1970's. Much cotton has been displaced in end uses such as cordage. However, in end uses such as transportation upholstery and sewing thread, cotton apparently is still holding its own.

The equation for industrial uses explains 98 percent of the variation in cotton use over the years analyzed. The Durbin-Watson test was satisfactory. All regression coefficients are significant at the 1-percent probability level.

The trend variable coefficient is negative. This probably reflects development and implementation of manmade fibers for specialized purposes. The total demand variable was positive and large--the coefficient indicates a 10-percent increase in the market elicits about an 8-percent increase in cotton use. As in MA, this would indicate that given similar technology, cotton would be competitive with manmade fibers.

The price ratio is the highest of all markets analyzed. The coefficient indicates that a 10-percent change in the cotton/noncellulosic price relationship elicits about a 6-percent response in cotton demand. This relatively high elasticity could indicate substantial price competition between cotton and noncellulosic fiber. But more likely, it indicates only that most potential cotton displacement has already transpired and future use may depend largely on industrial activity. The statistical fit of the equation for cotton demand in industrial uses is shown in table A-3.

## One-third of All Wool Used in Men's Apparel

Total demand for wool in end-use consumption has declined over the past two decades. During the 1960's alone, wool lost about 5 percent of the total fiber market. Noncellulosic fibers such as polyester and acrylic have cut sharply into wool's markets. As with cotton, blending of manmade fibers with wool in formerly all-wool uses has accelerated losses. Thus, in the analyses of various end uses, wool demand was related to the demand shifter variable, time from 1964 to 1970 to reflect technology, and the relative prices of wool and noncellulosic fiber. Analysis of wool demand was the least satisfactory of all fiber analyses, probably reflecting low levels of use and inelastic demand. The results of regression analysis, satisfactory only for household furnishings, are shown in table 8.

Men's apparel.--Men's apparel accounts for about a third of total wool use. Wool nearly held its own competitively in the 1950's, retaining about one-eighth of the total market. In the 1960's, however, wool fell from one-eighth to about one-sixteenth of the total market for men's apparel. During the 1960's the actual level of wool used fell about a third, although use of all fiber in MA rose a fourth. In men's apparel, wool suffered its greatest competitive losses in sweaters and suits. Noncellulosic fiber displacement accounted for most of the decline of wool in sweaters. In suits, the total market declined slightly; noncellulosic use was about constant.

The equation for wool use in MA was unsatisfactory. Coefficients were small and insignificant, probably reflecting low levels of per capita use with very small year-to-year changes.

Women's apparel.--Wool use in women's apparel remained constant in the 1950's at about one-eighth of the total market; about one-half of all wool used was consumed here. But during the last decade, wool lost about 8 percent of the market for women's apparel. Although the market still uses about three-tenths of total wool consumed on a poundage basis, wool consumption was nearly halved although the total WA market increased by about three-tenths. Wool was displaced during the 1960's in significant quantities in all end uses except slacks, where the level of use has remained relatively constant.

Table 8--Wool demand in major end uses, 1953-70

| End use | Statistical measures | | | Regression coefficients | | |
|---|---|---|---|---|---|---|
| | $R^2$ | D.W. | S.E. | $P^w/P^{nc}$ | $T_{64-70}$ | $D^T_{seu}$ |
| Men's apparel | | | | | | |
| Coefficient | Coefficients small, insignificant | | | | | |
| T - value | | | | | | |
| $\bar{x}$ - elasticity | | | | | | |
| Women's apparel | | | | | | |
| Coefficient | Coefficients small, insignificant | | | | | |
| T - value | | | | | | |
| $\bar{x}$ - elasticity | | | | | | |
| Household furnishings | 0.85 | 2.15 | 0.08 | | | |
| Coefficient | | | | -0.58 | 0.01 | -0.09 |
| T - value | | | | (2.19) | (0.74) | (3.60) |
| $\bar{x}$ - elasticity | | | | -3.9 | +1.3 | --- |
| Other consumer products | | | | | | |
| Coefficient | Small level of use | | | | | |
| T - value | | | | | | |
| $\bar{x}$ - elasticity | | | | | | |
| Industrial uses | | | | | | |
| Coefficient | Level of use very small | | | | | |
| T - value | | | | | | |
| $\bar{x}$ - elasticity | | | | | | |

No satisfactory equation for wool could be developed to reflect demand in WA. Coefficients for price were small, insignificant, and carried the wrong sign. The trend coefficient was small and significant; the shift variable was small and insignificant. As the equation was statistically unacceptable, no elasticities were computed.

Household furnishings.--Wool use in household furnishings, as in most other categories, about held its own competitively in the 1950's. But the advent of manmade fibers precipitated significant losses during the following decade. Wool suffered its greatest competitive losses in the home furnishings market. Wool fell from about a tenth to about 3 percent of the market during the 1960's. Wool use was about halved, while total fibers used in HF increased by more than three-fourths. Home furnishings presently account for about one-fourth of wool use, only slightly less than in the 1950's.

In home furnishings, most wool is used in carpets. Carpet wool is coarser than apparel wool, and all that is consumed in the United States is imported. Noncellulosic staple use in rugs and carpets has increased rapidly, capturing or causing the rapidly expanding market as well as displacing wool.

The equation for wool demand in home furnishings explained 85 percent of the variation in use from 1953 to 1970. The price coefficient was significant at the 10-percent level with the expected sign. It indicated that a 10-percent change in the relationship between wool and noncellulosic fiber prices elicits about a 4-percent response. That is, holding noncellulosic price constant, a 10-percent increase in wool price would cause wool use to fall 4 percent. The coefficient for the time variable was positive and insignificant. The total fiber demand variable indicated that as the total home furnishings market increases, wool use declines only slightly. The statistical fit of the equation for wool demand in household furnishings is shown in table A-4.

Other consumer products.--Wool use in other consumer products grew slightly over the 1960's, reflecting an increase in wool used in handiwork yarns. Still, it has failed to grow with the market and now accounts for less than a tenth of total wool use.

No analysis of wool use in other consumer products was successful. Little variation was explained and all regression coefficients were insignificant.

Industrial uses.--Only insignificant amounts of wool went for industrial uses, primarily felting. Industrial use has remained about stable over the past decade as technology has advanced and manmade fibers have been increasingly used in felting.

No analysis of demand for wool in industrial uses was satisfactory, as the dependent variable showed no measurable change.

## Noncellulosic Growth Spectacular in Household Furnishings

Demand for noncellulosic fibers increased dramatically over the past two decades, as use leaped from less than 5 percent of the fiber market in the early 1950's to over 40 percent by 1970. Noncellulosic fibers displaced cotton, cellulosic fibers, and wool in all markets and in virtually all end uses. Both the level of noncellulosic fiber use and the percentage of noncellulosic fiber as a part of total use have increased in each market. Growth has been most spectacular in household furnishings, where substantial amounts of noncellulosic fiber are consumed in rugs and carpets.

Attempts to analyze noncellulosic fiber use in terms of competitive price ratios proved less satisfactory than when price levels were used. This reflected the low levels of direct price

competition during the 1950's. As noncellulosic prices fell, these fibers became more competitive until they presently either compete pound for pound with other fibers or enjoy price advantages. So in this analysis, a weighted average price for noncellulosic fibers deflated by the Wholesale Price Index was incorporated, along with total demand in each market and time. Time served as a proxy for the advance in manmade fiber/cotton blending technology of the mid-1960's. The statistical results of the analysis of noncellulosic fiber in major end uses are shown in table 9.

Table 9--Noncellulosic fiber demand in major end uses, 1953-70

| End use | Statistical measures | | | Regression coefficients | | |
|---|---|---|---|---|---|---|
| | $R^2$ | D.W. | S.E. | $P^{nc}_{t-1}$ | $D^{T}seu$ | $T_{64-70}$ |
| Men's apparel | 0.99 | 1.69 | 0.24 | | | |
| Coefficient | | | | -0.01 | 0.21 | 0.50 |
| T - value | | | | (4.40) | (4.05) | (9.54) |
| $\bar{x}$ - elasticity | | | | -5.5 | +14.9 | --- |
| Women's apparel | 0.99 | 2.41 | 0.15 | | | |
| Coefficient | | | | -0.01 | 0.23 | 0.34 |
| T - value | | | | (6.39) | (4.68) | (8.12) |
| $\bar{x}$ - elasticity | | | | -4.4 | +10.0 | --- |
| Household furnishings | 0.99 | 0.91 | 0.22 | | | |
| Coefficient | | | | -0.01 | 0.25 | 0.40 |
| T - value | | | | (2.31) | (5.48) | (6.46) |
| $\bar{x}$ - elasticity | | | | -10.9 | +17.3 | --- |
| Other consumer products | 0.97 | 1.37 | 0.10 | | | |
| Coefficient | | | | 1/-0.07 | 0.38 | 0.01 |
| T - value | | | | (1.21) | (4.15) | (0.22) |
| $\bar{x}$ - elasticity | | | | -5.4 | 35.7 | --- |
| Industrial uses | 0.98 | 2.43 | 0.22 | | | |
| Coefficient | | | | -0.02 | 0.35 | 0.25 |
| T - value | | | | (9.38) | (3.41) | (5.36) |
| $\bar{x}$ - elasticity | | | | -6.2 | +11.1 | --- |

1/ Ratio of noncellulosic staple price to cotton price.

Men's apparel.--Noncellulosic fiber used in MA increased from less than one-twentieth of the men's and boys' market in 1953 to over a third in 1970. Most of this penetration was at the expense of cotton and wool. The most dramatic growth occurred during the 1960's, particularly in shirts and slacks. Use of noncellulosic fiber in utility clothing has also grown dramatically since 1964. On a percentage basis, noncellulosic fiber used in MA increased over fivefold in the 1960's.

The noncellulosic demand equation for MA, using deflated price of noncellulosic fiber, trend beginning in 1964, and total demand, explained 99 percent of the variation in noncellulosic fiber use during 1953-70. The Durbin-Watson test was satisfactory. Regression coefficients for price and time were significant at the 1-percent level as was the coefficient for the total demand variable.

The coefficients indicated noncellulosic fiber is price inelastic in MA. A 10-percent increase in price would elicit about a 5.5-percent decline in demand. The total demand variable carries the positive sign. It reflects the ability of noncellulosic fiber to sharply penetrate fiber end uses. A 15-percent direct response of noncellulosic fiber is indicated when total use changes 10 percent. The statistical fit of the equation for noncellulosic fiber demand in men's apparel is shown in table A-5.

Women's apparel.--From 1953 to 1970, noncellulosic use in women's apparel increased from just under a tenth to nearly half the market. Its penetration of the total fiber market was particularly sharp during the 1970's, as it moved into all major end uses. Some of the most significant gain occurred in dresses.

The equation for noncellulosic fiber use in WA explained 99 percent of the variation in use for the years analyzed. Price inelasticity is indicated; a 10-percent increase in price elicits about a 4.4-percent inverse response. The trend variable is positive, at a rate of about one-third pound per year. The total demand varible is positive and indicates noncellulosic fiber is responsible for all growth in the total market. The coefficient indicates that noncellulosic use increases a pound for each pound the total women's apparel market increases. The statistical fit of the equation for noncellulosic fiber demand in women's apparel is shown in table A-5.

Household furnishings.--Household furnishings is presently the largest market for noncellulosic fiber, accounting for about one-third of all noncellulosic fiber consumed. Growth of noncellulosic fiber use in household furnishings has been quite dramatic. In the early 1950's, only about 1 or 2 percent of the fiber used in household furnishings was noncellulosic. By the early 1970's, noncellulosics accounted for over half the total. Soaring use in carpets and rugs accounted for most of the increase.

The equation for noncellulosic fiber demand in household furnishings explained 99 percent of the variation during the years analyzed. The Durbin-Watson test was inconclusive although this is not unexpected when data exhibit pronounced trends.

The price and total demand coefficients were significant at the 1-percent probability level. The price coefficient indicates that a 10-percent increase in noncellulosic fiber price will cause use to fall just over 2 percent. The trend coefficient is positive, indicating an annual increase of nearly one-half pound. The total demand coefficient also is positive and indicates continued penetration of the HF market by noncellulosic fiber. A 10-percent increase in total demand is related to about a 17-percent increase in noncellulosic consumption. The statistical fit of the equation for noncellulosic fiber demand in household furnishings is shown in table A-5.

Other consumer products.--Other consumer products is the smallest outlet for noncellulosic fiber, currently accounting for less than a tenth of total noncellulosic use. As in other markets, noncellulosic fiber displaced natural fibers in the 1950's and 1960's, moving from less than 1 percent of the market in the early 1950's to nearly half by the early 1970's. Use of noncellulosic fiber grew significantly in apparel linings, retail piece goods, and miscellaneous items such as sails and sports equipment.

The equation for noncellulosic demand in OP was statistically unacceptable, as only the coefficient for total demand was significant.

Industrial uses.--The market for industrial fibers currently uses about one-fifth of all noncellulosic fiber. Over three-fifths of all fibers consumed in industrial uses are noncellulosic, up from about a tenth in the early 1950's. Tires and reinforced plastics are the largest end-use outlets for noncellulosics. Growth has been spectacular in each of these two major end uses.

The equation for noncellulosic fiber demand in industrial uses explained 98 percent of the variation in use during 1953-70. The Durbin-Watson statistic was satisfactory. All regression coefficients were significant at the 1-percent level of probability. The price coefficient indicated that as noncellulosic price increases 10 percent, use declines about 6 percent. The total demand coefficient implies that a 10-percent increase in the industrial use market elicits an 11-percent increase in noncellulosic fiber use. The trend variable indicated an uptrend of about one-fourth pound per year per person. The statistical fit of the equation is shown in table A-5.

## Cellulosic Use Increasing in All Markets Except Industrial

Cellulosic fiber use, on a poundage basis, varied somewhat during the 1950's but exhibited no particular trend. Consumption increased during the 1960's, but much more slowly than use of noncellulosic fibers. During the two decades, cellulosic fiber's share of the total fiber market fell about 2 percentage points. The declining share reflects several factors. First, larger noncellulosic use has increased the size of the total market. Second, some cellulosic fibers have been displaced by noncellulosics. And third, cotton prices were relatively low during the late 1960's, allowing cotton to compete vigorously with rayon. Nevertheless, the level of cellulosic use has increased in each major market, except industrial uses.

Despite hypothetically strong competition between cotton and cellulosic fibers during the 1960's, changes in ratios of cellulosic price to cotton price had little effect on demand, probably because cotton and cellulosic staple are such close substitutes that their prices move in the same directions. Competition was hypothesized between cellulosic and noncellulosic fibers. Much of this competition is in industrial uses and primarily manifests itself in the tire cord end use. To reflect this competition, a price ratio between cellulosic and noncellulosic fibers was incorporated in which the staple component was reflected by prices of high tenacity cellulosic staple. The other variables were, of course, time and total fiber demand in each category. The results of regression analysis are shown in table 10.

Men's apparel.--Men's and boys' apparel is the smallest outlet for cellulosic fibers, presently accounting for only about 5 percent of use. Cellulosic fiber use declined during the 1950's both in the aggregate and as a percentage of the market. Through the 1960's, cellulosic's share of the market remained at about 4 percent. Men's apparel used about one-twentieth of the total cellulosic fiber used in the major markets. The most important cellulosic end uses in this category are woven sport shirts and separate slacks.

The equation for cellulosic demand in MA is not shown, as it was unsatisfactory. It explained only about half the variation for the years analyzed. The Durbin-Watson test indicated serial correlation. The unsatisfactory results probably indicate that demand for cellulosic fibers in MA is highly inflexible and that in this particular use, there is little price competition between cellulosic and noncellulosic fibers.

Women's apparel.--Women's apparel is the largest outlet for cellulosic fiber. Cellulosic fiber use remained about constant during the 1950's, then grew faster than the total market during the

Table 10--Cellulosic fiber demand in major end uses, 1953-70

| End use | Statistical measures | | | Regression coefficients | | |
|---|---|---|---|---|---|---|
| | $R^2$ | D.W. | S.E. | $P^C/_{P}nc$ | $D^T seu$ | $T_{64-70}$ |
| Men's apparel | | | | | | |
| Coefficient | Coefficients small, insignificant | | | | | |
| T - value | | | | | | |
| $\bar{x}$ - elasticity | | | | | | |
| Women's apparel | 0.86 | 1.29 | 0.27 | | | |
| Coefficient | | | | -0.87 | +0.46 | -0.23 |
| T - value | | | | (0.40) | (2.35) | (5.71) |
| $\bar{x}$ - elasticity | | | | -1.0 | +25.5 | --- |
| Household furnishings | | | | | | |
| Coefficient | Price coefficient, wrong sign | | | | | |
| T - value | | | | | | |
| $\bar{x}$ - elasticity | | | | | | |
| Other consumer products | | | | | | |
| Coefficient | Price coefficient, wrong sign | | | | | |
| T - value | | | | | | |
| $\bar{x}$ - elasticity | | | | | | |
| Industrial uses | 0.93 | 2.18 | 0.16 | | | |
| Coefficient | | | | -5.34 | 0.37 | -0.14 |
| T - value | | | | (5.54) | (5.58) | (4.57) |
| $\bar{x}$ - elasticity | | | | -16.1 | +16.6 | --- |

1960's. Today, cellulosics hold nearly one-fourth of the WA market. Women's apparel accounts for over one-fourth of total consumption. The largest use is in dresses.

The equation for cellulosic demand in women's apparel explained nearly nine-tenths of the variation in use during 1953-70. The coefficients for total demand and time were significant at the 5-percent level of probability. The price ratio coefficient was not significant but carried the proper sign. The equation indicates that a 10-percent change in the price relationship between cellulosics and noncellulosics elicits a 1-percent change in use. Although the price variable was insignificant, the equation was retained as the size of the coefficient appeared reasonable. The total fiber demand coefficient--reflecting the growth patterns of cellulosic fiber in the 1960's in women's apparel--indicated that as the total market increased 10 percent, cellulosic use would increase 26 percent. The statistical fit of the equation for cellu-

losic use in women's apparel is shown in table A-6.

Household furnishings.--About one-fourth of cellulosic fiber currently used goes into household furnishings. Carpets, drapery, upholstery, and slip covers are the major end uses for cellulosic fiber in this market. In the early 1950's, cellulosic fiber provided about 15 percent of the fiber consumed in the market. This share climbed to about an eighth by the end of the decade. Competitively, the most severe losses for cellulosics occurred in carpets and rugs, where noncellulosic gains were phenomenal.

Other consumer products.--Other consumer products is currently the second largest outlet for cellulosic fibers. The market has grown steadily over the past two decades and cellulosic fiber has maintained its competitive position. This market now accounts for about one-fourth of all cellulosic fiber used in major end-use markets.

No analysis was satisfactory for cellulosic fiber in other consumer products, as no satisfactory price coefficients could be developed.

Industrial uses.--Cellulosic fiber in industrial uses has trended down over the past two decades. The sharpest decline occurred during the 1960's as consumption dropped to less than an eighth of the market. The importance of industrial uses as an outlet for cellulosic fiber slipped similarly. Most of the competitive loss was in tires, where noncellulosic fiber made sharp inroads. So to reflect price competition, the ratio of cellulosic price to noncellulosic price was used.

The demand equation for cellulosic fiber in industrial use explained over nine-tenths of the variation in cellulosic use over the period analyzed. The Durbin-Watson statistic was satisfactory and the regression coefficients were significant at the 1-percent level.

The equation indicates a 10-percent increase in cellulosic price evokes a 16-percent decline in cellulosic use in industrial products, if noncellulosic price remains constant. Demand for cellulosic fiber increases as the industrial fiber market grows. A 17-percent increase in cellulosic use is indicated as industrial demand increases 10 percent. The statistical fit of the cellulosic fiber demand equation is shown in table A-6.

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# APPENDIX

## Sources of Data

Throughout this study, sources of data have been noted on the appropriate tables. However, several time series have been compiled from various periodicals spanning several years. This section explicitly enumerates those periodicals and other publications used.

### Population

Estimates of the total population and of the male and female population were compiled from the following publications:

United States Department of Commerce, Bureau of the Census.
1954. Estimates of the Population of the United States and of the Components of Change, by Age, Color, and Sex: 1940 to 1950. Current Population Reports, Series P-25 No. 98. 20 pp.

1965. Estimates of the Population of the United States and Components of Change, by Age, Color, and Sex: 1950 to 1960. Current Population Reports, Series P-25 No. 310. 56 pp.

1965. Estimates of the Population of the United States by Age, Color, and Sex: July 1, 1960 to 1965. Current Population Reports, P-25 No. 321. 35 pp.

1966. Estimates of the Population of the United States by Age, Color, and Sex: July 1, 1966. Current Population Reports, Series P-25 No. 352. 22 pp.

1970. Estimates of the Population of the United States by Age, Race, and Sex: July 1, 1967 to July 1, 1969. Current Population Reports, Series P-25 No. 441. 22 pp.

### End Use Consumption

Data for achieving quantities of fiber used in each end use market were compiled from the following Textile Organons:

Textile Organon, Textile Economics Bureau, Inc. New York. Dec. 1963, Jan. 1969, Nov. 1971, and Nov. 1972.

## Consumption

Estimates of consumption used in the projecting section of the paper for cotton and manmade fibers were compiled from the following:

Statistics on Cotton and Related Data, 1930-67, U.S. Dept. Agr., Econ. Res. Serv., Statis. Bul. No. 417 and supplements, 1968-71.

Wool consumption data are contained in:

Wool Statistics and Related Data, 1930-69, U.S. Dept. Agr., Econ. Res. Serv., Statis. Bul. No. 455 and supplements, 1970 and 1971.

## Prices

Cotton and wool prices are contained in the Statistical Bulletins listed above. Manmade fiber prices are from various issues of Modern Textiles from 1953 to 1970.

Table A-1--Domestic per capita cotton-equivalent fiber consumption, prices, income, and population, 1952-70
(Data used in projecting equation)

| Year | Total domestic consumption 1/ | Personal disposable income 2/ | Fiber price level 3/ | Population 4/ | Wholesale Price Index 5/ |
|---|---|---|---|---|---|
| | Pounds/capita | Dollars/capita | Cents/pound | Million | |
| 1952 | 41.5 | 1,518 | 63.87 | 157.0 | 88.6 |
| 1953 | 41.5 | 1,583 | 60.39 | 159.6 | 87.4 |
| 1954 | 38.3 | 1,585 | 60.05 | 162.4 | 87.6 |
| 1955 | 43.5 | 1,666 | 60.71 | 165.3 | 87.8 |
| 1956 | 41.6 | 1,743 | 60.41 | 168.2 | 90.7 |
| 1957 | 39.3 | 1,801 | 62.79 | 171.3 | 93.3 |
| 1958 | 37.8 | 1,831 | 59.83 | 174.1 | 94.6 |
| 1959 | 43.6 | 1,905 | 60.18 | 177.1 | 94.8 |
| 1960 | 41.0 | 1,938 | 57.79 | 180.7 | 94.9 |
| 1961 | 40.7 | 1,984 | 59.85 | 183.7 | 94.5 |
| 1962 | 44.4 | 2,066 | 61.87 | 186.5 | 94.8 |
| 1963 | 45.7 | 2,139 | 63.78 | 189.2 | 94.5 |
| 1964 | 49.3 | 2,284 | 62.00 | 191.9 | 94.7 |
| 1965 | 54.2 | 2,436 | 59.36 | 194.3 | 96.6 |
| 1966 | 58.5 | 2,605 | 59.42 | 196.6 | 99.8 |
| 1967 | 58.4 | 2,751 | 60.83 | 198.7 | 100.0 |
| 1968 | 65.6 | 2,946 | 66.78 | 200.0 | 102.5 |
| 1969 | 66.2 | 3,130 | 65.58 | 202.7 | 106.5 |
| 1970 | 65.1 | 3,358 | --- | 204.9 | 110.4 |

1/ "Domestic" consumption data derived by adjusting mill consumption for raw fiber equivalent of U.S. foreign trade in textile products and for consumption of manmade waste fiber. The trade balance for manmade textile fiber products was allocated on the basis of relative production figures computed from Textile Economics Bureau reports. The manmade fiber waste was allocated on the basis of information provided by Stanley Hunt of the Textile Economics Bureau, Inc.; it does not include flax and silk. Based on cotton-equivalent factors as follows: (a) regular and intermediate tenacity rayon and acetate filament yarn - 1.51; (b) rayon and acetate staple fiber - 1.10; (c) high tenacity rayon yarn--prior to 1953 - 1.53, 1954 - 1.64, 1955 - 1.71, 1956 - 1.74, 1957 - 1.77, 1958 to date - 1.80; (d) noncellulosic fiber for uses other than tires - 1.74; (e) noncellulosic fiber used in tires - 2.73; (f) noncellulosic staple fiber - 1.37; and (g) glass fiber - 1.70. Wool fiber based on cotton-equivalent factor - 0.55.

2/ Personal disposable income per capita. Department of Commerce. Oct. 1971.

3/ Weighted price index consisting of the following series: Cotton - Group B mill points, SM 1-1/16 inch cotton. Source: USDA. Wool - Apparel-Price per pound, Australian wool, 64's, 70's good top making, clean basis (American yield), Boston (duty paid). Source: USDA. Carpet-Price per pound, Buenos Aires wool, 5/6's (40/36's) clean basis (American yield), Boston (in bond). Source: USDA. Cellulosic - Regular yarn-American viscose 150 denier 60 filament on cones, tubes. High tenacity yarn-American viscose 1650 denier. Staple-American viscose 1.5 denier. Noncellulosic - Filament-Nylon, 70 denier. High tenacity filament-Nylon 840 denier. Glass - DE-150-1/0, Owens Corning. Staple-Nylon 1.5 denier through 1958; dacron 1.5 denier 1959-1970. Source for all manmade fiber prices: Modern Textiles.

4/ Total population July 1 (50 States after 1960). Source: Bureau of the Census.

5/ All commodities. Source: Bureau of Labor Statistics.

Table A-2--Fiber prices, 1952-70

| Year | Cotton 1/ | Wool 2/ | | Cellulosic 3/ | | | Noncellulosic 4/ | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Apparel | Carpet | Yarn | High tenacity | Staple | Yarn | High tenacity | Staple |
| | Cents per pound | | | | | | | | |
| 1952 | 43.24 | 175.5 | 75.5 | 77 | 63 | 40 | 201 | 166 | 175 |
| 1953 | 37.10 | 202.2 | 73.9 | 77 | 63 | 35 | 201 | 166 | 175 |
| 1954 | 38.14 | 197.6 | 79.2 | 77 | 63 | 34 | 201 | 149 | 157 |
| 1955 | 39.91 | 165.1 | 82.2 | 82 | 64 | 34 | 201 | 147 | 139 |
| 1956 | 39.56 | 164.1 | 82.5 | 86 | 66 | 32 | 172 | 133 | 130 |
| 1957 | 39.68 | 181.3 | 89.7 | 91 | 59 | 31 | 176 | 130 | 133 |
| 1958 | 40.06 | 143.3 | 66.3 | 80 | 58 | 31 | 176 | 123 | 150 |
| 1959 | 38.75 | 133.4 | 74.4 | 80 | 60 | 32 | 176 | 114 | 136 |
| 1960 | 36.09 | 142.1 | 80.3 | 82 | 49 | 30 | 176 | 97 | 130 |
| 1961 | 36.70 | 136.5 | 76.5 | 82 | 50 | 28 | 176 | 95 | 117 |
| 1962 | 38.00 | 141.0 | 66.1 | 82 | 50 | 28 | 176 | 95 | 114 |
| 1963 | 37.71 | 154.0 | 81.5 | 82 | 50 | 28 | 176 | 95 | 114 |
| 1964 | 33.74 | 164.0 | 88.8 | 82 | 50 | 28 | 176 | 92 | 99 |
| 1965 | 28.74 | 141.0 | 72.7 | 83 | 50 | 28 | 176 | 83 | 86 |
| 1966 | 27.72 | 151.4 | 67.4 | 85 | 50 | 28 | 176 | 83 | 82 |
| 1967 | 29.96 | 140.8 | 44.7 | 85 | 50 | 28 | 176 | 83 | 65 |
| 1968 | 34.09 | 143.5 | 44.4 | 89 | 50 | 28 | 176 | 83 | 61 |
| 1969 | 29.24 | 142.9 | 47.7 | 89 | 50 | 28 | 176 | 83 | 61 |
| 1970 | 28.37 | 119.6 | 47.7 | 93 | 50 | 28 | 176 | 82 | 61 |

1/ Group B mill points, SLM 1-1/16 inch cotton. Source: USDA

2/ Wool prices: Apparel-Price per pound, Australian wool, 64's, 70's good top making, clean basis (American yield), Boston (duty paid). Source: USDA. Carpet-Price per pound Buenos Aires wool, 5/6's (40/36's), clean basis (American yield), Boston (in bond). Source: USDA.

3/ Cellulosic fiber - Regular yarn-American Viscose, 150 denier 60 filament on cones, tubes. High tenacity yarn-American Viscose 1650 denier. Staple-American Viscose 1.5 denier.

4/ Noncellulosic fiber - Filament-Nylon, 70 denier. High tenacity filament-Nylon 840 denier. Staple-Nylon 1.5 denier through 1958; dacron 1.5 denier 1959-1970. Source: Modern Textiles.

Table A-3--Cotton consumption in end-use markets, actual 1/ and estimated 2/, 1953-70

| Year | Men's apparel | | Women's apparel | | Household furnishings | | Other consumer products | | Industrial uses | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated |
| | Pounds per capita | | | | | | | | | |
| 1953 | 13.9 | 14.2 | 7.5 | 7.2 | 6.1 | 5.9 | 2.7 | 2.6 | 4.7 | 4.5 |
| 1954 | 13.2 | 13.6 | 7.3 | 7.4 | 5.9 | 6.0 | 2.6 | 2.7 | 4.3 | 4.4 |
| 1955 | 14.0 | 13.9 | 8.0 | 7.3 | 6.1 | 6.1 | 2.7 | 2.6 | 4.5 | 4.4 |
| 1956 | 14.0 | 13.8 | 7.0 | 7.3 | 6.0 | 6.0 | 2.6 | 2.6 | 4.1 | 4.1 |
| 1957 | 13.2 | 13.0 | 7.1 | 7.1 | 5.7 | 5.7 | 2.5 | 2.4 | 3.8 | 3.8 |
| 1958 | 13.1 | 13.0 | 7.0 | 7.2 | 5.6 | 5.7 | 2.4 | 2.4 | 3.5 | 3.6 |
| 1959 | 14.3 | 14.1 | 7.2 | 7.1 | 6.0 | 5.8 | 2.4 | 2.5 | 3.7 | 3.8 |
| 1960 | 13.9 | 13.7 | 7.1 | 7.1 | 5.9 | 5.8 | 2.4 | 2.4 | 3.4 | 3.4 |
| 1961 | 13.6 | 13.9 | 6.9 | 7.0 | 5.7 | 6.0 | 2.4 | 2.5 | 3.3 | 3.2 |
| 1962 | 14.5 | 14.6 | 6.7 | 6.8 | 5 9 | 6.0 | 2.4 | 2.4 | 3.1 | 3.1 |
| 1963 | 14.2 | 14.6 | 6.6 | 6.7 | 5.9 | 6.2 | 2.4 | 2.4 | 3.0 | 3.0 |
| 1964 | 15.4 | 14.9 | 6.4 | 6.4 | 6.3 | 6.2 | 2.4 | 2.4 | 3.0 | 3.0 |
| 1965 | 15.2 | 14.9 | 6.1 | 6.1 | 6.6 | 6.4 | 2.5 | 2.5 | 3.2 | 3.2 |
| 1966 | 14.9 | 14.6 | 5.7 | 6.0 | 6.5 | 6.4 | 2.6 | 2.6 | 3.4 | 3.5 |
| 1967 | 13.5 | 13.2 | 5.3 | 5.6 | 6.5 | 6.4 | 2.6 | 2.7 | 3.3 | 3.3 |
| 1968 | 12.6 | 12.5 | 5.0 | 4.9 | 6.4 | 6.4 | 2.6 | 2.5 | 3.0 | 3.2 |
| 1969 | 11.7 | 11.5 | 4.6 | 4.5 | 6.1 | 6.0 | 2.4 | 2.4 | 2.7 | 2.6 |
| 1970 | 11.1 | 10.9 | 4.5 | 4.3 | 5.9 | 6.1 | 2.4 | 2.5 | 2.5 | 2.4 |

1/ Per capita consumption data are derived from end-use data published in the Textile Organon.

2/ Estimates based on regression equations shown in table 7.

Table A-4--Wool consumption in end-use markets, actual 1/ and estimated 2/, 1953-70

| Year | Men's apparel | | Women's apparel | | Household furnishings | | Other consumer products | | Industrial uses | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated |
| | Pounds per capita | | | | | | | | | |
| 1953 | 2.6 | 3/ | 2.9 | 3/ | 1.0 | 0.9 | 0.2 | 3/ | 0.2 | 3/ |
| 1954 | 2.3 | 3/ | 2.2 | 3/ | 0.8 | .9 | .2 | 3/ | .1 | 3/ |
| 1955 | 2.6 | 3/ | 2.6 | 3/ | 0.9 | .7 | .2 | 3/ | .1 | 3/ |
| 1956 | 2.6 | 3/ | 2.2 | 3/ | 1.0 | .9 | .2 | 3/ | .1 | 3/ |
| 1957 | 2.4 | 3/ | 2.0 | 3/ | 0.8 | .8 | .2 | 3/ | .1 | 3/ |
| 1958 | 2.2 | 3/ | 1.6 | 3/ | 0.7 | .8 | .2 | 3/ | .1 | 3/ |
| 1959 | 2.3 | 3/ | 1.9 | 3/ | 1.0 | .9 | .2 | 3/ | .1 | 3/ |
| 1960 | 2.2 | 3/ | 1.6 | 3/ | .9 | .9 | .1 | 3/ | .1 | 3/ |
| 1961 | 2.1 | 3/ | 1.5 | 3/ | .8 | .9 | .1 | 3/ | .1 | 3/ |
| 1962 | 2.1 | 3/ | 1.5 | 3/ | .8 | .9 | .2 | 3/ | .1 | 3/ |
| 1963 | 2.0 | 3/ | 1.4 | 3/ | .9 | .9 | .2 | 3/ | .1 | 3/ |
| 1964 | 1.7 | 3/ | 1.5 | 3/ | .8 | .8 | .2 | 3/ | .1 | 3/ |
| 1965 | 1.9 | 3/ | 1.5 | 3/ | .7 | .7 | .1 | 3/ | .1 | 3/ |
| 1966 | 1.7 | 3/ | 1.4 | 3/ | .7 | .6 | .1 | 3/ | .1 | 3/ |
| 1967 | 1.6 | 3/ | 1.2 | 3/ | .5 | .6 | .1 | 3/ | .1 | 3/ |
| 1968 | 1.6 | 3/ | 1.3 | 3/ | .5 | .6 | .2 | 3/ | 0 | 3/ |
| 1969 | 1.5 | 3/ | 1.1 | 3/ | .5 | .5 | .2 | 3/ | 0 | 3/ |
| 1970 | 1.2 | 3/ | 0.9 | 3/ | .4 | .4 | .2 | 3/ | 0 | 3/ |

1/ Per capita consumption data are derived from end-use data published in the Textile Organon.

2/ Estimates based on regression equations shown in table 8.

3/ No annual estimates. Regression analysis unsatisfactory.

Table A-5--Noncellulosic fiber consumption in end-use markets, actual 1/ and estimated 2/, 1953-70

| Year | Men's apparel | | Women's apparel | | Household furnishings | | Other consumer products | | Industrial uses | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated |
| | Pounds per capita | | | | | | | | | |
| 1953 | 0.6 | 0.6 | 1.0 | 1.3 | 0.1 | 0.1 | 0 | 0.1 | 0.6 | 0.8 |
| 1954 | .6 | .3 | 1.3 | 1.2 | .1 | 0 | 0 | .1 | .7 | .4 |
| 1955 | .5 | .6 | 1.4 | 1.4 | .3 | .3 | .1 | .1 | .9 | 1.1 |
| 1956 | .7 | .9 | 1.6 | 1.4 | .4 | .5 | .2 | .2 | 1.0 | .9 |
| 1957 | .8 | .9 | 1.7 | 1.8 | .4 | .7 | .2 | .2 | 1.1 | 1.2 |
| 1958 | .9 | 1.0 | 1.8 | 1.8 | .5 | .6 | .2 | .2 | 1.3 | 1.2 |
| 1959 | 1.2 | 1.2 | 2.0 | 1.9 | .6 | .6 | .2 | .2 | 1.7 | 1.6 |
| 1960 | 1.2 | 1.2 | 2.0 | 2.0 | .9 | .7 | .4 | .4 | 1.6 | 1.6 |
| 1961 | 1.5 | 1.3 | 2.3 | 2.2 | 1.2 | 1.0 | .4 | .4 | 1.8 | 2.0 |
| 1962 | 1.7 | 1.6 | 2.6 | 2.5 | 1.4 | 1.2 | .4 | .4 | 2.1 | 2.1 |
| 1963 | 2.0 | 1.7 | 2.7 | 2.7 | 1.8 | 1.6 | .5 | .5 | 2.2 | 2.0 |
| 1964 | 2.4 | 2.5 | 2.9 | 3.1 | 2.3 | 2.3 | .6 | .6 | 2.5 | 2.4 |
| 1965 | 3.2 | 3.4 | 3.7 | 3.6 | 3.0 | 3.1 | .7 | .8 | 2.9 | 3.0 |
| 1966 | 3.7 | 4.2 | 4.1 | 4.1 | 3.3 | 3.7 | .9 | 1.0 | 3.7 | 3.8 |
| 1967 | 4.9 | 4.8 | 4.6 | 4.8 | 4.0 | 4.3 | .9 | 0.9 | 3.7 | 4.0 |
| 1968 | 6.3 | 5.8 | 5.8 | 5.7 | 5.4 | 5.3 | 1.3 | 1.4 | 4.7 | 4.5 |
| 1969 | 6.0 | 6.1 | 5.9 | 6.0 | 6.2 | 5.9 | 1.4 | 1.5 | 5.2 | 4.8 |
| 1970 | 6.5 | 6.5 | 6.7 | 6.6 | 6.4 | 6.3 | 2.1 | 1.8 | 4.4 | 4.7 |

1/ Per capita consumption data are derived from end-use data published in the Textile Organon.

2/ Estimates based on regression equations shown in table 9.

Table A-6--Cellulosic fiber consumption in end-use markets, actual 1/ and estimated 2/, 1953-70

| Year | Men's apparel | | Women's apparel | | Household furnishings | | Other consumer products | | Industrial uses | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated | Actual | Estimated |
| | Pounds per capita | | | | | | | | | |
| 1953 | 1.8 | 3/ | 3.2 | 2.6 | 1.0 | 3/ | 0.8 | 3/ | 2.9 | 3/ |
| 1954 | 1.5 | 3/ | 2.6 | 2.4 | 1.1 | 3/ | .7 | 3/ | 2.2 | 3/ |
| 1955 | 1.4 | 3/ | 2.4 | 2.6 | 1.5 | 3/ | .7 | 3/ | 2.6 | 3/ |
| 1956 | 1.2 | 3/ | 2.2 | 2.2 | 1.6 | 3/ | .8 | 3/ | 2.2 | 3/ |
| 1957 | 1.0 | 3/ | 2.1 | 2.2 | 1.7 | 3/ | 1.0 | 3/ | 2.0 | 3/ |
| 1958 | 1.0 | 3/ | 2.1 | 2.1 | 1.6 | 3/ | 1.0 | 3/ | 1.6 | 3/ |
| 1959 | .9 | 3/ | 2.2 | 2.5 | 1.8 | 3/ | 1.0 | 3/ | 1.9 | 3/ |
| 1960 | .8 | 3/ | 2.3 | 2.6 | 1.5 | 3/ | 1.0 | 3/ | 1.6 | 3/ |
| 1961 | .8 | 3/ | 2.8 | 3.0 | 1.6 | 3/ | 1.2 | 3/ | 1.5 | 3/ |
| 1962 | .8 | 3/ | 3.1 | 3.2 | 1.9 | 3/ | 1.2 | 3/ | 1.5 | 3/ |
| 1963 | .9 | 3/ | 3.7 | 3.6 | 2.3 | 3/ | 1.2 | 3/ | 1.4 | 3/ |
| 1964 | .9 | 3/ | 3.7 | 3.5 | 2.4 | 3/ | 1.3 | 3/ | 1.5 | 3/ |
| 1965 | 1.0 | 3/ | 3.2 | 3.4 | 2.5 | 3/ | 1.3 | 3/ | 1.5 | 3/ |
| 1966 | 1.0 | 3/ | 3.3 | 3.2 | 2.5 | 3/ | 1.5 | 3/ | 1.4 | 3/ |
| 1967 | .9 | 3/ | 3.6 | 3.4 | 2.2 | 3/ | 1.7 | 3/ | 1.2 | 3/ |
| 1968 | 1.2 | 3/ | 4.0 | 4.1 | 2.4 | 3/ | 1.6 | 3/ | 1.3 | 3/ |
| 1969 | 1.1 | 3/ | 3.8 | 3.6 | 2.1 | 3/ | 1.9 | 3/ | 1.1 | 3/ |
| 1970 | .8 | 3/ | 3.5 | 3.7 | 1.7 | 3/ | 1.9 | 3/ | .9 | 3/ |

1/ Per capita consumption data are derived from end-use data published in the Textile Organon.

2/ Estimates based on regression equations shown in table 10.

3/ No annual estimates. Regression analysis unsatisfactory.

END