An Analysis of Substitution Relationships Between Short and Long Staple Cotton

By John Craven

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INTRODUCTION

Statement of the Problem

Total disappearance of United States Upland Cotton has been relatively stable since the early 1930's. However, within this aggregate disappearance the importance of short staple cotton[1] has declined considerably. A brief review of historical data helps to point out the degree of this decline. During the 1938-1941 period disappearance of short staple cotton was 48% of the total disappearance of U. S. Upland Cotton. In the 1962-1966 period this figure had declined to 22%. The decline in the disappearance of short staple cotton relative to the disappearance of long staple cotton[2] has been accelerated by the following factors:

1. The prices of short staple cotton relative to the prices of long staple cotton
2. Changes in technology
3. Consumer income, tastes and preferences. types of work, manner of living

Relative support prices of short to long staple cotton have apparently been higher in the past than the demand for short staple

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[1]Upland Cotton stapling less than 1 inch

[2]Upland Cotton stapling 1 inch and over

cotton would justify. This relationship caused large amounts of short staple cotton that were produced to remain unsold and thus be accumulated in Commodity Credit Corporation stocks. This relationship has changed somewhat in recent years with the change in relative price supports.

Changes in technology have had perhaps the most visible effect on the disappearance of short staple cotton. Increased spindle speeds of the more advanced textile machinery requires the use of stronger fibers in order to keep thread breakage low. Quality tests show that long staple cotton is usually stronger than short staple cotton. Another technological factor which has caused a decrease in the use of short staple cotton is the increased use of cotton/man made blends. Most of these blends utilize long staple cotton.

U. S. consumer income has increased in recent years largely because of the increasing "white collar" working force. As consumer income increases, and modes of living change, consumers usually substitute high quality goods for low quality goods. Cloth made of short staple cotton is coarser than cloth made of long staple cotton; thus with the rise in consumer income and changes in the mode of living in the U. S. population, the demand for goods made with short staple cotton has declined.

In recent years, farmers on the High Plains of Texas have produced, on the average, approximately 50% of the total United States short staple cotton production. Several characteristics of short staple cotton give it a comparative advantage over long staple cotton in this area. These advantages include a slightly shorter growing season and better protection against weather due to a tighter boll.

In recent years textile manufacturers have indicated that their use of short staple cotton would decline still further if they had an adequate supply of long staple cotton, regardless of the price of short staple cotton. In spite of the contentions made by the textile industry there is considerable evidence that the disappearance of short staple cotton is considerably affected by the price relationship between short and long staple cotton. This price relationship is largely determined by government price support policy.[3] This implies that the loss of market caused by the downward shift in the demand for short staple cotton can be offset by a change in government price support policy. In any case, those people concerned with the formulation of government programs should be well aware of the existing conditions, the relationships involved, and the implications they have in formulating public policy.

General Objective

The general objective of this project was to determine the effect of relative prices on the disappearance of short and long staple cotton.

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[3] See Louis Glass' Ag. Eco. 430 report, An Analysis of Substitution Relationships Among Different Staple Lengths of Cotton, Summer, 1968.

Specific Objectives

There were several specific objectives of this project.

Objective A was to present a review of trends in the supply and disappearance of U. S. Upland Cotton.

Objective B was to review related work done previously by Louis Glass and Bob Baxter.

Objective C was to determine an estimate of the short and long run elasticities of substitution between short and long staple cotton, utilizing a least squares estimating equation.

Objective D was (1) to determine unbiased estimates for the structural coefficients of price and disappearance equations for short and long staple cotton, and (2) utilize these estimates in determining the respective short and long run elasticities of substitution.

Procedure

Most of the data used in this report was transformed U.S.D.A. data. Most of the calculations involved were made by and contained in Ag. Eco. 430 reports by Louis Glass and Bob Baxter.

Objective A was achieved by compiling data contained in U.S.D.A. publications and presenting it in written and graphic form.

Objective B was achieved by summarizing significant findings of Glass and Baxter in their Ag. Eco. 430 reports.

Objective C was achieved by obtaining estimates of short and long run elasticities of substitution between short and long staple cotton, utilizing a linear least squares estimating method.

Objective D was achieved by solving a set of price and disappearance equations simultaneously. Coefficients obtained for these equations were then used to determine estimates of short and long run elasticities of substitution.

Review of Literature

There have been many studies concerning demand interrelationships among competing products. Schultz[4] developed the theoretical framework for the "rough test" to distinguish between competing and completing products. Meinken, Rojko, and King[5] utilized price and consumption ratios to obtain an estimate of the elasticity of substitution between beef and pork. Waugh[6] utilized lagged price and consumption ratios of cotton and rayon to obtain estimates for coefficients of long run demand equations. Working[7] devised a method whereby the slopes or elasticities of short and long run demand curves could be obtained simultaneously. A later review by Gislason[8]

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[4]Schultz, Henry. The Theory and Measurement of Demand. Chicago: University of Chicago Press, 1938. pages 570-571.

[5]K. W. Meinken, A. S. Rojko, and G. A. King. "Measurement of Substitution in Demand from Time Series Data--A Synthesis of Three Approaches". Journal of Farm Economics, Vol. 38 (August, 1956) pages 711-735.

[6]Waugh, Frederic V. Demand and Price Analysis - Some Examples From Agriculture. T. B. No 1316, ERS, U.S.D.A. 1964. pages 57-62.

[7]Working, Elmer J. "Appraising the Demand for Agricultural Output During Rearmament". Journal of Farm Economics. Vol. 34 (May, 1952) pages 206-224.

[8]Gislason, Conrad. "A Note on Long Run Price Elasticity". Journal of Farm Economics. Vol. 39 (August 1957) pages 798-802.

clarified this method. All of these studies used the single equation least squares estimating technique. Several authors have suggested that the assumptions which must hold ~~true~~ in order for a single equation approach to be of value are in fact not always true and suggest the use of a simultaneous equations approach in these cases. Haavelmo[9] produced the first major article suggesting this approach. Fox[10] lists several questions which must be answered before determining which approach would be more useful. Foote[11] discusses the simultaneous equation approach and applies this technique to pork, beef, and export crops.

Many of the concepts forwarded by these authors will be used in the preparation of this report.

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[9] Haavelmo, Trygve. "The Statistical Implications of a System of Simultaneous Equations". Econometricia Vol 11. 1943 pages 1-12.

[10] Fox, Karl A. The Analysis of Demand for Farm Products. T.B. 1081 U.S.D.A. 1953.

[11] Foote, R. J. Analytical Tools for Studying Demand and Price Structures. Ag. Handbook No. 146 U.S.D.A.

CONCEPTUAL FRAMEWORK

Relative Demand and Related Concepts

Relative demand can be defined as the quantity of one product (A) that will be consumed relative to the quantity of another product (B) at all alternative relative price levels of A to B, when all other factors affecting the demand for either product are held constant. Figure 1 illustrates a relative demand curve for two competing products A and B. It can be seen that when the price ratio is lowered from point 1 to point 3, the consumption ratio of A to B increases from point 2 to point 4. Figure 2 illustrates a case in which the relative demand curve shifts from D_1 to D_2. This can occur due to changes in technology, consumer income, tastes, or preferences. In order for the relative quantity of A consumed to remain at the same level on curve D_2 as on curve D_1, the price ratio must decrease from point 1 to point 3. However, if the price ratio remained at its previous level, the relative quantity of A consumed would decrease from point 2 to point 4. This concept implies that in the case of two competing commodities, a loss in consumption of one commodity can be offset by lowering the relative price of that commodity. Therefore, if short and long staple cotton do in fact act as substitute goods, and the demand for short staple cotton shifts downward over time, relatively more short staple cotton would be consumed if the price ratio of short to long staple cotton were lowered.

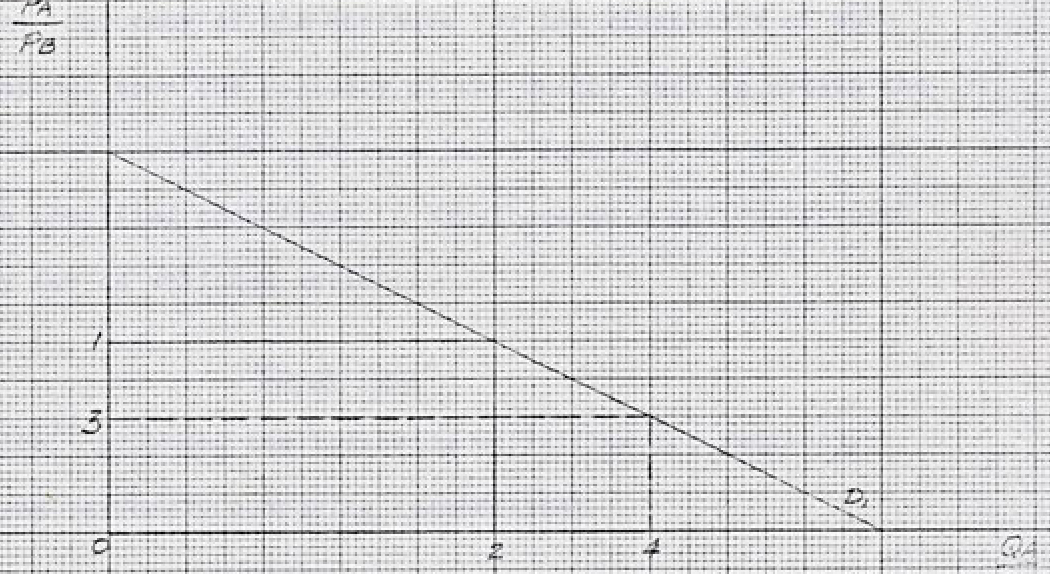

FIG. 1. RELATIVE DEMAND OF A to B

FIG. 2. SHIFT IN RELATIVE DEMAND CURVE

The degree of substitutability can be measured by the elasticity of substitution. Accuracy of the estimate for the elasticity of substitution depends upon the validity of the method used to obtain the estimate. If the variables used in a least squares analysis do not meet certain specified conditions, a simultaneous equation approach is necessary for an unbiased estimate.

"Rough Test"

Schultz[12] proposed the following definition for perfectly completing and perfectly competing commodities:

> Two commodities are perfectly completing if they cannot be used separately but only jointly in a fixed ratio. Two commodities are perfectly competing if they can be substituted for each other in a certain fixed constant ratio.

While he states that these are not precise definitions for intermediate cases of interrelated products, he proposes that they be used in formulating a "rough test" to determine whether or not two commodities are completing or competing in comsumption. According to the "rough test" two commodities are completing if the ratio of the two quantities consumed fluctuates relatively less than their price ratio. The commodities are competing if their price ratio fluctuates relatively less than their consumption ratio. Therefore, if two commodities are substitute goods (competing), a

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[12] Schultz, Henry. The Theory and Measurement of Demand. Chicago: University of Chicago Press, 1938. pages 570-571.

small change in their price ratio would cause a relatively larger change in their consumption ratio.

Elasticity of Substitution

Elasticity of substitution is defined as the percentage change in the consumption ratio of two competing goods associated with a small percentage change (usually 1%) in the price ratio of these goods. Expressed in equation form:

$$(1) \quad E_s = \frac{\Delta Qr}{\Delta Pr} \cdot \frac{Pr}{Qr}$$

where E_s = the elasticity of substitution

Qr = the consumption ratio of the two competing goods

Pr = the price ratio of the two competing goods

Δ = a small change

Values of E_s indicate the ease with which one good will substitute for another at a particular point on their relative demand curve. High values of E_s indicate the goods are easily substituted while low values indicate the goods are not easily substituted.

Methods of Estimating Elasticities

The usual method employed for estimating elasticities utilizes a linear least squares regression analysis with the variables expressed either in natural units or logarithms. When natural units are used computations such as those in equation (1) are performed. When logarithms are used elasticities are obtained directly as coefficients. Several authors have proposed modifications to this method.

Waugh Method[13]

Waugh used an estimating equation of the following form to estimate the long run elasticity of substitution between cotton and rayon.

$$(2) \quad Q_t = a_1 + b_1 P_t + b_2 P_{(t-3)} + b_3 P_{(t-6)} + b_4 P_{(t-9)}$$

where Q_t = the current 3 year average consumption ratio of cotton to rayon

P_t = the current 3 year average price ratio of cotton to rayon

$P_{(t-3)} P_{(t-6)} P_{(t-9)}$ = the 3 year average price ratio lagged and centered 3, 6, and 9 years, respectively.

Waugh then divided the coefficients obtained in the estimating equation by 3 to put the data on an annual basis and graphed these values against time to form a "distributed lag curve." Values for each year on the distributed lag curve were then added and used as a cumulative weight. Waugh estimated the long run elasticity of substitution by multiplying this cumulative weight by the mean value of the price ratio relative to the consumption ratio. A drawback in using this method is that unequal weights are arbitrarily assigned to different years of the analysis depending upon the time lag used.

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[13] Waugh, Frederic V. Demand and Price Analysis -- Some Examples from Agriculture. T.B. No. 1316, ERS, U.S.D.A. pages 57-62.

Working Method[14]

Working utilized a single least squares estimating equation to obtain slopes of short and long run demand curves. Values obtained for the slopes can then be used to calculate elasticities. Working used an equation of the following form.

(3) $X_{1(t)} = a + b_1X_{2(t)} + b_2X_{3(t-1)}$

where X_1 = price

X_2 = quantity consumed

X_3 = average quantity consumed over a designated number of years

t = current year

$t-1$ = immediately preceding year

He then defined b_1 as the slope of the short run demand curve and postulated the long run demand equation as:

(4) $X_4 = a + b_3X_3$

where X_4 = the average price averaged over the same period of time as used for X_3.

He then demonstrated that b_3, which is the slope of the long run linear demand curve, is equal to $b_1 + b_2$ in equation 3. As pointed out by Gislason this means that the slope of the long run

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[14]As reviewed by Conrad Gislason, "A Note on Long Run Price Elasticity." Journal of Farm Economics. Vol. 39 (August 1957) pages 798-802.

demand curve is equal to the slope of the short run demand curve plus the shift coefficient of the short run demand curve which is attached to the long run variable. These demand equations can be expressed in terms of quantities dependant upon price with no change in the concept involved. When the equations are expressed in this manner the values obtained for the short and long run slopes can then be multiplied by price/quantity ratios to obtain the corresponding short and long run elastiticies of substitution.

Simultaneous Equation Approach for Estimating Structural Coefficients[15]

In their discussion of the simultaneous equation approach Fox and Foote state that:

> A single equation least squares analysis of demand assumes (1) that the demand function is such that one variable can be selected as dependant upon the others, and that all residual errors or disturbances are concentrated in the dependant variable; (2) that none of the independant variables in the demand function are in fact influenced by or determined simultaneously with the dependant variable; (3) that the disturbances in the dependant variable tend to be normally distributed and not serially correlated.

If these conditions do not hold true for the variables used, the least squares method may not give unbiased estimates of structural coefficients. The simultaneous equations method can be used to obtain unbiased estimates of these coefficients. In most discussions of the

[15] This section is mainly developed from Foote, R. J., and Fox, Karl A. Analytical Tools for Measuring Demand. Ag Handbook No. 64 U.S.D.A., pages 39-45.

simultaneous equations approach several basic terms are used. These are defined below.[16]

Structure - process by which a set of economic variables is believed to be generated.

Endogeneous variables - variables whose values are explained by the structure.

Exogenous variables - variables whose values are explained outside the structure.

Predetermined variables - exogenous and lagged endogenous variables.

Model - Set of structures compatible with the researcher's advance assumptions about the statistical universe from which data is drawn.

Two major problems must be dealt with in formulating a simultaneous equations system. These include specifying the economic model and identifying the structural equations. The economic model must be specified so that the number of structural equations is equal to the number of endogenous variables whose values are to be explained by the system. Also, each equation must be identifiable. If each equation is "just identified," the system can be solved quite simply. An equation is "just identified" when:[17]

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[16]Definitions are from Foote, R. J. Analytical Tools for Studying Demand and Price Structures. Ag Handbook No. 146. U.S.D.A. page 7.

[17]Identification Rules are from Foote, R. J. Analytical Tools for Studying Demand and Price Structures. Ag Handbook No. 146. U.S.D.A. page 62.

(5) $K^{**} \leq G^{*} - 1$

where K^{**} = the number of predetermined variables in the system but excluded from the equation.

G^{*} = the number of endogenous variables included in a particular equation.

If these conditions are met it is then possible to transform the structural equations into least squares equations, each containing one endogenous variable. Coefficients obtained by least squares analysis can then be transformed back into estimates of structural coefficients by algebraic manipulation. These estimates will not be biased.

RESEARCH METHODS AND PROCEDURES

All data used in this report were secondary and were obtained from U.S.D.A. publications on cotton.

Objective A was achieved by (1) compiling supply and disappearance data for short and long staple cotton, and (2) graphing this data so that trends could be readily seen.

Objective B was achieved by reviewing related work done previously by Louis Glass and Bob Baxter. Significant findings of Glass and Baxter are presented in this report.

Objective C was achieved by utilizing the Working method to obtain estimates for short and long run elasticities of substitution between short and long staple cotton. The following least squares estimating equation was used.

(6) $X_1 = a + b_1X_2 + b_2X_3 + b_3X_4$

where $X_1 = Qr_{(t)}$ the current disappearance ratio of short to long staple cotton.

$X_2 = Pr_{(t)}$ the current price ratio of middling 15/16" to middling 1 1/16" Upland Cotton.

$X_3 = Pr^*_{(t-1)}$ the average of X_2 for the preceding 5 years, current year not included.

X_4 = time, 1943 = 1

The period of analysis was from 1943 to 1966. With the equation set up in this form b_1 is defined as the slope[18] of the short run relative demand curve and b_2 is the shift coefficient for the short run relative demand curve which is attached to the long run variable. The slope of the long run demand curve is defined as $b_1 + b_2$.[19] Estimates of the short and long run elasticities of substitution were obtained by multiplying the slopes of the short and long run relative demand curves by the mean relative price to the mean relative disappearance ratio.

$$(7) \quad E_s \text{ (short run)} = b_1 \frac{\bar{X}_2}{\bar{X}_1}$$

$$(8) \quad E_s \text{ (long Run)} = (b_1 + b_2) \frac{\bar{X}_2}{\bar{X}_1}$$

where b_1 = slope of short run relative demand curve.

$b_1 + b_2$ = slope of long run relative demand curve

$\bar{X}_1$ = mean of X_1 as defined previously

$\bar{X}_2$ = mean of X_2 as defined previously

Objective D wasacheieved by solving a set of structural equations simultaneously. Coefficients obtained for the structural equations were then utilized in determining short and long run elasticities of substitution. The following structural equations

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[18]Slopes with quantity ratios on the vertical axis

[19]See page 12.

were used.

$$(9) \quad Pr_{(t)} = a_1 + b_{11}Qr_{(t)} + b_{12}Ps_{(t)} + b_{13}T + b_{14}Sr_{(t)}$$

$$(10) \quad Qr_{(t)} = a_2 + b_{21}Pr_{(t)} + b_{22}Pr^*_{(t-1)} + b_{23}T + b_{24}Sr_{(t)}$$

where $Pr_{(t)}$ = current price ratio of short to long staple cotton.

$Qr_{(t)}$ = current disappearance ratio of short to long staple cotton.

$Ps_{(t)}$ = current price support ratio of middling 15/16" to middling 1 1/16" cotton.

T = time, 1943 = 1

$Sr_{(t)}$ = current supply ratio of short to long staple cotton.

$Pr^*_{(t-1)}$ = average $Pr_{(t)}$ for the preceding 5 years not including the current year.

The model or set of structural equations satisfies the rules of specification and identification. The model is specified so that the number of endogenous variables whose values are to be explained (namely $Pr_{(t)}$ and $Qr_{(t)}$) is equal to the number of structural equations. The structural equations are "just identified". As stated in the conceptual framework an equation is "just identified" when:

$$(11) \quad K^{**} = G^* - 1$$

where K^{**}= the number of predetermined variables in the system but excluded from the equation.

G^* = the number of endogenous variables included in a particular equation.

The structural equations used in this system are identified as follows.

Equation 9

$K^{**} = Pr^*_{(t-1)} = 1$

$G^* = Pr_{(t)}$ and $Qr_{(t)} = 2$

$K^{**} = G^* - 1$

Equation 10

$K^{**} = Ps_{(t)} = 1$

$G^* = Pr_{(t)}$ and $Qr_{(t)} = 2$

$K^{**} = G^* - 1$

The following method was used to estimate eoefficients for the structural equations.

A. The structural equations were rewritten to place both endogenous variables on the same side.

$$(12)\quad Pr_{(t)} - b_{11}Qr_{(t)} = a_1 + b_{12}Ps_{(t)} + b_{13}T + b_{14}Sr_{(t)}$$

$$(13)\quad -b_{21}Pr_{(t)} + Qr_{(t)} = a_2 + b_{22}Pr^*_{(t-1)} + b_{23}T + b_{24}Sr_{(t)}$$

B. Equation 12 was multiplied by b_{21} to obtain equation 14. Equation 13 was multiplied by b_{11} to obtain equation 15.

$$(14)\quad b_{21}Pr_{(t)} - b_{11}b_{21}Qr_{(t)} = b_{21}a_1 + b_{13}b_{21}T + b_{12}b_{21}Ps_{(t)} + b_{14}b_{21}Sr_{(t)}$$

$$(15)\quad -b_{11}b_{21}Pr_{(t)} + b_{11}Qr_{(t)} = b_{11}a_{12} + b_{11}b_{22}T + b_{11}b_{23}Pr^*_{(t-1)} + b_{11}b_{24}Sr_{(t)}$$

C. Equations 12 and 15, and Equations 13 and 14 were then added to obtain reduced form equations whose coefficients could be estimated without bias by a least squares analysis.

$$(16)\quad Qr_{(t)} = \frac{a_2 + b_{21}a_1}{1 - b_{11}b_{21}} + \frac{(b_{22} + b_{13}b_{21})T}{1 - b_{11}b_{21}} + \frac{b_{23}}{1 - b_{11}b_{21}} Pr^*_{(t-1)} + \frac{(b_{14} + b_{11}b_{24})}{1 - b_{11}b_{21}} Sr_{(t)} + \frac{b_{12}b_{21}}{1 - b_{11}b_{21}} Ps_{(t)}$$

$$(17)\quad Pr_{(t)} = \frac{(a_1 + b_{11}a_2)}{1 - b_{11}b_{21}} + \frac{b_{13} + b_{11}b_{22}}{1 - b_{11}b_{21}} T + \frac{b_{12}}{1 - b_{11}b_{21}} Ps_{(t)} + \frac{b_{11}b_{23}}{1 - b_{11}b_{21}} Pr^*_{(t-1)} + \frac{(b_{14} + b_{11}b_{24})}{1 - b_{11}b_{21}} Sr_{(t)}$$

D. The coefficients for the reduced form equations were then estimated using a least squares regression analysis. This analysis was run on the IBM 360 computer at Texas Tech Computer Center. As can be seen in Step C the reduced form coefficients are in terms of the structural coefficients. When values are obtained for the reduced form coefficients the structural coefficients can then be obtained through algebraic manipulation. For example:

$$(18)\quad b_{11} = \frac{\dfrac{b_{11}b_{23}}{1 - b_{11}b_{21}}}{\dfrac{b_{23}}{1 - b_{11}b_{21}}}$$

$$b_{11} = \frac{b_{11} b_{23}}{1 - b_N b_{21}} \cdot \frac{1 - b_N b_{21}}{b_{23}}$$

Estimates of the structural coefficients were then used in computing the short and long run elasticities of substitution. The method and procedure used were the same as that used in obtaining Objective C.

FINDINGS

Trends in Supply and Disappearance Of U. S. Upland Cotton

Total supply of U. S. Upland Cotton has varied considerably from year to year since 1935 but has trended upward since reaching a low point in 1947. Total supply of short staple cotton declined considerably in the 1935-1950 period and has trended slight upward since 1950. The proportion of the short staple supply composed of the longer staple lengths in that group (middling 15/16" and middling 1 1/16")has increased rather steadily since 1937 and comprises a major portion of the total short staple cotton supply. These relationships can be seen in figure 3.

Trends in the disappearance of U. S. Upland Cotton point out the declining importance of short staple cotton. Figure 4 indicates that total disappearance of U. S. Upland Cotton has tended to increase slightly since 1934. The disappearance of short staple cotton has decreased in this period. Figure 5 indicates the declining importance of short staple cotton in relation to total U. S. Upland Cotton disappearance. Domestic Mill consumption accounts for a large proportion of total U. S. Upland Cotton disappearance (see figure 6). However, since 1952[20] exports have risen to a level

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[20] Export data on a staple length basis was first made available in 1952.

of approximately equal importance as domestic consumption in the disappearance of short staple cotton (see figure 7). In view of the trend towards utilizing more long staple cotton due to technological reasons the export market will probably continue to be of major significance as far as consumption of short staple cotton is concerned.

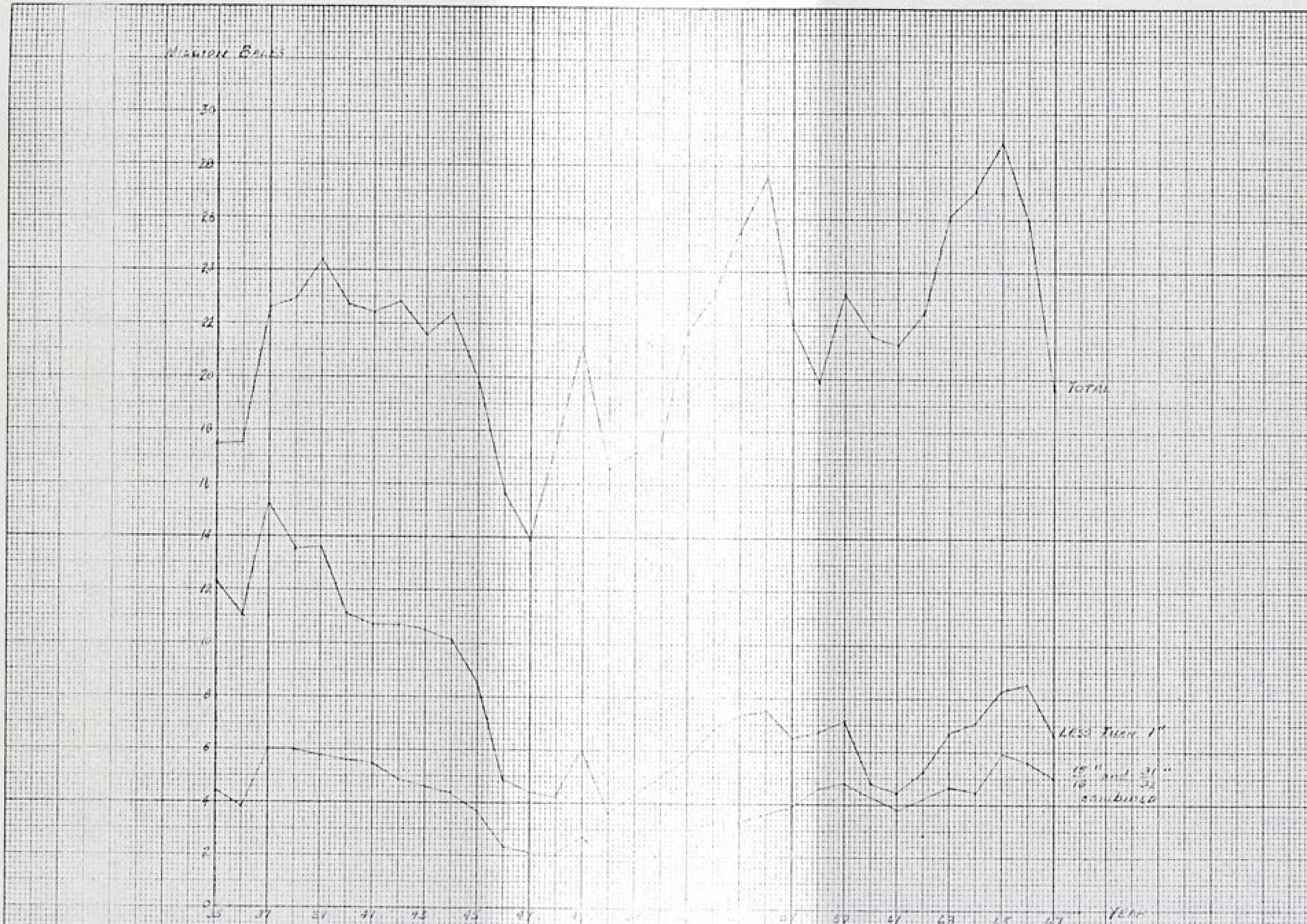

FIG. 3. SUPPLY OF U.S. UPLAND COTTON [illegible] 1935 - 1967

SOURCE: [illegible]

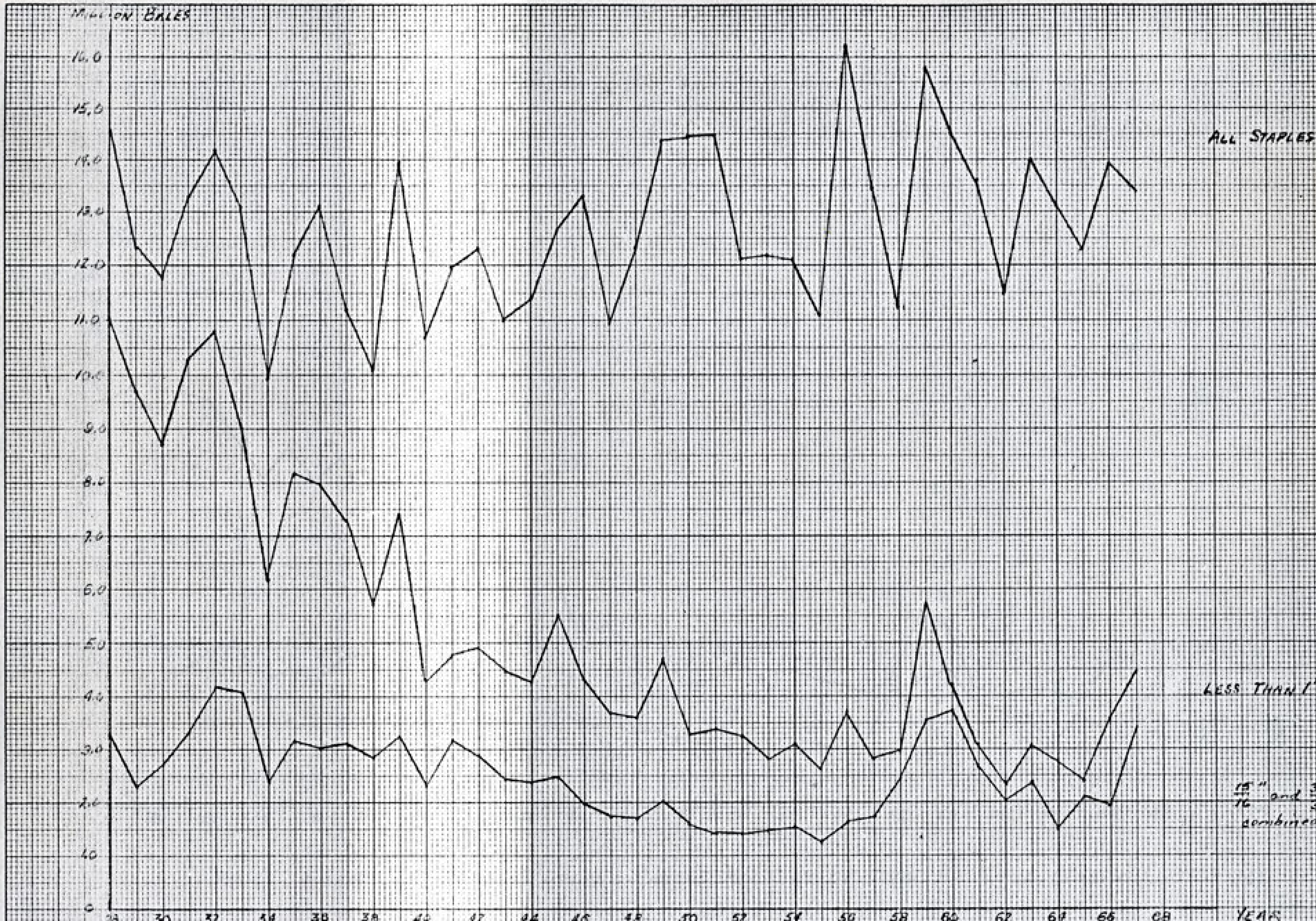

FIG. 4. DISAPPEARANCE OF U.S. UPLAND COTTON: BY STAPLE LENGTHS, 1928-1968

SOURCE: APPENDIX TABLE 1

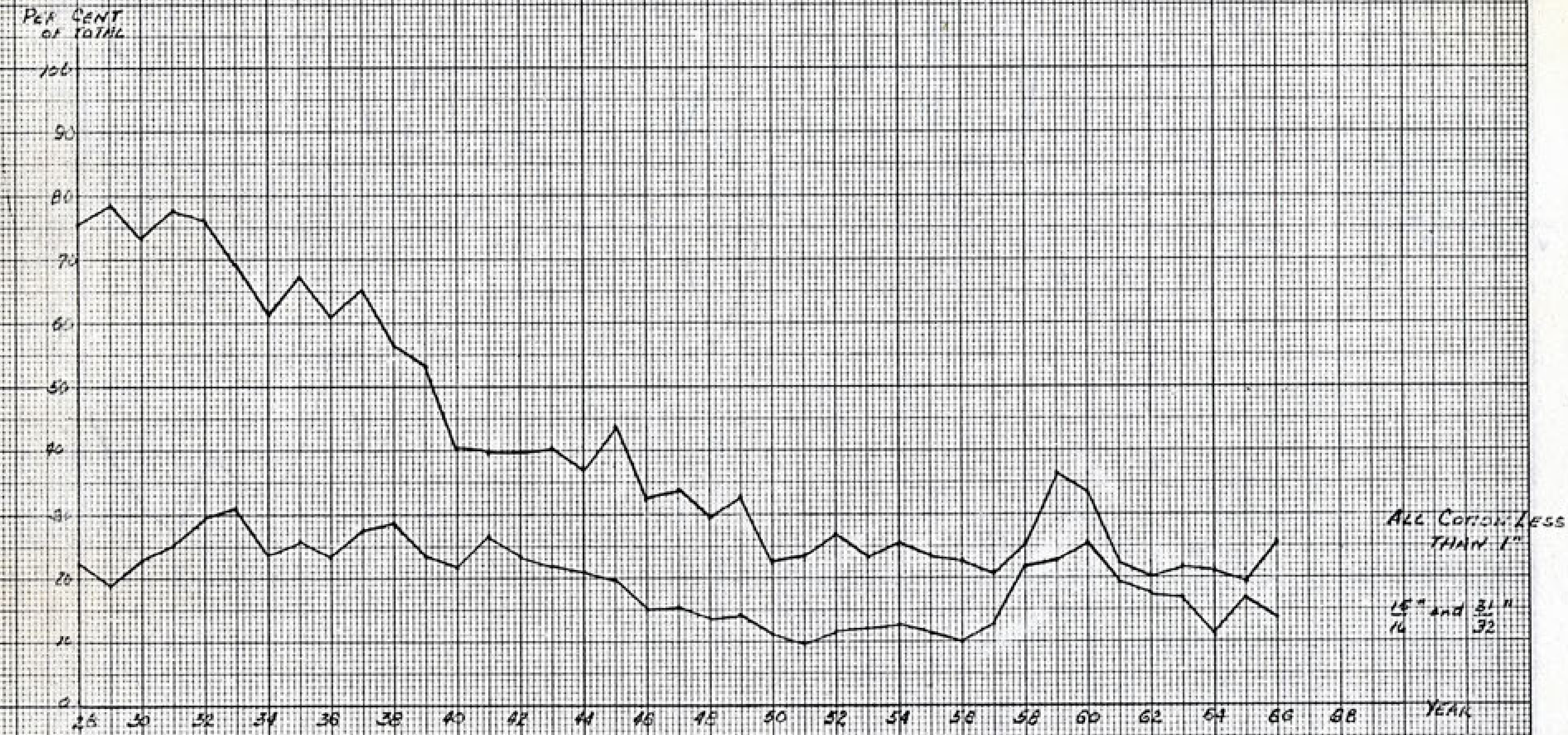

FIG 5. , DISAPPEARANCE OF U.S. UPLAND COTTON: PER CENT OF TOTAL BY STAPLE LENGTHS; 1928-1968

SOURCE: APPENDIX TABLE 1.

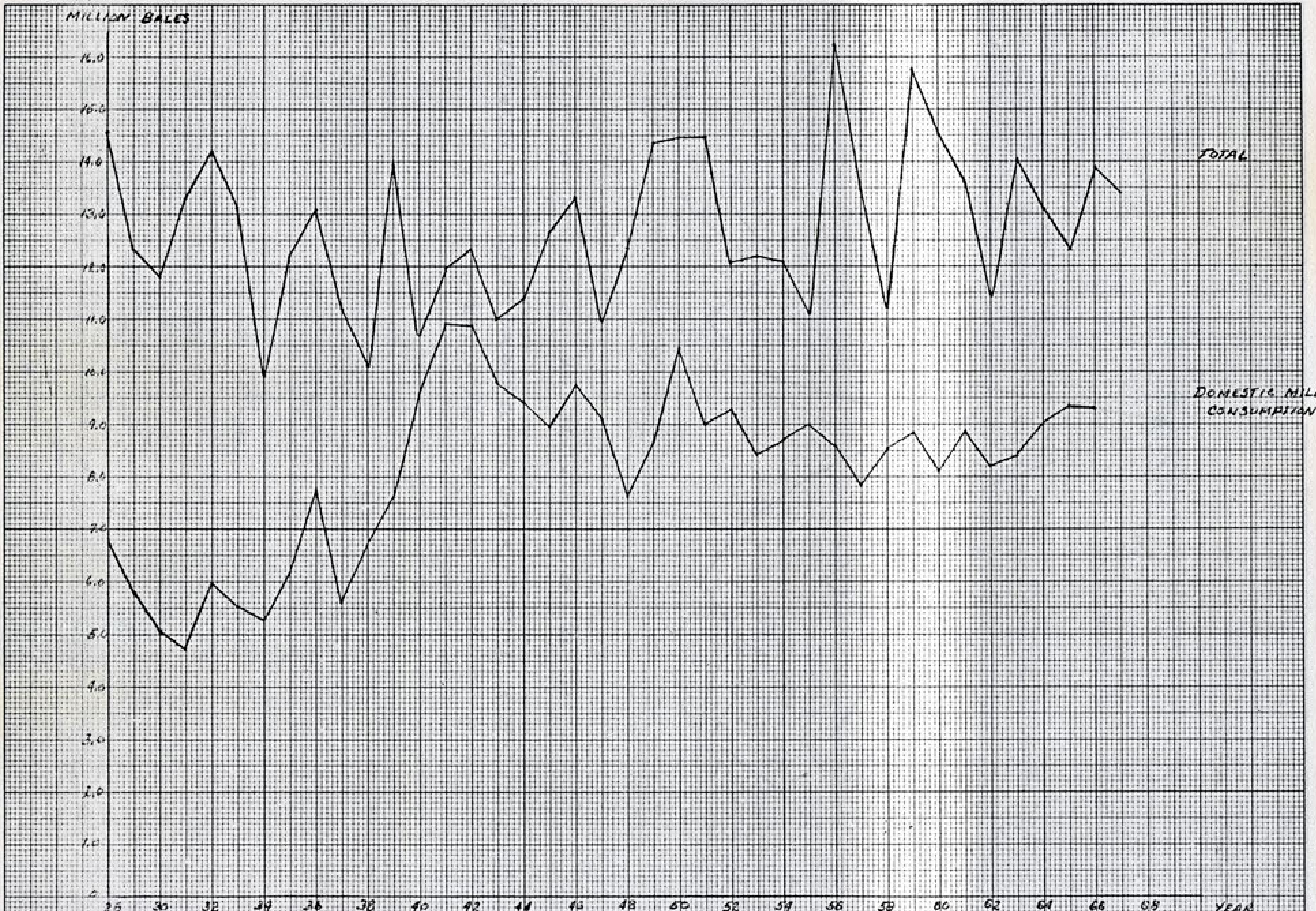

FIG 6. DISAPPEARANCE OF U.S. UPLAND COTTON: DOMESTIC MILL USAGE AND TOTAL, 1928-1968

SOURCE: [illegible]

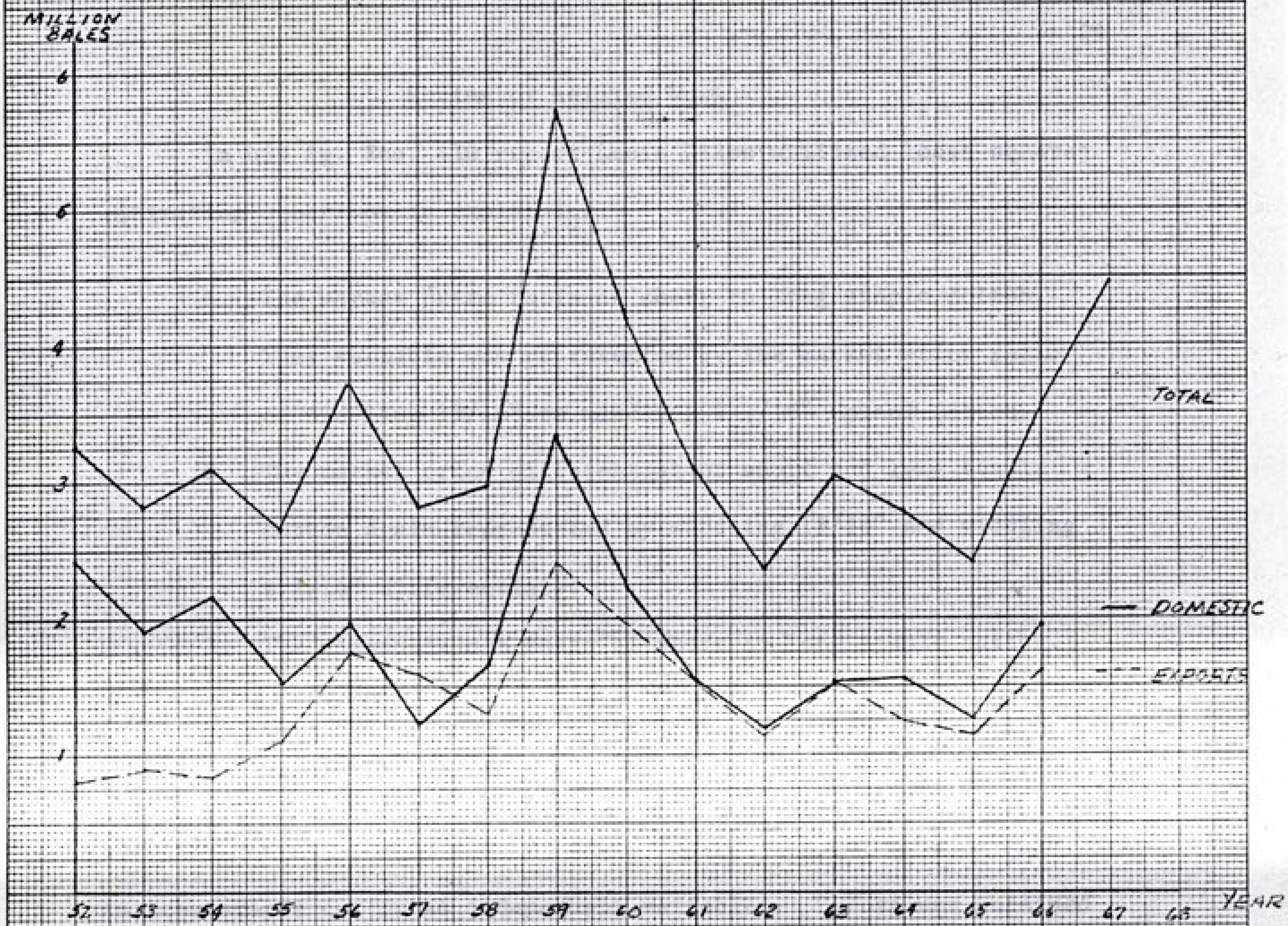

FIG 7. DISAPPEARANCE OF U.S. UPLAND COTTON: UNDER 1" STAPLE LENGTH; 1952-1966

SOURCE. APPENDIX TABLE 4

Review of Related Work

In his Ag. Eco. 430 report Louis Glass utilized least squares estimating equations in explaining:

1. The market price ratio of short to long staple cotton. This variable was represented by the market price ratio of middling 15/16" to middling 1 1/16" Upland Cotton.
2. The market price differential of short and long staple cotton again represented by middling 15/16" and middling 1 1/16" differentials.
3. The disappearance ratio of short to long staple cotton.

In explaining the market price ratio, best results were obtained utilizing the price support ratio of middling 15/16" to middling 1 1/16" Upland Cotton, time, and the supply ratio of short to long staple cotton as independant variables. "t" values obtained for the coefficients indicated that the price support coefficient was significant at the 99% confidence level, and coefficients for time and the supply ratio were significant at the 95% confidence level. A R^2 value of .89 indicated that these variables explain 89% of the variation in the market price ratio.

The best results in explaining the market price differential were obtained using basically the same equation as above, with the price support differential of middling 15/16" and middling 1 1/16" replacing the price support ratio. In this equation time was statistically significant at the 99% confidence level, while the supply ratio and price support differential were significant at the

95% confidence level. The R^2 value was again .89. The time period for both studies was from 1943 to 1966.

Results utilizing the consumption ratio of short to long staple cotton as the dependant variable were generally not as satisfactory as results using some form of price as the dependant variable in terms of R^2 values obtained. However, many of the independant variables used were highly significant. In one equation the disappearance ratio was estimated, using the market price ratio and time as independant variables. Coefficients of both independant variables were significant at the 99% confidence level and the R^2 value was .74. However, when the market price ratio lagged one year was added to the equation, the coefficient for the current market price ratio was not statistically significant. The time period used for these equations was from 1938 to 1966.

In brief summary, Glass' results indicate that government price supports are the dominant factor in explaining market price ratios and price differentials while time and lagged market price ratios were the major variables explaining disappearance ratios.

Bob Baxter's Ag. Eco. report was concerned mainly with determining estimates of the short and long run elasticities of substitution between short and long staple cotton. He estimated the short run elasticity of substitution by utilizing a least squares estimating equation in which the first difference[21] of the

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[21] Change from the preceding year's value

disappearance ratio (ratio of short to long staple disappearance) was dependant upon the first difference of the price ratio. The price ratio utilized was the market price of middling 15/16" to middling 1 1/16" Upland Cotton. The equation utilized logarithms to put the coefficients on a percentage basis. When using this procedure the coefficient of the price ratio is an estimate of the elasticity of substitution. He obtained a value of -6.02 for the short run elasticity of substitution.

Baxter used a method presented by Waugh for determining the long run elasticity of substitution. This method is reviewed in the conceptual framework. He used three basic natural and logrithmic least squares estimating equations in which (1) a centered 3 year moving average of the disappearance ratio between short and long staple cotton and (2) the first difference of this value were used as dependant variables. Independant variables included were (1) a centered 3 year moving average of the price ratio of short to long staple cotton, (2) various lagged values of these price ratios, and (3) time. His results showed that the moving averages lagged for a period longer than 3 years were of minor importance. The moving averages which were current or lagged for periods up to 3 years were of major significance. Time was also of major significance. He concluded that the elasticity of substitution between short and long staple cotton is very elastic in the short run, but his findings were generally inconclusive as far as an estimate for the long run elasticity of substitution was concerned.

Least Squares Estimates for Short and Long Run Elasticities of Substitution

The empirical results of the least squares estimating equation (equation 6, page 16) were:

$$(6)\quad Qr_{(t)} = 688.765 - 1.746\ Pr_{(t)} - 4.716\ Pr^*_{(t-1)} - 3.385\ T$$

$$(-2.303)^{**}\ ^{22} \qquad (-3.548)^{***} \qquad (-7.880)^{***}$$

$R^2 = .78$ Period of analysis: 1943-1966.

Employing the Working method, the coefficients are interpreted as follows:

b_1 = slope of the short run demand curve

b_2 = shift coefficient for short run demand curve attached to long run variable

$b_1 + b_2$ = slope of the long run demand curve.

Since the quantity ratio is in the dependant position,

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[22]The numbers in parentheses below all least squares coefficients in this report are t values. Astericks indicate the significance of these values in the following manner:

(a) No * - insignificant at the 90% confidence level.
(b) * - significant at the 90% confidence level.
(c) ** - significant at the 95% confidence level.
(d) *** - significant at the 99% confidence level.

$$(19)\quad E_s \text{ (short run)} = b_1 \frac{\bar{X}_2}{\bar{X}_1}$$

$$= -1.746 \cdot \frac{93.129}{39.446}$$

$$= -1.746 \cdot 2.361$$

$$= -4.122$$

$$(20)\quad E_s \text{ (}\sout{\text{short}}\text{ long run)} = (b_1 + b_2) \frac{\bar{X}_2}{\bar{X}_1}$$

$$= -6.462 \cdot 2.361$$

$$= -15.257$$

The signs of the coefficients in the estimating equation are consistant with economic theory. The coefficient of time indicates a downward trend in the consumption ratio of 3.385 percentage points per year, with the value of all other independant variables held consistant. "t" values for the coefficients indicate that all independant variables used are of major importance in explaining the disappearance ratio.

Algebraic signs of the elasticities of substitution indicate that a change in the price ratio will be accompanied by a change in the opposite direction in the disappearance ratio. As indicated by the value for the short run elasticity of substitution, this change will be relatively large in the first year. If the price ratio changes and is held at its new level for a period of 6 years the change in the disappearance ratio will be much larger. The value for the long run elasticity of substitution indicates this relationship.

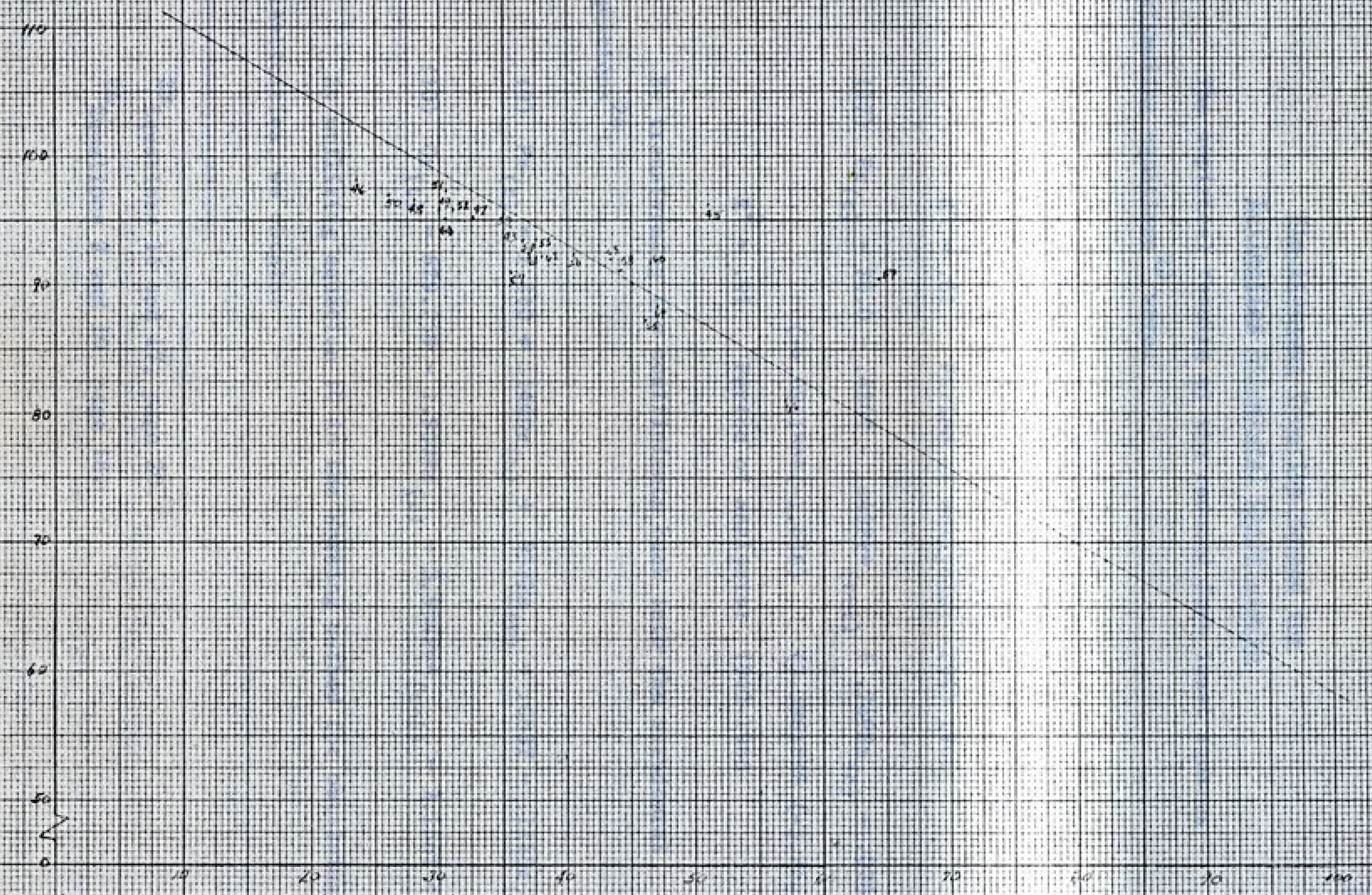

FIG. 7. RELATIVE DEMAND CURVE OF SHORT TO LONG STAPLE COTTON: $T_2(t-1)$ and T HELD CONSTANT AT THEIR MEANS: 1943-1966.

Simultaneous Equation Method for Estimating Structural Coefficients

The empirical results of the reduced form least squares estimating equations[23] were:

$$(16)\quad Qr_{(t)} = 488.128 - 2.344T - 3.125Pr^*_{(t-1)} - 1.448Ps_{(t)} + .241Sr_{(t)}$$

$$(-4.071)^{***}\ (-2.008)^{*}\qquad (-1.173)\qquad (1.837)^{*}$$

$R^2 = .81$ Period of analysis: 1943-1966

$$(17)\quad Pr_{(t)} = 74.0 - .420T - .449Pr^*_{(t-1)} + .749Ps_{(t)} - .076Sr_{(t)}$$

$$(-4.091)^{***}\ (-1.616)\qquad (3.396)^{***}\ (-3.242)^{***}$$

$R^2 = .91$ Period of analysis: 1943-1966

By transforming the coefficients back into the structural equations[24]:

$$(9)\quad Pr_{(t)} = 2.810 + .144Qr_{(t)} + .957Ps_{(t)} - .083T - .111Sr_{(t)}$$

$$(10)\quad Qr_{(t)} = 629.259 - 1.933Pr_{(t)} - 3.994Pr^*_{(t-1)} - 3.156T + .087Sr_{(t)}$$

By utilizing equation 10 in the Working method for obtaining elasticities, we obtain:

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[23]Equations 16 and 17, page 20.

[24]Equations 9 and 10, page 18.

$$(21) \quad E_s \text{ (short run)} = b_1 \cdot \frac{\overline{Pr_{(t)}}}{\overline{Qr_{(t)}}}$$

$$= -1.933 \cdot \frac{93.129}{39.446}$$

$$= -1.933 \cdot 2.361$$

$$= -4.564$$

$$(22) \quad E_s \text{ (long run)} = (b_1 + b_2) \cdot \frac{\overline{Pr_{(t)}}}{\overline{Qr_{(t)}}}$$

$$= (-1{,}933 - 3.994) \cdot \frac{93.129}{39.446}$$

$$= -5.927 \cdot 2.361$$

$$= -13.994$$

In reduced form equation (16), all signs of coefficients are consistant with economic theory. The coefficients are significant at the 90% confidence level.with the exception of the coefficient for the price support ratio. In equation (17) the sign of the 5 year average price ratio lagged one year is not consistant with economic theory. However its coefficient is not significant at the 90% confidence level. All other signs of the coefficients are as expected and are highly significant. The coefficient of time was highly significant in both reduced form equations.

When the reduced form coefficients are transformed into structural coefficients, all signs are as expected. The coefficients of equation 10, which were used in calculating elasticities, are quite similar to those obtained in least squares equation (6).

Elasticities calculated by utilizing equation 10 have the expected signs and are comparable to those obtained in the single equation least squares analysis.

SUMMARY AND CONCLUSIONS

The trends in the supply and disappearance of short staple cotton strengthen the hypothesis that the demand for short staple cotton is shifting downward over time. Least squares regression analysis which include time as an independant variable affecting consumption lend further support to this hypothesis.

This study provides strong evidence that lower relative prices for short staple cotton would cause its consumption to increase in spite of the trends towards utilizing more long staple cotton.

According to theory and the values obtained for short and long run elasticities of substitution a 1% change in the relative price of short staple cotton would cause its disappearance ratio to change almost 4% immediately. The change in the disappearance ratio would be in the opposite direction from the change in the price ratio. If the price ratio was held constant for 6 years after changing the disappearance ratio would change approximately 13-15% within the 6 year period.

No definite conclusion can be drawn concerning which method (least squares or simultaneous equations) is "best" in determining the elasticities of substitution. Both methods yield comparable values and the elasticity of substitution concept is best used in determining the relative degree of change, not as a measure of the exact magnitude of change.

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APPENDIX

Table 1. Supply and Disappearance of U. S. Upland Cotton: By Staple Lengths, 1928-1966.

	Disappearance				Supply		
Year	15/16" and 31/32"	< 1"	All Staples	Domestic Mill Consumption	15/16" and 31/32"	< 1"	All Staples
	1000 running bales				1000 running bales		
1928	3,255	11,009	14,565	7,091	3,652	12,212	16,688
1929	2,320	9,689	12,238	6,106	3,145	12,408	16,642
1930	2,718	8,691	11,800	5,263	4,246	13,297	18,046
1931	3,334	10,337	13,301	4,866	6,038	16,730	22,861
1932	4,176	10,795	14,191	6,137	6,375	15,687	22,261
1933	4,078	9,047	13,086	5,700	6,191	13,927	20,724
1934	2,239	6,117	9,967	5,360	4,178	11,219	17,096
1935	3,168	8,176	12,202	6,351	4,427	12,285	17,532
1936	3,017	7,956	13,072	7,950	3,876	11,021	17,454
1937	3,083	7,291	11,183	5,748	5,897	15,173	22,619
1938	2,869	5,724	10,091	6,858	5,938	13,522	23,034
1939	3,266	7,411	13,942	7,793	5,849	13,602	24,395
1940	2,328	4,303	10,703	9,721	5,582	11,115	22,714
1941	3,184	4,780	11,970	11,170	5,519	10,741	22,445
1942	2,881	4,921	12,308	11,100	4,921	10,747	22,838
1943	2,465	4,474	11,040	9,943	4,633	10,534	21,599
1944	2,386	4,259	11,384	9,568	4,396	10,128	22,390
1945	2,479	5,515	12,650	9,163	3,707	8,477	19,815
1946	1,993	4,326	13,288	10,024	2,336	4,858	15,680
1947	1,719	3,689	10,960	9,354	2,117	4,382	13,948
1948	1,705	3,654	12,349	7,795	2,061	4,155	17,565
1949	2,028	4,715	14,376	8,850	2,732	5,985	21,121
1950	1,605	3,302	14,477	10,509	1,796	3,612	16,591
1951	1,432	3,394	14,461	9,196	1,816	4,303	17,170
1952	1,417	3,256	12,089	9,461	2,098	5,011	17,567
1953	1,477	2,817	12,181	8,576	2,853	5,706	21,731
1954	1,551	3,105	12,128	8,841	3,294	6,827	23,127
1955	1,258	2,641	11,118	9,209	3,304	7,338	25,500
1956	1,623	3,715	16,233	8,608	3,626	7,488	27,484
1957	1,712	2,820	13,459	7,999	3,869	6,532	22,052
1958	2,442	2,974	11,228	8,703	4,622	6,695	19,946
1959	3,538	5,737	15,774	9,017	4,777	7,169	23,164
1960	3,718	4,205	14,512	8,279	4,270	4,804	21,589
1961	2,637	3,076	13,615	8,953	3,814	4,454	21,341
1962	2,019	2,365	11,474	8,419	4,237	5,219	22,479
1963	2,382	3,041	14,023	8,609	4,656	6,729	26,134
1964	1,494	2,785	13,123	9,171	4,467	7,126	27,142
1965	2,087	2,407	12,300	9,496	5,920	8,337	28,866
1966	1,913	3,567	13,886	9,485	5,647	8,489	26,056
	(1)	(2)	(3)				

Sources of Data for Table 1:

Disappearance and Supply:

1928-1934 - Statistics on Cotton and Related Data, 1920-1956. Statistical Bulletin No. 99 (Revision of February 1957) Agricultural Marketing Service. U.S.D.A. Table 98, page 120.

1935-1966 - figures are from Statistics on Cotton and Related Data, 1930-1967. Statistical Bulletin No. 417. Economic Research Service. U.S.D.A. Table 108, pp. 139-140.

Domestic Mill Consumption:

1928&1929 - Statistics on Cotton and Related Data, 1925-1962. Statistical Bulletin No. 329, ERS, U.S.D.A. Table 1, page 1.

1930-1966 - figures are from Statistics on Cotton and Related Data, 1930-1967. Statistical Bulletin No. 417. Economic Research Service. U.S.D.A. Table 9, page 8.

Table 2. Average Market and Government Support Prices Of U. S. Upland Cotton: Specified Staple Lengths, 1943-1966.

Year	Middling 15/16"		Middling 1 1/16"	
	Avg. Mkt. Price	Support Price	Avg. Mkt. Price	Support Price
1943	20.65	19.26	21.82	20.46
1944	21.86	21.08	23.04	22.13
1945	25.96	21.09	26.96	22.29
1946	34.82	24.38	35.45	25.43
1947	34.58	27.94	36.31	28.64
1948	32.15	30.74	33.27	32.34
1949	31.83	29.43	33.22	30.58
1950	42.58	29.45	43.78	30.80
1951	39.42	31.71	40.49	32.96
1952	34.92	31.96	36.00	32.96
1953	33.55	32.70	35.08	34.15
1954	33.88	33.23	36.17	34.83
1955	34.38	33.50	36.72	35.50
1956	32.35	31.59	35.02	33.99
1957	32.93	31.16	36.12	33.76
1958	32.96	33.63	36.14	36.83
1959	30.27	29.74	33.46	32.84
1960	29.43	27.61	32.43	30.81
1961	32.43	31.49	35.08	34.39
1962	32.26	34.22	34.93	33.77
1963	31.85	31.22	34.68	33.82
1964	22.89[1]	28.70	25.90[1]	31.40
1965	22.44[1]	27.65	25.71[1]	30.55
1966	20.20	19.60	24.73	22.80

[1] 1964 and 1965 market prices are adjusted -6.5 and -5.75 cents per pound respectively.

Authority: 1964 - Cotton Price Statistics Vol. 46 No. 12, U.S.D.A. Table 15, page 22.
1965 - Cotton Price Statistics Vol. 47 No. 13, U.S.D.A. Table 35, page 35.

Sources of Data:

Columns 2 and 4:

1943-1948 - Statistics on Cotton and Related Data, 1920-1956. Statistical Bulletin No. 99, Agricultural Marketing Service, U.S.D.A. page 158.

1949-1958 - Statistics on Cotton and Related Data, 1925-1962. Statistical Bulletin No. 417, Economic Research Service, U.S.D.A. page 131.

1959-1966 - Cotton Price Statistics. Vol. 48 No. 13, U.S.D.A. page 5.

Columns 3 and 5:

1943-1953 - Cotton Quality. Agricultural Marketing Service U.S.D.A. 1944-1954.

1954-1966 - Cotton Price Statistics, May 1955-1967, U.S.D.A.

Table 3. Price, Consumption and Supply Ratios of < 1" to ≥ 1"
U. S. Upland Cotton: 1943-1966

Year	Market Price Ratio[2]	Price Support Ratio	$Pr^*_{(t-1)}$ [1]	Supply Ratio	Consumption Ratio
1943	94.64	94.31	95.45	95.20	68.14
1944	94.88	95.26	95.55	82.60	59.78
1945	96.29	94.62	95.23	74.77	77.30
1946	98.22	95.87	95.29	44.89	48.27
1947	95.24	97.56	95.73	45.81	50.74
1948	96.63	95.05	95.85	30.98	42.02
1949	95.82	96.24	96.25	39.54	48.80
1950	97.26	95.62	96.44	27.83	29.63
1951	97.36	96.21	96.63	33.44	30.67
1952	95.89	96.97	96.46	39.91	36.86
1953	95.64	95.75	96.59	35.61	30.08
1954	93.67	95.41	96.39	41.88	34.41
1955	93.63	94.37	95.96	40.40	31.15
1956	92.38	92.94	95.24	32.45	29.68
1957	91.17	92.30	94.24	42.09	26.51
1958	91.20	91.31	93.30	50.54	36.03
1959	90.44	90.56	92.41	44.81	57.16
1960	90.75	89.61	91.76	28.62	40.80
1961	92.45	91.57	91.19	26.37	29.18
1962	92.36	92.45	91.20	30.24	25.95
1963	91.84	92.31	91.44	34.68	27.70
1964	88.38	91.40	91.57	35.60	26.95
1965	87.28	90.51	91.16	40.62	24.32
1966	81.68	85.96	90.46	48.32	34.57

[1] 5 year average Market Price Ratio immediately preceding but not including the current year

[2] These ratios are prices of middling 15/16" relative to middling 1 1/16"

Sources of Data:
Columns 1, 2, and 3: See Table 2
Columns 4 and 5: See Table 1

Table 4. Disappearance of Cotton Stapling less than 1": 1952-1966

Year	Exports (1000 bales)	Domestic Consumption (1000 bales)	Total (1000 bales)
1952	819	2,437	3,256
1953	906	1,911	2,817
1954	845	2,260	3,105
1955	1,116	1,525	2,641
1956	1,743	1,972	3,715
1957	1,587	1,233	2,820
1958	1,314	1,650	2,974
1959	2,393	3,334	5,737
1960	1,966	2,239	4,205
1961	1,543	1,533	3,076
1962	1,155	1,210	2,365
1963	1,524	1,517	3,041
1964	1,244	1,541	2,785
1965	1,146	1,261	2,407
1966	1,618	1,949	3,567

Sources:

Exports:

1952 - Cotton Situation. Economic Research Service, U.S.D.A., September, 1953.
1953 - _______. October, 1954.
1954-1966 - _______. November, 1955-1966.

Total: See Table 1.

Domestic Consumption: Computed by subtracting Exports from the Total Disappearance.