THE ROLE OF STAPLE LENGTH IN THE INTERNATIONAL MARKET FOR COTTON

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June 1983

The University of Arizona
College of Agriculture
Agricultural Experiment Station, Technical Bulletin 248

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I. Introduction

Both observers and participants in the international cotton market utilize staple length as a criterion to differentiate among the varieties of cotton traded on the world market. The market for extra-long staple (ELS) varieties has received particular scrutiny as a specialty market largely independent of the rest of the world cotton market. A number of developments over the last two decades, however, suggest changes in the economic relationships between the markets for different staple lengths. The emergence of synthetic fibers and advances in spinning technologies indicate that the ELS market may not be independent of the markets for other staple lengths.

If the cotton market is integrated across staple lengths, the demand curve for ELS cotton can be considered infinitely elastic. Decreases in ELS production, for example, will not result in higher prices for ELS varieties, but instead will cause increased use of shorter staple fibers or synthetics in the manufacture of yarns traditionally dependent on ELS varieties. Alternatively,if markets for different staple lengths are independent, changes in the supply of ELS can be expected to influence prices and the elasticity of international market demand becomes an important parameter in the determination of optimal production patterns. A second policy issue related to integration arises because shorter staple varieties provide higher yields than ELS varieties. If the market is integrated, determination of the appropriate premia for ELS cottons becomes important for the determination of optimal production patterns. If yield increases more than offset the discounts for shorter staple cottons relative to ELS varieties, a reallocation in the choice of varieties toward shorter staple cotton would result in increases in both producer incomes and foreign exchange earnings from cotton exports.

This paper examines the price behavior of different staple lengths of cotton in order to test the hypothesis that the markets for different staple lengths of cotton are independent. Particular attention is given to the distinction between ELS and shorter staple lengths. The following section reviews the concept of market integration and describes the methodology used to test for the presence of independent markets. Section III presents the results, and Section IV discusses their implications for cotton policy.

II. The Analysis of Market Integration

The distinction between homogenous and differentiated products has obvious importance for the formulation of empirical models of international trade. A homogeneous commodity obeys the law of one price, in which prices across countries can differ by no more than the cost of commodity arbitrage. Empirical analysis can focus on a relatively small set of equations, in which changes in a single price can be used to analyze consumer or producer behavior. A market dominated by differentiated products requires more elaborate treatment. Armington-type demand systems must be estimated, with separate demand and expenditure elasticities for each differentiated product. Analyses of international trade have often focussed on the country of origin or destination (Isard, 1977; Sirhan and Johnson, 1971; Johnson _et al._, 1979) or quality variation (_e.g._, Chen, 1976; French, 1980) as parameters by which to differentiate commodities. Estimation of parameters for a complete set of differentiated products requires vast quantities of data which may not be available on a continuous basis. If significant gaps exist, little insight may be gained about the overall commodity market structure.

Integrated markets for a differentiated product are defined as markets in which prices of different qualities do not behave independently. The demand for different qualities of the same commodity can be represented by standard demand functions in which the price of a particular quality is dependent on supply, substitutes, and income level. For the simple case of two qualities, A and B,

$$P_A = f(Q_A^s, \bar{P}_2, Y_A)$$

$$P_B = g(Q_B^s, \bar{P}_3, Y_B)$$

where P_A, P_B = prices of alternative qualities of commodity 1,

Q^s = supply,

$\bar{P}_2$, $\bar{P}_3$ = vectors of the prices of substitutes and

Y_A, Y_B = income of consumers of A and B, respectively.

The above equations help define the economic mechanisms which cause prices of the two qualities to be dependent. The first linkage would result from substitution in the production process. If producers of commodity 1 can shift from quality A to quality B, then Q_A^s is dependent on P_B (and vice versa), and supply-side substitution can be expected to maintain a consistent relationship between the prices of different qualities. Given the temporal delays in the response of agricultural production to price changes, market linkage effects from supply-side adjustments are likely to require periods in excess of a year.

Price linkages among different qualities of agricultural products within a year is thus likely to indicate adjustment among consumers. In the above equations, the dependence of the prices of quality A on quality B is indicated by the presence of P_B in the vector of substitute prices $\bar{P}_2$. This result is expected if final consumers are willing to substitute freely among qualities or if intermediate consumers (such as processors) are able to produce identical end products from either quality. With respect to the cotton market, for example, the capability of cotton spinners to produce a particular yarn from a variety of cotton qualities represents a critical technological constraint on cross-quality substitution and market integration. A less obvious possibility for linkage of markets arises if the two qualities face a common substitute. In terms of the above equations, the quantity consumed of quality B can be expressed as a function of the price of the substitute good, which can in turn be entered in the price function for quality A. In the cotton market, the role of polyester and rayon as competitors for all qualities of cotton may be important in the maintenance of an integrated cotton market.

The linkage between markets for different qualities may be examined using a bivariate linear relation,

$$P_A = \alpha + \beta P_B \quad (1)$$

Independence of the two qualities implies that price movements are distributed randomly with respect to each other, and the β coefficient is expected to equal zero. A significant t-statistic for the β coefficient thus indicates nonindependence of the two prices. If the β coefficient is significantly nonzero, a number of price relationships may exist. Figure 1 illustrates four possible outcomes, and displays what we shall call perfect integration. In each of the diagrams the solid line is the fitted regression line and the dotted line has a slope of one. If the slope of the regression line is not significantly different from one and the constant term is not significantly different from zero, the two prices are statistically identical (Figure 1a). Figure 1b shows the case where the slope is significantly greater than 1, intercept equalling zero, suggesting a percentage premium for P_B over P_A. Relationships 1a and 1b imply constant relative prices and occur whenever the technical substitution curve (for intermediate consumers) or the utility curve (for final consumers) is linear over a significant range. An absolute premium is shown in 1c, reflecting a fixed differential (such as transport costs) beween the two qualities. Figure 1d shows a situation where both percentage and absolute elements are present in the premium.[1/]

The second analytical technique involves the estimation of an hedonic index (see Petzel and Monke, 1981). Hedonic analysis involves the association of a set of quality characteristics (entered as integer-valued dummy variables) which correspond to each observed price. The estimated equation is of the form

$$P = \alpha + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \ldots \quad (2)$$

where P = average price, and D_1, D_2, $D_3 \ldots$ = dummy variables signifying different quality characteristics.

The coefficients on the quality dummies identify the premia or discount associated with that characteristic. If price is entered in logarithms, small coefficients may be considered percentage differences, but this approximation increasingly underestimates the percentage difference as the coefficient grows. Equation 2 can be fitted to any sample of prices and average premia

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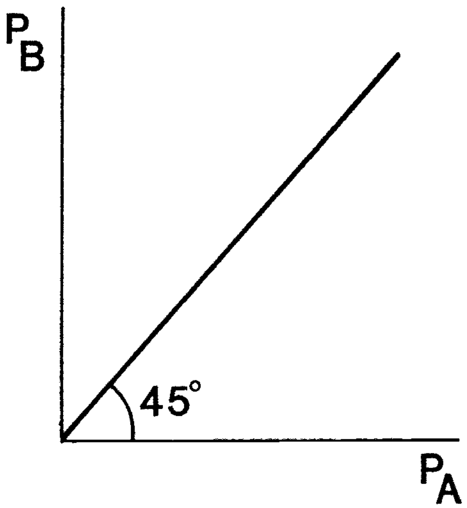
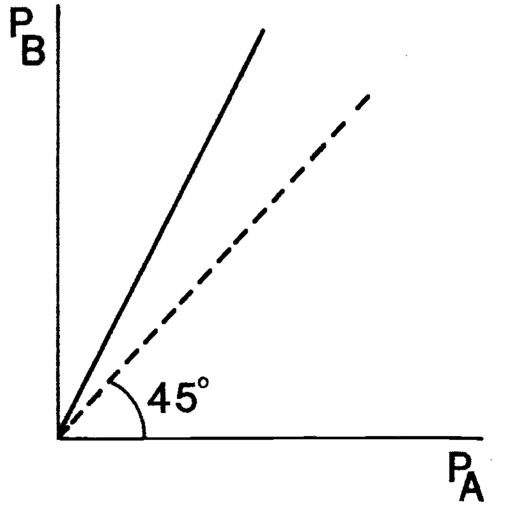
1/ Time will certainly affect the picture. In the very short run there may be little opportunity for technical substitution, but as the time for adjustment increases the technical substitution curve could approach linearity over a wide range, and integration would improve.

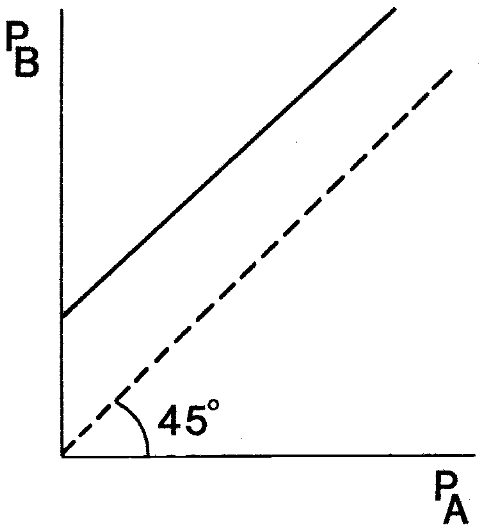
Figure 1.
Two Variable Price Relationships
(Solid line is the regression line)



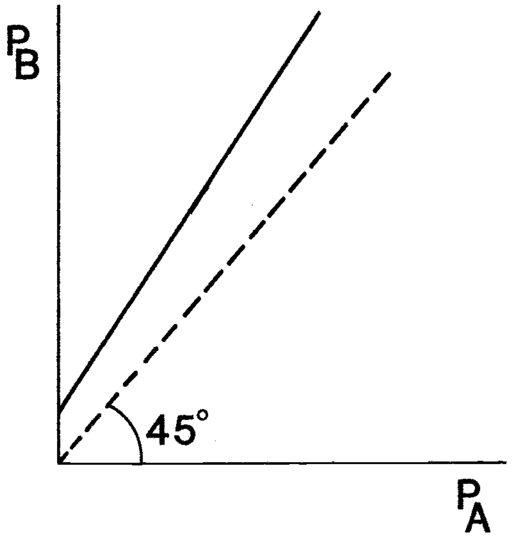
a. Statistically the same price



b. Percentage premium P_B over P_A



c. Absolute premium P_B over P_A



d. Percentage and absolute premia P_B over P_A

will be measured, but this says little about market integration. Evidence that discounts and premia are relatively stable through time would support the market integration hypothesis. In this study a (0,1) valued time dummy identifies the two radically different time periods before and after July 1973. This dummy is used not only as an intercept shifter to identify the large increase in cotton price after that date, but also as a multiplicative factor to test for significant shifts in the values of the β coefficients between the two periods.

III. Integration of the International Cotton Market

Staple length is perhaps the most widely utilized quality characteristic in the cotton market. Fiber fineness and fiber tensile strength are positively associated with staple length, and longer staples generally result in yarns with better appearance, strength and abrasion resistance than those made from shorter staple cotton. Staple lengths are graded by thirty-seconds of an inch and categorized as short (less than one inch), medium (one to 36/32 inch), long (36/32 to 44/32 inch) and extra-long (greater than 44/32 inch). Long and extra-long staple cottons are produced primarily from varieties of Gossypium barbadense, while the shorter categories are produced from G. hirsutum varieties.

Additional indicators of cotton quality include grade, fiber length uniformity, fiber strength, and micronaire reading. Grade is determined by cotton color, waste content of ginned cotton (leaf particles and other trash), and preparation (the presence of small knots of tangled fibers, or neps). Specific definitions of grade differ among countries, but lower grades usually imply higher processing costs or lower quality end products. Neps, for example, result in defects in yarn and fabrics and are often impossible to remove. Increased variation of fiber length makes processing more difficult and leads to increased waste and reduced output quality. Micronaire readings are a measure of fiber fineness, and optimum values are dependent on the particular variety of cotton. Within each varietal class, unusually low micronaire values suggest the presence of immature fibers, which are susceptible to the formation of neps and dyeing irregularities and cause poor yarn appearance.

Unfortunately, the only characteristic for which there is a reasonable time series for international prices is staple length, and thus the influence of other quality parameters on prices cannot be tested. The price effects of non-staple length characteristics can be substantial. Grade differences, for example, are currently responsible for as much as a 30 percent variation in the price of a given staple length of U.S. cotton. El-Kholei and Abbas (1980) have documented the deterioration of quality in Egyptian cotton over the period 1951-77. The aggregate costs of quality deterioration were estimated to fall between 10 and 45 million Egyptian pounds (L.E.), and were particularly significant for ELS varieties.

The lack of data on additional quality characteristics creates two statistical problems for the estimation procedure. First, an omitted variable problem arises from incomplete specification of the right-hand side of equations (1) and (2). Second, variation in the price variable on the left-hand side of equation (1) may be caused by quality characteristics other than staple length, resulting in an error in the measurement of the dependent variable. Since the variation in these other quality characteristics are largely determined by weather, they are not correlated with staple length and the omitted variables create no bias in the estimates of the price coefficient. Estimates of the error variance are biased upward. Errors in the measurement of the dependent variable cause similar effects on the price coefficient and its estimated variance, which asymptotically decline with increasing sample size. Thus the lack of information about additional quality characteristics results in unbiased coefficients and underestimates of t-statistics. The empirical estimates may result in the acceptance of independence across staple lengths when in reality the markets are integrated.

The data for the estimation of the pairwise price relationships and the hedonic analysis included 54 series of monthly prices. Domestic, free on board (fob) and cash insurance and freight (cif) prices are represented, and a description of each series is provided in Appendix 1. Twenty of the most complete price series were selected for the estimation of the bivariate regressions of equation (1). Monthly prices were averaged arithmetically to produce annual series (calendar year basis) for the period 1962-79. Annual data were chosen so that there would be enough time to allow for technological adjustment across staple lengths, to avoid the problems of lag times between order and receipt of the commodity, and to lessen the problem of gaps in the quotes for international prices. To generate stable time series and reduce the possibility of spurious correlations, the prices are deflated by the World Bank index of cif prices. When necessary, the estimations were corrected for autocorrelated errors. There is no predilection toward a particular functional form of equation (1). Estimation in nominal form suggests a constant relationship between prices, while a logarithmic form indicates a constant relationship between the proportional changes in the prices. The results give little indication of a preferred model. Logarithmic estimation yielded a slightly larger number of statistically significant relationships, while the nominal form provided generally larger t-statistics.

Table 1 presents the β coefficients from the nominal-form price equations in matrix form. Thirteen international price series are included, and the data are organized by staple length to facilitate the analysis of intra- and inter-staple length relationships. Within each staple length category (the blocks nearest the diagonal), the international cotton market appears spatially integrated. In general, the prices are statistically identical, although the more heterogeneous staple length categories (long and extra-long) demonstrate some cases of constant percentage premia. With respect to inter-staple length relationships, price linkages appear strongest between immediately proximate categories. All the short-medium coefficients, all the medium-long coefficients and all the long-extra long coefficients are significant. As expected, staple length is positively associated with price, with the exception of U.S. short staple prices, which appear equal or greater than the prices of medium staple growths of Mexico and Guatemala.

The pattern of relationships among staple lengths suggests a transitive sequence of adjustment rather than a pattern in which the prices of all staple

Table 1. β Coefficients for Bivariate Price Equations, $P_A = \alpha + \beta P_B$.
International Market Prices for Cotton 1961-79.

	SHORT STAPLE		MEDIUM STAPLE						LONG STAPLE		EXTRA-LONG STAPLE			
	US	Pakistan	US	US	Mexico	Nicaragua	USSR	Guatemala	Uganda	Sudan	Egypt	Egypt	Peru	
Dependent Variables	cif Liverpool	cif Liverpool	cif Liverpool	cif Osaka	cif Bremen	cif Liverpool	cif Liverpool	cif Osaka	cif Bremen	cif Liverpool	Giza 67 fob Alexandria	Menoufi cif Liverpool	cif Liverpool	
US		.99*	.83**	1.00*	1.15**	.93*	.80**	1.02*	.79**	.54**	.14	.26**	.16	SHORT STAPLE
Pakistan			.52**	.63**	.70*	.61**	.58**	.71*	.39**	.31**	.14**	.12**	.07	
US				1.18**	1.27**	1.05*	.97*	1.08*	.88*	.62**	.16	.23**	.45**	
US					1.02*	.81*	.74**	1.08*	.61**	.43**	.07	.25**	.26	
Mexico						.78**	.71**	.84*	.62**	.49**	.12	.15**	.34**	MEDIUM STAPLE
Nicaragua							.92*	1.06*	.80**	.49**	.11	.17**	.33**	
USSR								1.06*	.83*	.55**	.13	.22**	.41**	
Guatemala									.42**	.28**	-.04	.01	.14	
Uganda										.59**	.23**	.25**	.61**	LONG STAPLE
Sudan											.38**	.29**	.55**	
Egypt (Giza 67)												.92*	1.38*	EXTRA-LONG STAPLE
Egypt (Menoufi)													1.77**	

Key: * $\beta > 0, \beta = 1$
** $\beta > 0, \beta \neq 1$
No * indicates β not significantly different from zero

Sources: Liverpool prices were taken from International Cotton Advisory Council, Cotton: World Statistics; Bremen and Osaka prices were provided by the United States Department of Agriculture, Foreign Agriculture Service; Alexandria prices were provided by the Ministry of Agriculture, Arab Republic of Egypt.

Note: All tests of significance were based on a 95 percent confidence level.

lengths adjust simultaneously. Within the year, short staple prices are linked to medium prices, medium staple prices are linked to long staple and long staple are linked to extra-long. But the adjustments between short and extra-long and medium and extra-long prices appear less complete. Only three of the six short-extra long and nine of eighteen medium-extra long coefficients are significantly different from zero. Complete adjustment of prices among these categories may require more than one year.

Table 2 presents β coefficients from bivariate regressions between seven series of domestic market prices and seven series of international prices. The domestic-international characteristic indicates the potential importance of institutional barriers which segregate international from domestic cotton markets. Of the seven domestic price series analyzed, Indian and Pakistan prices show no relationship to any of the international price series, while the prices of Mexico, Brazil, Turkey, Greece and U.S. Pima demonstrate close correlation. These results have implications for the construction of international trade models, as changes in world prices are not always communicated to domestic producers or consumers. In such countries an export surplus (import deficit) model may become the appropriate description of international trade participation.

The hedonic estimation (equation 2) provides the second test of integration across staple lengths. A "base" value is established for one and one-sixteenth inch cotton sold at Liverpool, and percentage discounts and premia are identified by significant coefficients on the characteristics. Initial tests were performed on monthly prices in the Bremen, Osaka, and Liverpool markets. These results suggested that once staple length was controlled for, premia associated with the selling market were quite stable. This result allows the examination of the Liverpool market alone. The advantages of the Liverpool data are the larger number of staple lengths represented, and a longer time series of consecutive monthly prices (1968-78). The only data problem was one of "nominal prices," that is, quotes that are stated but in fact may not represent prices at which sales actually occurred. An example of this problem occurs in the years 1968 and 1969 for the Egyptian LS and ELS series. Of a total of 24 monthly quotes, 18 are listed as nominal. An alternative to reliance on the Liverpool LS and ELS series is to use the Alexandria f.o.b. quotes. The disadvantage is that shipping costs are not included, but if this a relatively constant value, the problem should be minor. Both quotes were used in the estimation. Differences among the two price series are discussed in Appendix 3.

The period 1968-78 was chosen because this was the longest time span for which a wide variety of quotes was available. The series examined includes U.S. cottons of lengths 32, 34, and 36, Mexican and Turkish 34's, Sudanese 38's and Egyptian LS (44) and ELS (>44). All prices are in United States cents per pound. The form of the estimated equation is given below.

$$\ln \text{Price} = b_0 + \sum_{1}^{5} b_i L_i + b_6 D + \sum_{7}^{11} b_i (D^* L_i)$$

Table 2. β Coefficients for Bivariate Price Equations, $P_A = \alpha + \beta P_\beta$. International Versus Domestic Market Prices for Cotton, 1961–79.

Dependent Variable	SHORT STAPLE Pakistan cif Liverpool	Mexico cif Bremen	MEDIUM STAPLE Brazil cif Liverpool	Turkey cif Bremen	LONG STAPLE Sudan cif Liverpool	EXTRA-LONG STAPLE Egypt (Menoufi) cif Liverpool	Peru cif Liverpool
SHORT STAPLE							
MEXICO							
Wholesale, Torrean	.97*	1.13*	1.01*	.82*	.47**	.22**	.38**
PAKISTAN							
Wholesale, Karachi	-.12	.05	-.43	-.002	-.07	-.20	-.53**
INDIA							
Wholesale, Bombay	.29	-.08	.12	-.31	.04	-.34	-.61
MEDIUM STAPLE							
BRAZIL							
Wholesale, Sao Paulo	.97*	1.77**	1.58*	1.24*	.62**	.36	.32
TURKEY							
Wholesale, Adana	.37	1.09*	.94*	.81**	.42**	.20**	.55**
GREECE							
Ex-mill	-.22	1.16*	1.07*	.98*	.53**	.27**	.58**
EXTRA-LONG							
U.S.							
Wholesale, El Paso and Phoenix	.69*	1.82**	1.82**	1.52**	.68*	.59**	.43**

Sources: See Table 1. U.S. domestic prices are taken from United States Department of Agriculture, Agricultural Marketing Service, Long Staple Cotton Review; Greek prices were taken from Hellenic Republic, Hellenic Cotton Board, Annual Review of the Cotton Situation; Remaining domestic price series are taken from Food and Agriculture Organization, Monthly Bulletin of Agricultural Economics and Statistics.

where L_i are dummy variables signifying staple length ($i = 1,5$; L_i = 32, 36, 38, 42, >44 respectively), D is a dummy for the post July 1973 period, and ($D*L_i$) are interaction terms.

The inclusion of the dummy variable examines the consistency in the behavior of the premia over two time periods. In mid-1973 the price of cotton nearly doubled. If the market for cotton of different characteristics was strongly connected, the relative advantage of one type of cotton over another should have remained approximately the same. In the analysis of cotton prices this consistency is tested first by introducing a dummy variable to flag the post-July 1973 period and then a series of slope interaction dummies to see if the original premia changed from one period to the next.

The base staple length is 34, and the values of b_1 through b_5 will give the value of the discounts or premia from this base for the other staple lengths. At b_6 is the shift in the average value of the base staple length. Thus the antilog of b_0, the intercept, is the average price of cotton having a staple length of 34 in the period prior to July 1973 while $b_0 + b_6$ is the average value after July 1973. The values of b_7 through b_{11} are critical to the analysis of market integration since they represent how the discounts or premia associated with different staple lengths changed between the two periods. If b_7 through b_{11} are individually and jointly not significantly different than zero, then the percentage differences in price across staple lengths were completely stable between these two periods. This would be strong evidence of market integration across staple length.

The results are presented in Table 3. Equation 2.1 uses the Liverpool quotes for the Egyptian prices while the Alexandria quotes are used in 2.2. The coefficients for L_1 through L_5 and D are as expected and statistically significant. Cotton of staple length 32 trades at a discount to the 34's, while the longer staple lengths trade at increasing premia. The dummy value for the post July 1973 period is large and quite significant.[2/]

The slope dummies suggest an interesting story which is shown graphically in Figure 2. There is no significant change in the relative values for lengths shorter than 38. However, the value of the Egyptian LS cotton (44) grew dramatically, widening the gap between itself and the shorter cottons, and narrowing the relative advantage of the ELS varieties. There were mixed results on the overall position of the ELS premium. The Liverpool quotes

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2/ Heteroskedasticity may pose difficulties in the hedonic analysis. The presence of dummy variables marking two distinct time periods renders the usual tests like Goldfeld-Quandt inappropriate, since the same regression may not be performed on the different sample periods. More casual examination of the residuals did not reveal major problems, but if the error variance increased in the second period, the effect would be to bias downwards the estimated standard errors of the coefficients on the interaction terms. This would in turn increase the chance of rejecting the market integration hypothesis.

Table 3--Hedonic Price Analysis for the International Cotton Market
(Dependent variable, natural logarithm of price)

Independent variables	2.1 Egyptian prices cif Liverpool		2.2 Egyptian prices fob Alexandria	
Constant	3.51	(265.19)	3.51	(177.80)
L1	-.097	(-4.25)	-.097	(-2.88)
L2	.068	(2.97)	.068	(2.01)
L3	.169	(7.37)	.169	(4.98)
L4	.425	(18.56)	.294	(8.70)
L5	.633	(27.63)	.567	(16.80)
D	.730	(37.02)	.738	(26.70)
DL1	-.009	(-.26)	-.015	(-.32)
DL2	-.028	(-.82)	-.022	(-.48)
DL3	.035	(1.02)	.063	(1.31)
DL4	.137	(4.02)	.186	(3.89)
DL5	.066	(1.94)	.033	(.70)
R^2	.903		.803	
F (11,912)	703.4		338.4	

Note: t statistics in parentheses.

L1 through L5 are dummy variables signifying staple length. 34 is the base length, with L1 through L5 standing for 32, 36, 38, 44, 48 respectively. D is a time dummy equal to 1 for the period after July 1973. DL1-DL5 are interaction terms between D and L1-L5.

(shown in Figure 2) suggest a slight increase in the premium, which is not supported by the Alexandria quotes. The ELS varieties command a premium of approximately 60 percent, and demonstrates the strongest statistical association with medium staple prices. In summary, the markets for most different staple lengths do not appear independent. With the exception of the Egyptian LS variety, the market appears to provide constant premia for particular staple lengths.

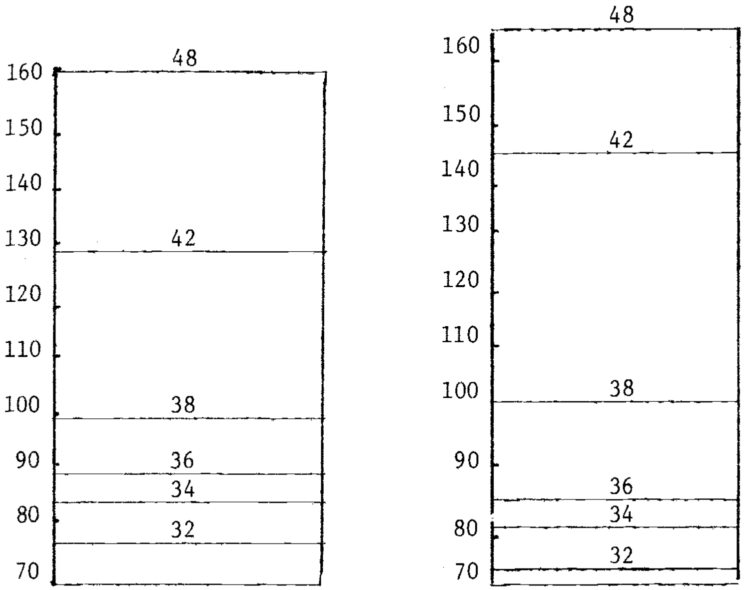
These results do not identify mechanisms which cause markets to be linked across staple lengths, but a number of possibilities appear plausible. First, existing staple lengths and grades do not represent fixed limits on the quality of final products. A recent study by Rogers (1978) of U.S. spinning mills, for example, revealed that both the grade and staple length of cotton were in excess of the minimum qualitites needed by the textile industry. Less than 11 percent of the cotton used by mills required a staple length above 34. Actual production of 34 staple cottons accounted for nearly one-half of total production. In terms of grade, less than one percent of the cotton required a grade of middling, while in actual production middling grades accounted for nearly 20 percent of the total.

Perhaps the most important factor responsible for market integration is the capability of spinning mills to substitute across staple lengths in the manufacture of particular count threads and yarns. In general, spinning mills prefer longer staple length cotton, but improvements in the drafting process have given spinners substantial latitude with respect to the choice of staple length. These advances were developed in the 1950's, but probably not universally incorporated into commercial operations until the 1960's. These improvements have facilitated the use of blending, the adulteration of ELS or LS varieties with shorter staple (and less expensive) varieties. Finally, additional cleaning processes may be introduced before spinning. Extra combing removes additional short staple fibers and imperfections, thereby increasing uniformity and average fiber length.

The production of sewing threads is perhaps the most restrictive in the substitution across staple lengths, since both strength and fineness are critical properties of threads. Even in this category of end products, however, substantial substitution occurs. If micronaire readings are sufficiently low, staple lengths of 42-44 are readily substituted for ELS varieties. Latitude for substitution across staple lengths appears somewhat greater in the yarn spinning industry, as strength constraints are not as critical in the manufacture of yarn for fabrics. In addition to blending and increased combing, improvements in the regularity of yarns has increased the use of one-ply yarns relative to two-ply yarns and thus increased the capacity of spinners to substitute across staple lengths. Combed yarn counts of 60's and 70's needed for high quality shirting fabrics, for example, can be produced from cottons in the LS lengths and no longer require the 2 x 120 counts possible with ELS varieties.

The emergence of synthetic fibers represents a second important influence on the integration of the cotton market. The production of blended yarns underwent major technological change during the 1960s and 1970s, and the development of products such as synthetic core yarns wrapped with cotton, the

Figure 2. --Relative Values of Staple Lengths Before and After July 1973, Liverpool Sample Staple Length 38 = 100



Before July 1973 — After July 1973

Staple length	Percentage points changed
48	+5.0*
42	+14.00***
38	---
36	-5.5
34	-3.8
32	-3.3

* Significantly different from zero at the 90% level

*** Significantly different from zero at the 99% level discovery of the ability of polyester to "carry" relatively low quality cotton, and improvements in the ability to manufacture polyester staple identical to ELS have undoubtedly eroded the market position of extra-long staple cotton in the production of high count yarns. Further technological advances (such as the development of synthetics which "breathe") and improved understanding of the relationships between fiber properties and end-use requirements are likely to further intensify the competition between synthetic fibers and cotton.

In summary, technological advance has expanded the substitution possibilities among cotton inputs in the production of textiles. Very few end-products--fabric bound to rubber, embroidery thread, voile--uniquely require ELS cotton as an input, and these end uses do not account for a substantial share of total production. In the vast majority of cases, the choice of cotton staple length in the production of yarn has become an economic issue, dependent on the costs of alternative raw materials and their implications for operating costs of spinning machinery. As the bivariate regressions suggest, price linkages across staple lengths are achieved by incremental shifts in demands by end-product manufactures. Cotton of 34 staple may not directly substitute for a 48 staple, but incremental adjustments among the intermediate staple lengths create in a transitive pattern of linkages and price adjustment. The result is an integrated market.

IV. Conclusion

This paper has attempted to draw inferences about price-quantity relationships based solely on the analysis of price data. Ideally, cross-price elasticities would be estimated explicitly, and values approaching infinity would provide direct indication of an integrated market. Such data are rarely available, however, requiring second-best approaches of the type described above. Since differentiated products will demonstrate independence of price movements, this criterion may represent a useful means of determining whether the research needs to build disaggregated systems of equations at the expense of increased computational cost and a more difficult delineation of market structure and functions.

The first implication of these results is that the world market for cotton can be considered a single market with respect to staple length. Few end uses exist for which ELS fiber is uniquely required, and the marginal elasticity of substitution across qualities appears sufficiently large to prevent changes in the relative prices of different staple lengths. The pattern for price adjustments within the market may involve a time lag, however, with the initial impetus for price changes determined by changes in the demand for particular end products. Increases in demand for medium staple products will eventually affect ELS demand and prices as manufacturers are forced to buy increasingly longer staple cotton with which to make their products. Initial increases in ELS demands will ultimately affect medium staple prices in a similar manner. The rate at which changes in demand occur will be influenced by mill-level variations in managerial ability, vintage of capital stock, and costs of alternatives in the production process.

The second implication of these results is that the policies which treat ELS production independently of other staple lengths may be usefully re-examined. ELS varieties have maintained a premium of about 80 percent relative to medium staple varieties over the last two decades and loan rates could be structured to reflect the relative market premia. In addition, the stability of price relationships suggest that separate acreage restrictions for ELS cottons unnecessarily restrict the decision-making power of farmers, since increases in unrestricted shorter staple production will influence the prices of ELS cottons in the same manner as increases in ELS production. Thus producers who have differential profitability between ELS and shorter staple varieties may experience reduced profits as a result of acreage restrictions.

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APPENDICES

Notes:

[a] Years in which data are missing for more than three consecutive months or more than five months are entered as missing observations.

Sources:

All Liverpool cif prices are taken from International Cotton Advisory Council, Cotton: World Statistics.

Bremen and Osaka cif prices were provided by the Foreign Agricultural Service, United States Department of Agriculture.

Egyptian fob prices were provided by the Ministry of Agriculture, Egypt.

Greek domestic prices were taken from Hellenic Republic, Hellenic Cotton Board Annual Review of the Cotton Situation, Athens, Greece. 1978.

Arizona producer prices were taken from Arizona Crop and Livestock Reporting Service, Arizona Agricultural Statistics, various years.

All remaining prices series were taken from United Nations, Food and Agricultural Organization, Monthly Bulletin of Agricultural Economics and Statistics, various issues.

APPENDIX 1. ANNUAL PRICE SERIES, 1962-79.

STAPLE LENGTH (32nd of an inch)	LOCATION	TYPE OF PRICE	COUNTRY OF ORIGIN	NUMBER OF OBSERVATIONS[a]
Short (30-32)	Liverpool	cif	U.S. (Orleans/Texas)	18
			India (Bengal Desi choice)	13
			Pakistan (289F-Punjab-SG)	13
			Pakistan (NT-Sind-RG)	7
	Bremen	cif	U.S.	9
	Osaka	cif	U.S. (Orleans/Texas)	9
			Pakistan (289F-Punjab)	7
	Torreon, Mexico	Wholesale	Mexico	16
	Pakistan	Domestic	Pakistan (289F-Punjab-RT,NTRG after September, 1975)	16
	Bombay, India	Wholesale	India (Bengal-Desi)	13
Medium (34)	Liverpool	cif	U.S. (Memphis)	18
			Mexico	18
			Nicaragua	18
			Syria	16
			USSR	18
			Iran	18
			Turkey (Izmir -RG)	10
			Brazil (Sao Paulo Type 5)	16
			Greece	18
			U.S.	18
			Mexico	18
			Nicaragua	18
			Syria	18
			USSR (Pervyi)	18
			Iran	18
			Turkey (Izmir)	18

STAPLE LENGTH (32^{nd} of an inch)	LOCATION	TYPE OF PRICE	COUNTRY OF ORIGIN	NUMBER OF OBSERVATIONS
	Osaka	cif	U.S. (Arizona)	15
			Mexico (Sonora)	16
			Nicaragua	15
			El Salvador	16
			Guatemala	17
			USSR (Pervyi)	13
	Sao Paulo	Wholesale	Brazil (Type 5)	16
	Adana, Turkey	Wholesale	Turkey (Cukorova)	15
Medium long (34-38)	Liverpool	cif	Uganda (FP52)	12
			BPA after 1970	
			Peru (Tanguis, Type 3)	14
	Bremen	cif	U.S. (36)	9
			U.S. (37)	10
			Uganda (BP52, BPA after 1970)	17
			Uganda (SAT)	6
	Lima, Peru	fob	Peru (Tanguis, Type 3)	14
Long (40-42)	Liverpool	cif	Sudan (G 5L, G58)	17
	Alexandria, Egypt	fob	Egypt (Giza 69)	11
			Egypt (Giza 67)	15
			Egypt (Dendera)	7
			Egypt (Giza 66)	10
Extra-long (>46)	Liverpool	cif	Egypt (Menoufi FG, Giza 68 after 1976)	18
			Sudan (G55, G5Vs)	13
			Peru (Pima #1)	15
	Alexandria, Egypt	fob	Egypt (Giza 45)	17
			Egypt (Menoufi)	15
			Egypt (Giza 68)	15
			Egypt (Giza 70)	6

APPENDIX 2. TABLE 1. RESULTS OF BIVARIATE PRICE REGRESSIONS FOR INTERNATIONAL COTTON PRICES, 1961-79.

$$P_A = \alpha + \beta_1 P_\beta.$$

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
1.[a]	12	SHORT STAPLE US	SHORT STAPLE Pakistan	3.72 (0.39)	.99 (6.74)	.81	1.26
2.[a]	17		MEDIUM STAPLE US, cif Liverpool	4.14 (1.18)	.83 (16.33)	.94	1.53
3.[a]	13		US, cif Osaka	-1.41 (-0.26)	1.00 (12.38)	0	1.94
4.	18		Mexico	-15.06 (-2.98)	1.15 (14.98)	.93	2.11
5.	18		Nicaragua	1.25 (0.36)	0.93 (17.03)	.95	1.56
6.[a]	17		USSR	5.52 (1.35)	0.80 (13.74)	.92	1.68
7.[a]	16		Guatemala	-1.41 (-0.17)	1.02 (7.94)	.02	2.00
8.[a]	15		LONG STAPLE Uganda	-2.54 (-0.33)	0.79 (8.71)	.04	1.85
9.[b]	15		Sudan	17.44 (2.06)	0.54 (5.94)	0.74	1.70

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
			EXTRA-LONG STAPLE				
10.	15		Egypt, Giza 67, fob Alexandria	45.63 (3.99)	0.14 (1.26)	.11	2.02
11.[a]	17		Egypt, Menoufi, cif Liverpool	26.76 (2.50)	0.26 (3.13)	.40	1.83
12.[a]	11		Peru, cif Liverpool	43.42 (3.94)	0.16 (1.39)	.06	1.74
			MEDIUM STAPLE				
13.[a]	12	Pakistan	US, cif Liverpool	24.80 (2.87)	0.52 (4.23)	.57	1.94
14.	10		US, cif Osaka	20.07 (1.88)	0.63 (3.93)	.66	2.59
15.[a]	12		Mexico	14.82 (0.93)	0.70 (2.91)	.45	2.30
16.[a]	12		Nicaragua	21.39 (2.36)	0.61 (4.40)	.61	2.03
17.[a]	12		USSR	19.89 (2.12)	0.58 (4.43)	.58	2.00
18.	12		Guatemala	17.19 (1.46)	0.71 (3.76)	.59	1.41
			LONG STAPLE				
19.[a]	12		Uganda	30.43 (2.94)	0.39 (2.98)	.43	2.43

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
20.[a]	12		Sudan	34.36 (6.41)	0.31 (5.06)	.71	2.30
21.[a]	9		EXTRA-LONG STAPLE Egypt, Giza 67	45.84 (6.62)	0.14 (2.17)	.03	1.82
22.[b]	11		Egypt, Menoufi	74.10 (5.21)	0.12 (2.16)	.38	1.94
23.[a]	10		Peru	51.58 (3.70)	0.07 (0.51)	.01	1.81
24.[a]	13	MEDIUM STAPLE US, cif Liverpool	MEDIUM STAPLE US, cif Osaka	-4.87 (-0.81)	1.18 (12.70)	0	1.97
25.	18		Mexico	-15.54 (-2.08)	1.27 (11.17)	.89	2.07
26.	18		Nicaragua	0.71 (0.18)	1.05 (16.99)	.95	1.77
27.	16		USSR	1.88 (0.53)	0.97 (18.66)	.96	2.11
28.	17		Guatemala	1.08 (0.08)	1.08 (4.78)	.60	0.89
29.	17		LONG STAPLE Uganda	-0.99 (-0.12)	0.88 (7.99)	.81	0.95

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
30.[b]	15		Sudan	18.48 (2.32)	0.62 (7.57)	.84	2.01
			EXTRA-LONG STAPLE				
31.	15		Egypt, Giza 67	49.96 (3.86)	0.16 (1.35)	.12	2.21
32.	18		Egypt, Menoufi	39.41 (3.51)	.23 (2.53)	.28	1.82
33.	15		Peru	22.90 (1.65)	0.45 (3.19)	.44	0.99
			MEDIUM STAPLE				
34.	15	US, cif Osaka	Mexico	-2.51 (-0.27)	1.02 (7.16)	.80	0.72
35.	15		Nicaragua	12.93 (1.73)	0.81 (6.88)	.78	0.29
36.	15		USSR	14.87 (1.75)	0.74 (5.83)	.72	0.44
37.	15		Guatemala	-1.91 (-0.22)	1.08 (7.75)	.82	1.72
			LONG STAPLE				
38.	14		Uganda	16.76 (1.35)	0.61 (3.85)	.55	0.60
39.[a]	12		Sudan	27.34 (4.36)	.43 (5.86)	.23	2.02

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
			EXTRA-LONG STAPLE				
40.	13		Egypt, Giza 67	55.07 (5.19)	0.07 (0.70)	.04	2.32
41.[b]	11		Egypt, Menoufi	31.26 (1.86)	0.25 (2.18)	.42	2.21
42.	12		Peru	39.24 (1.88)	0.26 (1.20)	.12	0.63
			MEDIUM STAPLE				
43.	18	Mexico	Nicaragua	16.12 (5.05)	0.78 (15.52)	.94	2.18
44.[a]	16		USSR	17.22 (4.22)	0.71 (11.86)	.90	1.98
45.	17		Guatemala	13.77 (1.45)	0.84 (5.45)	.66	1.51
			LONG STAPLE				
46.	17		Uganda	17.05 (2.25)	0.62 (6.40)	.73	1.30
47.	17		Sudan	37.01 (5.34)	0.34 (4.22)	.54	1.97
			EXTRA-LONG STAPLE				
48.	15		Egypt, Giza 67	52.68 (5.52)	0.12 (1.29)	.11	2.23
49.	18		Egypt, Menoufi	46.95 (5.42)	0.15 (2.14)	.22	1.74

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
50.	15		Peru	31.80 (2.44)	0.34 (2.60)	.34	0.92
51.[a]	17	Nicaragua	MEDIUM STAPLE USSR	1.00 (0.31)	0.92 (19.38)	.96	1.98
52.	17		Guatemala	-1.82 (-0.16)	1.06 (5.71)	.68	0.98
53.	17		LONG STAPLE Uganda	1.28 (0.15)	0.80 (7.29)	.78	1.24
54.	17		Sudan	22.77 (2.94)	0.49 (5.39)	.66	1.59
55.	15		EXTRA-LONG STAPLE Egypt, Giza 67	51.71 (4.20)	0.11 (0.92)	.06	2.23
56.	18		Egypt, Menoufi	42.05 (3.82)	0.17 (1.95)	.19	1.91
57.	15		Peru	30.18 (2.19)	0.33 (2.40)	.31	0.97
58.	17	USSR	MEDIUM STAPLE Guatemala	2.46 (0.18)	1.06 (4.67)	.59	1.14

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
			LONG STAPLE				
59.	17		Uganda	3.11 (0.32)	0.83 (6.56)	.74	0.88
60.[a]	16		Sudan	21.18 (2.61)	0.55 (5.86)	.70	1.60
			EXTRA-LONG STAPLE				
61.	15		Egypt, Giza 67	53.06 (4.06)	0.13 (1.09)	.08	2.20
62.	18		Egypt, Menoufi	39.49 (3.59)	0.22 (2.54)	.29	1.96
63.	15		Peru	26.24 (2.19)	0.41 (3.41)	.47	0.85
			LONG STAPLE				
64.	16	Guatemala	Uganda	28.51 (2.43)	0.42 (2.79)	.36	1.36
65.	16		Sudan	37.73 (4.62)	.28 (2.97)	.39	1.67
			EXTRA-LONG STAPLE				
66.	15		Egypt, Giza 67	65.16 (7.12)	-0.05 (-0.55)	.02	2.10
67.	17		Egypt, Menoufi	59.28 (5.67)	0.01 (0.17)	0	1.95
68.	14		Peru	47.32 (2.93)	0.14 (0.86)	.06	1.62

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
69.	16	LONG STAPLE Uganda	LONG STAPLE Sudan	28.36 (3.26)	0.59 (5.77)	.70	1.51
70.	14		EXTRA-LONG STAPLE Egypt, Giza 67	53.38 (3.92)	0.23 (1.79)	.21	2.37
71.	17		Egypt, Menoufi	46.80 (4.03)	0.25 (2.70)	.33	1.74
72.	14		Peru	16.96 (1.04)	0.61 (3.68)	.53	1.00
73.[a]	13	Sudan	Egypt, Giza 67	42.86 (2.57)	0.38 (2.49)	.12	2.17
74.	17		Egypt, Menoufi	48.19 (2.69)	0.29 (2.04)	.22	2.10
75.	14		Peru	28.57 (1.46)	0.55 (2.79)	.39	1.07
76.	15	EXTRA-LONG STAPLE Egypt Giza 67	Egypt, Menoufi	-13.54 (-0.77)	0.92 (6.74)	.78	2.59
77.	12		Peru	-33.63 (-0.57)	1.38 (2.34)	.35	2.68
78.	15	Egypt, Menoufi	Peru	-52.35 (-1.32)	1.77 (4.42)	.60	1.61

t-statistics in parentheses.

Notes: [a] First-order autocorrelation.
[b] Second-order autocorrelation.

APPENDIX 2. TABLE 2. RESULTS OF BIVARIATE PRICE REGRESSIONS FOR DOMESTIC AND INTERNATIONAL COTTON PRICES, 1962-79.

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β	R^2	Durbin-Watson
		(Domestic price)	(International price)				
1.[a]	12	Mexico	Pakistan	1.13 (0.09)	0.97 (4.76)	.73	1.67
2.[a]	15		Mexico	-18.28 (-2.14)	1.13 (8.86)	.86	2.28
3.	15		Brazil	-4.55 (-0.44)	1.01 (5.78)	.72	1.88
4.	16		Turkey	-0.10 (-0.01)	0.82 (8.04)	.82	1.69
5.[a]	15		Sudan	16.70 (2.52)	0.47 (6.35)	.74	1.78
6.	16		Egypt	27.82 (2.82)	0.22 (2.87)	.37	1.99
7.	14		Peru	17.38 (1.92)	0.38 (4.20)	.60	0.95
8.[b]	11	Pakistan	Pakistan	79.62 (3.19)	-0.12 (-0.39)	.54	1.63
9.[a]	15		Mexico	42.97 (2.11)	0.05 (0.17)	.35	1.59
10.	15		Brazil	73.81 (3.20)	-0.43 (-1.12)	.09	1.10

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
11.[a]	15		Turkey	46.66 (2.81)	−0.002 (−0.01)	.35	1.65
12.[a]	15		Sudan	52.42 (4.31)	−0.07 (−0.53)	.37	1.73
13.[a]	15		Egypt	72.35 (4.27)	−0.20 (−1.55)	.42	2.09
14.	14		Peru	102.46 (5.96)	−0.53 (−3.06)	.44	1.92
15.	10	India	Pakistan	38.41 (0.90)	0.29 (0.42)	.02	1.29
16.	13		Mexico	55.99 (1.08)	−0.07 (−0.09)	.001	0.99
17.	12		Brazil	−17.53 (−0.27)	1.22 (1.07)	.10	1.00
18.	13		Turkey	71.42 (1.66)	−0.31 (−0.47)	.02	1.04
19.	13		Sudan	47.97 (1.27)	0.04 (0.08)	.001	0.90
20.	13		Egypt	90.52 (2.87)	−0.34 (−1.26)	.13	1.00
21.	12		Peru	111.99 (3.15)	−0.61 (−1.67)	.22	1.28

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
22.	12	Brazil	Pakistan	-1.27 (-0.05)	0.97 (2.39)	.36	1.92
23.	15		Mexico	-57.21 (-3.53)	1.77 (7.24)	.80	2.40
24.	14		Brazil	-33.99 (-1.76)	1.58 (4.77)	.66	2.39
25.	15		Turkey	-22.66 (-1.46)	1.24 (5.34)	.69	2.50
26.	15		Sudan	8.31 (0.60)	0.61 (3.74)	.52	2.46
27.[a]	13		Egypt	15.91 (0.62)	0.36 (1.76)	.07	2.26
28.	13		Peru	27.44 (0.96)	0.32 (1.11)	.10	2.01
29.	12	Turkey	Pakistan	33.48 (1.42)	0.37 (1.00)	.09	1.14
30.	15		Mexico	-15.43 (-1.30)	1.09 (6.11)	.74	2.07
31.	14		Brazil	0.53 (0.06)	0.94 (6.00)	.75	2.21
32.	15		Turkey	2.76 (0.43)	0.80 (8.56)	.85	2.21

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
33.	15		Sudan	20.88 (2.17)	0.42 (3.80)	.53	2.23
34.	15		Egypt	31.64 (3.05)	0.20 (2.47)	.32	2.18
35.	13		Peru	2.07 (0.13)	0.55 (3.42)	.51	1.51
36.	12	Greece	Pakistan	77.24 (2.70)	-0.21 (-0.46)	.02	1.28
37.	16		Mexico	-11.02 (-0.67)	1.16 (4.58)	.60	1.54
38.	15		Brazil	1.05 (0.08)	1.07 (5.00)	.66	1.95
39.	16		Turkey	-0.46 (-0.06)	0.98 (7.94)	.82	1.18
40.	16		Sudan	20.55 (1.25)	0.53 (2.66)	.34	1.50
41.	16		Egypt	31.21 (3.39)	0.27 (3.63)	.48	2.20
42.	14		Peru	7.82 (0.49)	0.58 (3.64)	.52	1.50
43.[b]	11	US	Pakistan	-25.89 (-5.62)	0.69 (3.64)	.74	1.37

Regression Number	Number of Observations	Dependent Variable	Independent Variable	Constant	β_1	R^2	Durbin-Watson
44.[a]	16		Mexico	-26.87 (-1.22)	1.82 (6.25)	.67	2.74
45.[a]	14		Brazil	-53.26 (-1.71)	1.82 (8.49)	.02	1.57
46.[a]	16		Turkey	-22.24 (-1.02)	1.52 (8.82)	.79	2.08
47.[b]	15		Sudan	37.53 (2.28)	0.68 (3.65)	.42	2.08
48.[a]	16		Egypt	23.79 (0.96)	0.59 (3.10)	.42	1.70
49.[a]	11		Peru	40.35 (2.95)	0.43 (4.02)	0	1.16

APPENDIX 3.

PRICE RELATIONSHIPS FOR EGYPTIAN ELS AND LS VARIETIES

An analysis of Egyptian price series should recognize the differences that may exist across varieties within staple lengths. During the period of study, 1963-1978, there were four major extra long staple (ELS) varieties (Menoufi, Giza 45, Giza 68 and Giza 70) and three long staple (LS) varieties (Dendera, Giza 67 and Giza 69). Though the staple length is constant within groups, there may be variation in other characteristics that would lead to consistent price discounts or premia.

The price series used in this analysis are fob Alexandria and cif Liverpool. As older varieties are replaced through time with new strains the price series are incomplete. For example, the published Liverpool quotes for LS cotton begin with Giza 30, switch to Dendera in 1963 and then to Giza 67 in 1968. To arrive at a single price series for Egyptian LS and ELS cotton therefore requires an analysis of the intravariety price behavior to discover how the series may be compared.

Alexandria fob quotes by variety are available on a monthly basis. It is frequently the case that several varieties of a given staple length will be quoted at once, making possible a comparison of the value of their characteristics. The only reservation about this type of analysis is that as varieties are phased in or out the volume traded may be small, making the price quotes somewhat less reliable. If the period of overlap is sufficiently long, this should not be a serious problem.

The technique used here is to examine pairwise regressions of the two prices within variety during periods they are both quoted. If the null hypothesis is that the two varieties have near identical characteristics, this will be rejected if either the slope of the regression differs significantly from one or the intercept from zero.

Such regressions were run for ELS and LS varieties. The most interesting results are presented in Table 1. Since the hypothesis is tested by comparing the slope to one, the standard errors are presented in this table. All of the slopes are quite significantly different from zero, so the t statistics could be misleading.

Among the ELS varieties it was found that there was a significant premium for Giza 45 over both Menoufi and Giza 68. For Menoufi the picture is like Figure 1b (see test), a percentage premium, while for Giza 68, the premium seems absolute (Figure 1c). Not much should be read into this difference however. The key point is that Giza 45 has characteristics that are more highly valued than either Menoufi or Giza 68. When Menoufi is compared to Giza 68 or Giza 70, the pairs of prices are found to be statistically identical.

For the LS pairings Giza 67 and Giza 69 could not be distinguished statistically. When comparing Dendera and Giza 67 however, one finds a situation like Figure 1d. The reason for the "switch", Dendera holding a discount at low prices and a premium at high prices, is probably a statistical artifact due to small number of observations. A variety is either technically superior or it is not and a result like equation 1.5 must be rejected as being contrary to prior knowledge. This leaves us in the position of not being able to compare the price series for the Dendera and Giza 67 varieties.

Additional regressions were performed and no consistent relationships were found between Dendera and Giza 47, Dendera and Giza 69, and Giza 47 and Giza 67.

Appendix 3 Table 1.--Within Staple Length Price Regressions

A. ELS Varieties			
1.1)	MNUX = −58.6 + .951 G45 (65.7) (.016)	R^2 = .951	N = 178
1.2)	MNUX = 34.4 + .993 G68 (57.9) (.014)	R^2 = .969	N = 155
1.3)	MNUX = 287 + .951 G70 (225) (.039)	R^2 = .920	N = 53
1.4)	G45 = 234 + 1.005 G68 (69.4) (.017)	R^2 = .956	N = 164
B. LS Varieties			
1.5)	DEND = −953 + 1.59 G67	R^2 = .726	N = 66
1.6)	G67 = −59.9 + 1.015 G69	R^2 = .970	N = 118

Note: Standard errors in parentheses.

The variety names are:

MNUX: Menoufi, Dend: Dendera; G45: Giza 45, etc.