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# AN ECONOMETRIC STUDY OF COTTON PRODUCTION AND TRADE BEFORE 1860

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Expansion in cotton was one of the most pronounced features of the United States economy before 1860. Output of short-staple cotton grew remarkably from the mid-1790's forward, this development implemented by an unprecedented westward migration, which contributed toward a new pattern of regional specialization and consciousness. Cotton became at that time the single most important export commodity of the country: in ten separate years it accounted for more than half of total U.S. export revenues. This export growth has been given a prominent place by D. C. North as a propellor of U. S. economic development.[1]

In this paper an econometric model is developed in an attempt to assess the broad patterns of supply and demand prevailing in cotton production and trade during the 33-year period preceding the Civil War, 1828-1860. Considerable space is devoted to the actual "building" of the model, in an attempt to show how information from the more traditional sources of economic history can be incorporated in such work. The underlying thesis is that econometric models "can be described as a way of writing economic history."[2] Anyone who has read through lengthy "discussions" of the movements of economic variables over time can attest to the limited power of that particular form of "qualitative history" as well as its strong resistance to being pinned

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down to any solid hypothesis. An econometric model can bring together information from many statistical series, and if it correctly specifies the pattern of economic relationships (as understood from other sources), it can test whether relations thought to be "seen" in the raw data are actually tenable. "Model building is thus a way of organizing information . . . about a past period."[3]

## THE MODEL

Apart from the early invention of the cotton gin (35 years before the period under study here), and some improvements in seeds, the expansion of cotton production was almost entirely extensive: other crops were displaced by cotton, and more importantly, new cotton lands were purchased, settled, and cultivated. It is plain that any effort to estimate a price elasticity of supply must take into account the different supply situations in say, 1835 and 1855; the major difference was the immense new area of land brought into cultivation in the meantime. This process was to a great extent irreversible: farmers did not give up their lands and go back east, even when cotton prices had fallen well below the level which induced them to migrate in the first place. The basic supply function has therefore been written in terms of lagged price and lagged cumulative sales of land in the cotton regions:

(1) $$Y_0 = a + bP_{-1} + cL_{-2} ,$$

where $Y_0$ = annual cotton production, $P_{-1}$ = cotton price lagged one year, and $L_{-2} = \sum_{j=2}^{\infty} S_{-j}$ , and $S$ = annual land sales. Capital letters denote the natural logarithms of the original variables. Both independent variables are predetermined in the absence of serially correlated disturbances. Price should be lagged at least one year because the basic production decision -- how much acreage to plant in cotton -- had to be made without direct information about the price the cotton would bring when sold. I have been unable to find evidence of extensive abandonment of crops once they had been planted, a phenomenon which would have disturbed the relationship portrayed here. Broadly speaking, the process was to make the production decision and then to sell all that was produced at whatever price it would bring. Overambitious planters sometimes did not finish picking until February or March of the following calendar year,[4] but this output is all counted in the same agricultural year ending August 31.[5] Land sales should be cumulated up to two years previous, in order to allow time for the newly purchased land to be settled, cleared, and cultivated: even for land purchased in January of year 1 , it would have been extraordinary if all this could have been accomplished in time to affect the cotton crop of agricultural year 2; planting would have to begin only a few months after purchase. On the other hand, if land were purchased in December of year 1, the same argument implies that it might well be year 4 before the impact were felt in total output. Hence, both two- and three-year lags were tried.

But this equation alone would not give a satisfactory estimate of the effect of price on cotton output. The reason is that land sales were closely tied to recent experience in cotton prices. This relationship is one of the basic elements in North's version of the dynamics of the system.[6] Therefore a second equation has been added to make land sales a distributed lag function of cotton prices:

$$(2) \qquad S = d + e_o \sum_{j=o}^{\infty} \theta_o^j P_{-j} \qquad 0 < \theta < 1$$

One might reasonably argue that land prices would be more appropriate than cotton prices in a demand function for land. But "public land was sold under regulations of certain minimum prices per acre; the minimum prices (as we know) usually formed the actual price."[7] The price of land was not the major obstacle to migration, the supply being close to infinite -- even by 1860 large amounts of unimproved land were still unsold in the South. The question facing potential migrants was whether profits from cotton-growing were likely to be great enough to compensate for the expense and difficulty of migration, settlement, purchase of equipment, and bringing land into cultivation.

This particular form of the distributed lag -- with weights declining geometrically with time -- may in general be justified either in terms of a fixed "elasticity of adjustment" to a desired level of purchases, or a fixed "elasticity of expectations" relating actual price to expected price.[8] In our case, clearly an individual farmer either purchased land or he didn't (though the <u>amount</u> purchased by an individual may have been sensitive to the price of cotton.) The correct interpretation for this case, therefore, is that a threshhold price level existed for each farmer, but that the threshhold differed among members of the population. The <u>distribution</u> of the lag is thus an aggregation effect, the result of combining reactions of varying speeds into one equation. The reader may question whether cotton prices infinitely removed in time continued to exert influence on land sales; but this form allows the actual significance of cotton prices to become negligibly small beyond a few years, because of the geometrically declining weights. Furthermore, the equation can be transformed into a form convenient for estimation. We have

$$S_{-1} = d + e_o \sum_{j=o}^{\infty} \theta_o^j P_{-(j+1)} \qquad \text{or}$$

$$\theta_o S_{-1} = \theta_o d + e_o \sum_{j=o}^{\infty} \theta_o^{j+1} P_{-(j+1)} = \theta_o d + e_o \sum_{j=1}^{\infty} \theta_o^j P_{-j} \quad .$$

Therefore, subtracting the last equation from the original equation, we obtain

$$S - \theta_o S_{-1} = d - \theta_o d + e_o P \qquad \text{or}$$

(2')

$$S = d(1 - \theta_o) + e_o P + \theta_o S_{-1} \quad .$$

Land sales are thus a linear function of current price and land sales lagged one year. All of the parameters of the original equation can be found from the parameters of the transformed equation by algebraic manipulation.

The demand for cotton came primarily from textile producers in Great Britain and, especially in the latter part of the period, in the United States. Other countries also consumed American cotton, but no one of them in significant amounts; together, the U.S. and U.K. absorbed the great bulk of the U.S. cotton crop, often as much as 75% - 85%. Because in addition there are no good sources of time series data for these other countries, no attempt has been made to estimate demand functions outside of the U.S. and U.K., though the supply equations do reflect total production. This amounts to saying that exports to countries other than Great Britain are taken as exogenous.

Similarly, the United States was not the only supplier of cotton either to itself or to Great Britain. But it was by far the most significant supplier, and in fact its market share was increasing over time: in the British market, for example, U.S. cotton made up roughly 68.6% of supply for the years 1826-1830, and 84.5 % in the period 1856-1860. Therefore, no attempt was made to write cotton supply functions for other countries.

The essential character of cotton demand was that of derived demand for a factor of production. Cotton prices may have had some influence on the level of production and the amount of cotton used in cloth-making -- a major purpose of the model is to estimate the extent of this influence -- but once the production decision had been made regarding cotton textiles, the major part of the decision to purchase cotton had already been made. Demand functions were therefore written in the following way:

$$(3) \qquad Y_2 = g + hP + kT$$

$$(5) \qquad Y_3 = m + nP^* + qC$$

where $Y_2$ = U.S. cotton consumed domestically; $Y_3$ = U.S. cotton exports to Great Britain; P = price of cotton in the U.S.; P* = price of cotton including freight costs to Great Britain; T = U.S. output of cotton textiles; C = British cotton cloth production.

This specification of demand in terms of current price would not be correct if textile producers made large purchases of cotton for future use, that is, if they adjusted their inventories in a significant way. For the United States, however, the evidence from past historical studies indicates that they did not do this. Hammond writes: ". . . not many of the northern manufacturers were so situated that they could . . . afford to stock their warehouses with large supplies of raw cotton . . . The manufacturers, especially the smaller ones, carried very small stocks of cotton, seldom for more than a few weeks or a month in advance of needs, or if they were near the seaports, not even for so long a time."[9] It is on the basis of such accounts that the particular form of equation (3) was chosen. The British situation, where capital and commodity markets were better developed, is less clear; nevertheless, no alternative specification has been attempted. We should expect, therefore, a looser relationship between British production and her consumption of U.S. cotton, than would be found for the United States; that is, we should expect $q$ to be less than $k$. This would be doubly true because of the fact that British manufacturers made greater use of low-quality Egyptian and Indian cotton when both cotton prices and textile output were high. The United States, on the other hand, in addition to being further distant from alternative cotton suppliers, levied a tariff on imported cotton until 1845.

The price elasticities estimated in (3) and (5) will understate the total effect of cotton prices on demand, because they do not allow for an effect on textile output. Therefore two corresponding equations were estimated, with textiles output a distributed lag function of past prices:

$$(4) \qquad T = u + e_1 \sum_{j=o}^{\infty} \theta_1^j P_{-j} \qquad 0 < \theta_1 < 1$$

$$(6) \qquad C = v + e_2 \sum_{j=o}^{\infty} \theta_2^j P^*_{-j} \qquad 0 < \theta_2 < 1$$

The form of these equations may be justified in terms of delayed adjustment or delayed expectation-formation, as discussed with respect to (2). By identical manipulations, these functions may be transformed into

(4')
$$T = u(1 - \theta_1) + e_1 P + \theta_1 T_{-1}$$

(6')
$$C = v(1 - \theta_2) + e_2 P^* + \theta_2 C_{-1}$$

Finally, two identities are needed to complete the model:

(7)
$$p^* = p + fr$$

(8)
$$y_o = y_1 + y_2 + y_3$$

where the small letters denote the raw figures (as opposed to the logarithms), and $fr$ = freight costs; $y_1$ = exports of cotton to countries other than Great Britain. The last variable is taken as exogenous, as explained above.

It should be noted that most of the questions about the specification of equations -- such as the lags in (1) and the absence of lags in (3) and (5) -- should not necessarily be resolved by "trying it both ways" and choosing the equation with the higher F ratio. It is not at all uncommon for a "better fit" to be obtained in a misspecified equation, if there are purely statistical correlations which do not represent behavioral functions. If the model does not correctly reflect the pattern of economic relationships, little confidence can be placed on resulting conclusions which accept or reject historical hypotheses. Any disagreement with the specification used here ought best to be based on an alternative reading of the historical material, rather than merely on a higher "significance level" in the statistical sense.[10]

THE DATA

Any historical study of a period as early as this one faces serious data problems; this is especially true of an econometric model, which demands year-by-year series for each variable. To some degree the form of the model itself is influenced by tha data available: we might well be tempted, for example, to add more functional variables if there were many more available to choose from. But a more important influence works through the specific observed numbers inserted into the theoretical slots for which the algebraic symbols stand. In this case, some justification is required for practically every equation.

Production, exports and domestic consumption are taken from Hammond's figures,[11] and present no special difficulties apart from the general uncertainties of historical series. The basic cotton prices used are from the same source, and represent average annual New York prices for middling uplands. This particular price does not, of course, represent the price actually received by cotton growers; it would plainly be impossible, in any manageable model, to reflect fully all of the prices faced by all growers in all sections of the country. But one might argue that New Orleans prices[12] would be more appropriate with respect to supply. Unfortunately, they would almost certainly be less appropriate for explaining U.S. textiles demand. Both sets of prices cannot be used without some means of explaining the differences between them. But those differences, particularly in those days of slow communications, undoubtedly had a thousand erratic short-term causes, and these are well beyond the scope of a model which attempts to explain the broad forces beyond year-to-year developments. Since the choice between them is thus somewhat arbitrary, I have re-run several of the equations using New Orleans prices as a check on the conclusions. Neither method takes account of changes in internal transport costs, though ocean freight costs are included in (5).

Land sales are represented by public land sales receipts in five southern states,[13] cumulated from 1815. This is in some ways the least satisfactory series, since it mixes land price effects with acreage. However, we have already argued that land sales were generally made at an administratively fixed minimum price, and that the cost of land purchase was not the major obstacle to westward migration. Arthur Cole wrote: "For most of the period under consideration, the decades preceding 1860, it is, to be sure, a matter of indifference which set of data is used . . . the two quantities moved together. Indeed, if the annual receipts from the sale of public land for the country as a whole are plotted on a logarithmic scale with the other feature, the acreage annually disposed of, no significant variation between the curves will be found to appear before the very last years of the period are reached."[14] On the basis of this argument, it may reasonably be claimed that land sales receipts are fair proxies for the corresponding acreage figures.

U. S. cotton textiles output is entered in millions of yards, as estimated by Davis and Stettler.[15] Their figures were estimated by inflating appropriately the outputs of a sample of New England firms; the rest of the country is not included, but of course at that time New England produced the great bulk of the total. For (5) we use exports of cotton manufactures from Great Britain, in millions of yards.[16] Exports are not, of course, as appropriate as total production would be, but the export figures are readily available, and it may be argued that the resulting error will not be great. The greater part of cloth production was in fact exported, and furthermore the proportions may not have varied significantly.

Freight rates are taken from North's figures, in cents per pound, from New York to Liverpool.[17] The variable $p^* = p + fr$ is a constructed price, not actually observed in the Liverpool market. The justification for its use is that, while we know that freight costs added to the price of cotton in England over the price in the United States, beyond this we are not particularly interested in, and we have no means for, explaining the short-term discrepancies between prices in the two markets. The results of a consistency check suggest that these discrepancies were not of serious proportions.[18]

ESTIMATION

The model contains eight equations and eight endogenous variables, with two exogenous and four lagged endogenous variables, which we regard as predetermined. Each of the stochastic equations, (1) through (6), is overidentified. The first equation contains only one current endogenous variable and may be estimated by ordinary least-squares. The rest are estimated by two-stage least squares. That is, the variables P, P*, T, and C are replaced by an estimate based on variables which are predetermined in the model. The nonlinearity in the model makes this procedure somewhat different from the usual application of two-stage least-squares. That is, it does not follow from the model that P should be a linear function of fr and $y_1$ (nor of the logs FR and $Y_1$); hence, what we really have is a variant of the instrumental variables approach, where P, P*, T, and C are replaced by some estimate based on variables with which they are correlated (as the model indicates) and which are not correlated with the disturbance terms in the respective equations. (The assumption that the variables are predetermined implies that this is so by definition.) The estimate is linear simply as an approximation to a function of unknown form.

The results for the supply functions were as follows:[19]

(1) $$Y_o = -6.2646 + \underset{(0.1470)}{0.2451}P_{-1} + \underset{(0.0967)}{1.2497}L_{-2} \qquad R = 0.9208 \quad D\text{-}W = 0.85165$$

(2') $$S = -0.2426 + \underset{(0.8437)}{1.5376}\hat{P} + \underset{(0.1757)}{0.5009}S_{-1} \qquad R = 0.77098 \quad D\text{-}W = 1.85805$$

which corresponds to

(2) $$S = -0.4841 + (1.5376) \sum_{j=0}^{\infty} (0.5009)^j \hat{P}_{-j}$$

The figures in parenthesis are the standard errors of the second-stage regression.

It may be seen that the one-year price elasticity of supply was a relatively low 0.245; but when the longer-term effect on land sales is taken into account, the elasticity is 1.90 after five years adjustment (1.5376 times 0.5009 times 1.2497 plus similar terms for succeeding years). This short-run rigidity and long-run responsiveness provides a statistical basis for explaining the boom-and-bust pattern during the period: strong demand led to high prices and prosperity for a time, but these high prices then induced a great outpouring onto the market after a few years, causing a period of depression.

However, it should be noted that there is a serious problem of serial correlation in the residuals of (1): the Durbin-Watson statistic is well below the lower limit at 5 percent or 10 percent levels of significance. The pattern of residuals (Fig. 1) shows a block of over-estimates from 1836 to the mid-forties, followed by a block of under-estimates. These results should not, therefore, be accepted as they stand.

The demand equations for cotton on the part of U.S. and U.K. textile producers were estimated as follows:[20]

(3) $$Y_2 = -0.0861 + \underset{(0.2346)}{0.0208\hat{P}} + \underset{(0.0633)}{0.9871\hat{T}} \qquad R = 0.9442 \quad D\text{-}W = 1.1080$$

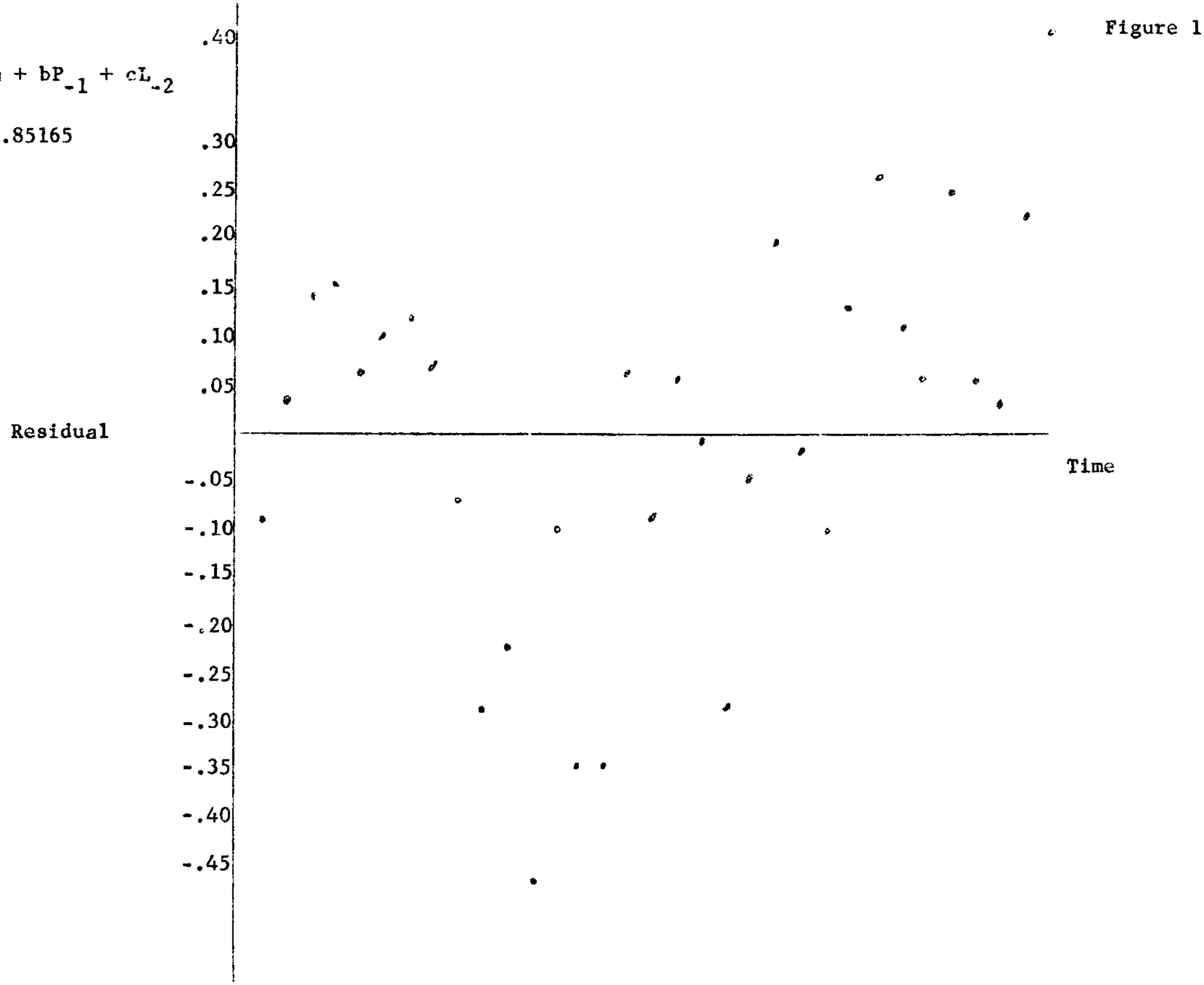
(5) $$Y_3 = 2.2233 - \underset{(0.1787)}{0.04007\hat{P}^*} + \underset{(0.0468)}{0.7073\hat{C}} \qquad R = 0.9419 \quad D\text{-}W = 1.8863$$

For both countries, the one-year demand elasticity, given textiles output, is essentially zero (in (3) the price elasticity is the wrong sign but insignificant). As expected, the coefficient of T is much closer to unity than the coefficient of C , either because of greater inventory fluctuations in Britain, or the increased proportionate use of Egyptian and Indian cottons at high levels of demand. A check of the Durbin-Watson statistics, however, reveals a remarkable result: the U.S. demand equation (3) has severe serial correlation in the residuals, while the British equation (5) has none. Figures 2 and 3 graph the residuals against time and show that (3) has a residual pattern nearly identical to that of (1), while the British equation has no such problem. It thus appears that there was some sort of U.S. cyclical movement, outside of the variables in the model, and not present in the U.K.

The reason for the sharp separation of the residuals for 1836-1845

(1) $Y_o = a + bP_{-1} + cL_{-2}$

D-W = 0.85165



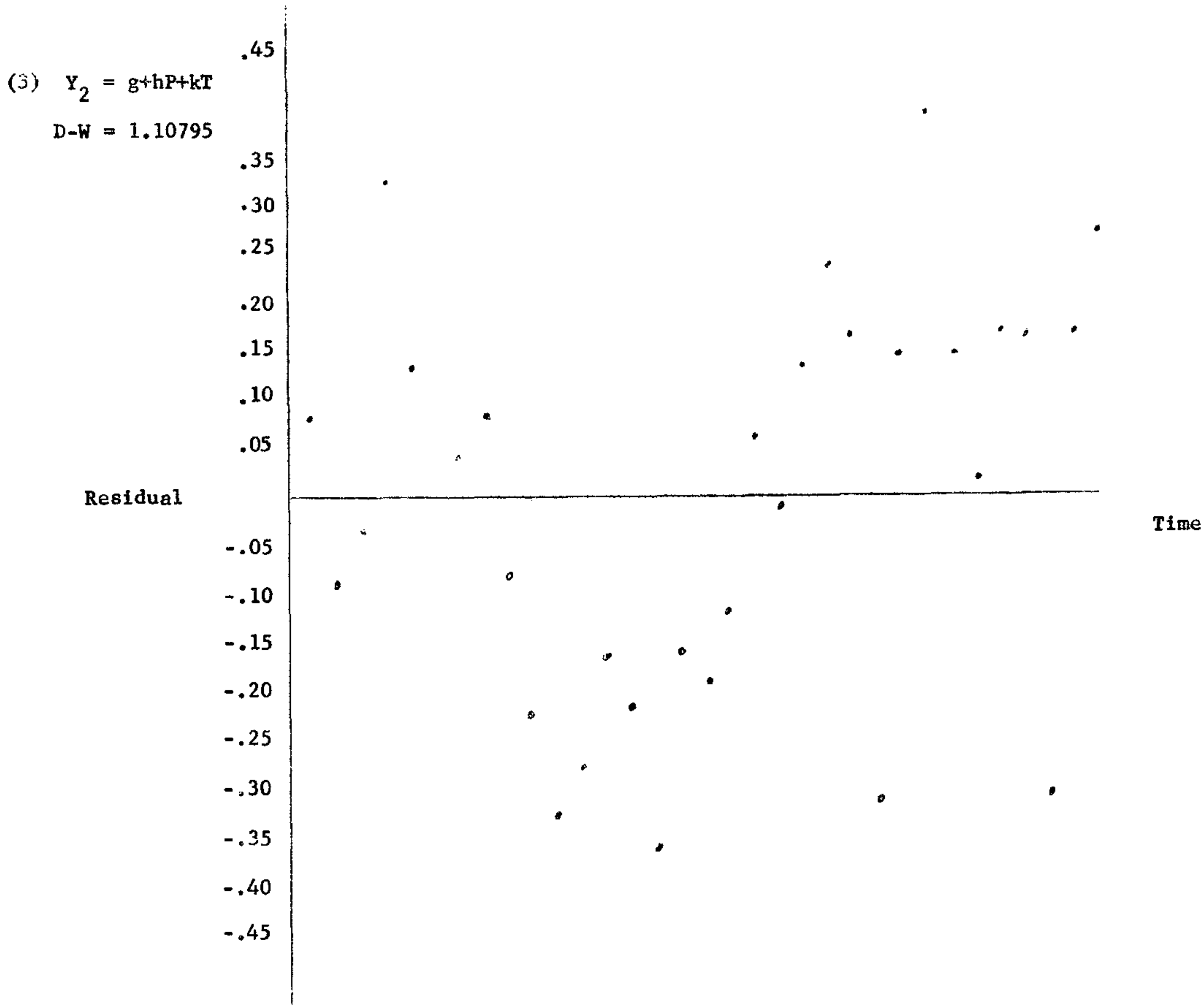
is not difficult to find: this was a depressed decade for the economy as a whole. The most recent evidence on early growth of real domestic product is that longstanding growth was interrupted by ten years of near-stagnation during exactly the period we are considering. Paul A. David writes:[21]

> ". . . the growth of per capita domestic production did undergo marked retardation midway through the 1830's. The average rate of increase dropped to the neighborhood of 0.6 percent per annum during the brief period from the mid-1830's to the mid-1840's, whereas, over the preceding decade and a half real GDP per capita may well have been growing at an average rate close to 2.5 percent per annum."

David identifies the period of retardation as 1834/35 to 1844/45,[22] almost precisely the dates of overestimation in the model at hand. This characterization of the decade seems clear enough to justify setting off those years by means of a dummy variable in equations (1) and (3), equal to unity for the depressed period and zero otherwise. The method allows a single elasticity estimate to be made, but the intercept is permitted to shift. If the observed serial correlation is eliminated by this procedure, this will provide a partial confirmation of the hypothesis that the low Durbin-Watson statistic was a result of three distinct blocks of observations, rather than a "true" year-by-year correlation.

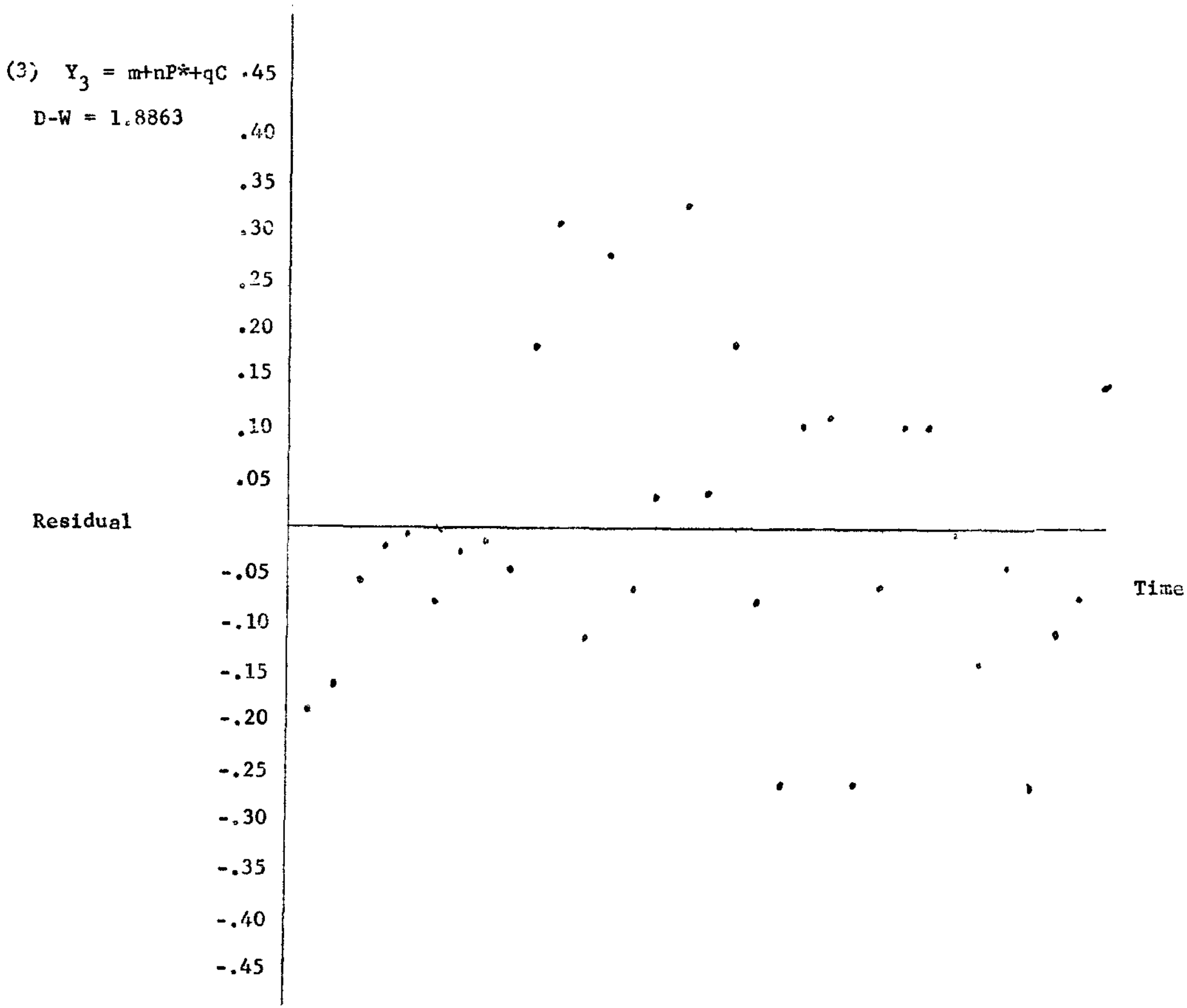
Rerunning all the equations estimated thus far yields the following results:[23]

Figure 2



(3) $Y_2$ = g+hP+kT
D-W = 1.10795
.45
.35
.30
.25
.20
.15
.10
.05
Residual
-.05
-.10
-.15
-.20
-.25
-.30
-.35
-.40
-.45
Time

Figure 3


(3) $Y_3$ = m+nP*+qC
D-W = 1.8863
.45
.40
.35
.30
.25
.20
.15
.10
.05
Residual
-.05
-.10
-.15
-.20
-.25
-.30
-.35
-.40
-.45
Time

(1) $$Y_o = -6.7901 + \underset{(0.1170)}{0.2896P_{-1}} + \underset{(0.0772)}{1.2949L_{-2}} - \underset{(0.0601)}{0.2616D} \qquad R = 0.9529, \quad D\text{-}W = 1.5272$$

(2') $$S = -0.4165 + \underset{(0.7731)}{2.0078P} + \underset{(0.1831)}{0.3628S_{-1}} \qquad R = 0.7951, \quad D\text{-}W = 1.88235$$

(2) $$S = -0.6536 + (2.0078) \sum_{j=o}^{\infty} (0.3628)^j P_{-j}$$

(3) $$Y_2 = 0.1366 - \underset{(0.1371)}{0.2412\hat{P}} + \underset{(0.0393)}{0.9646\hat{T}} - \underset{(0.0545)}{0.3358D} \qquad R = 0.9320, \quad D\text{-}W = 1.8858$$

(5) $$Y_3 = 2.5197 - \underset{(0.1689)}{0.1325\hat{P}^*} + \underset{(0.0490)}{0.6803\hat{C}} \qquad R = 0.9320, \quad D\text{-}W = 2.0076$$

Both of the dummy variables are very significant, and all of the obvious serial correlation is eliminated. The demand elasticities are somewhat higher, both of the right sign. The British demand elasticity is 0.132 and the U.S. demand elasticity is 0.241, both still quite low. (As noted in footnote 23, use of New Orleans prices yields a somewhat higher elasticity for the U.S. (0.593), with virtually no difference for the U.K. (0.094).) The supply elasticities are not changed greatly by the dummy: 0.299 within one year, and approximately 1.70 within five years.

In the supply equation, the elasticity with respect to cumulative land sales is greater than unity. This should not occasion surprise in view of the observed higher yields of western cotton lands, and the greater specialization in cotton in the west relative to that in the east. The overall supply result is consistent with North's contention that "the behavior of prices . . . was the major element in any explanation of economic change." While equation (1) would appear to show a lack of response to price, equation (2) shows that the delayed response was substantial, almost double in percentage terms the price increase that initiated the movement.

In the demand equations, the result still holds that quantity demanded varied mainly with output, with only mild variation due to price. The remaining task is to test to what extent output itself was influenced by the price of cotton. Equations (4) and (6) are designed to test this:

(4')
$$T = 1.6202 - \underset{(0.1532)}{0.2459\hat{P}} + \underset{(0.0395)}{0.8423T_{-1}} \qquad R = 0.9686, \quad D\text{-}W = 2.0823$$

(4)
$$T = 10.2739 - (0.2459)\ (0.8423)^{j}\ P_{-j}$$

(6')
$$C = 0.1593 - \underset{(0.1057)}{0.03779\hat{P}^{*}} + \underset{(0.0319)}{0.9900C_{-1}} \qquad R = 0.9853, \quad D\text{-}W = 2.5038$$

(6)
$$C = 159.3 - (0.03779)\ (0.9900)^{j}\ P^{*}_{-j}$$

Equation (4) indicates that the price of cotton did indeed influence the output of textiles in the United States. The one-year demand elasticity of 0.24 was raised to 0.97 over a five-year period. That is, a permanent fall in the price of cotton of 10 percent would have induced an increase in textiles output of about 10 percent in five years' time. The effect of the American cotton price on British textiles output, however, appears to be very small. The low demand elasticity of 0.13 for one year is raised only to 0.26 by the end of the fifth year. The total demand elasticity would of course be much closer to the British level because of its greater weight.

One implication of the low British demand elasticity is that the notion that falling freight rates were important in expanding U.S. - U.K. cotton trade, implied by North,[24] has no statistical support. Even a sustained 75 percent fall in freight rates (the figure obtained by comparison of the year of highest rates and the year of lowest) meant only about a 7.5 percent fall in price, which in turn would result in only about a 2 percent rise in quantity demanded, even after five years of adjustment. Of course, 75 percent is a greater drop in freight rates than was ever actually observed in a five-year period.

## CONCLUSION

By using available information about the economic structure of cotton production and trade before 1860, we have put together a compact picture of the economic parameters of the relevant markets. In many cases, the results simply confirm the literary descriptions in a statistical way: the inability or unwillingness to diversify in the face of a decline in the price of cotton, combined with the rush to settle cotton lands in response to a rise in expected revenues. The fact that the output of British textiles -- the main source of demand throughout the period -- was essentially exogenous in terms of all the variables used here, merely increased the susceptibility of cotton producers to the movements of the market, a susceptibility well described by contemporary and historical accounts. In other cases, however -- such as the significance of freight rates -- we have shown that what might seem to be significant from a less rigorously quantitative view may not actually be important.

1 See [9]. The North thesis has been challenged by several writers. See for example [4].

2 [7, p. 158].

3 [7, p. 158].

4 [5, Vol. II, p. 707].

5 It should be noted that only the simplest model of expectation-formation is used here, namely that the expected price is equal to the current price at the time of planting. The reason is that it would be difficult to distinguish the effect of past prices on expectations (and hence on quantity supplied from a given acreage) from their effect on land sales, as described by equation (2). It seems plain that the latter effect was the more important.

6 [9, p. 124].

7 [1, p. 42]. The minimum price of $1.25 per acre did not change during the period.

8 [8, pp. 54-63]. We refer here to a constant elasticity rather than simply to a constant coefficient, because the equations are to be estimated in logarithmic form.

9 [6, pp. 289-290].

10 It can be argued, of course, that one never entirely believes the specification of one's model, and that in fact, no model with a manageable number of equations can ever reflect the "true" structure. In the choice between $L_{-2}$ and $L_{-3}$ in equation (1), for example, it is clear from the discussion that neither simple hypothesis can possibly be "true" in the sense that it applied to all participants. In such a case -- where one is unwilling or unable to devise a more complicated model to take both kinds of behavior into account -- it might be argued that goodness-of-fit provides the only test. One can still argue, however, as I have throughout this paper, that certain structures are closer to reality than others, and consequently that greater reliance should be placed on their results.

11 [6, Appendix I].

12 [5, Vol. II, pp. 1027-1029].

13 The states are Arkansas, Alabama, Mississippi, Louisiana, and Florida. Computed from [9, p. 257].

14 [1, p. 42].

[3, p. 221].

[10].

[9, p. 258].

Comparison of (a) the Liverpool price as given by Hammond [6, Appendix I] with (b) the New York price plus freight rates between New York and Liverpool, and with (c) the New Orleans price plus freight costs between New Orleans and Liverpool, yields the following results for 35 observations: between (a) and (b) were 4 cases of greater than 2 cents differential (roughly 20 percent) and 16 cases greater than 1 cent differential (roughly 10 percent); between (a) and (b) were 9 cases greater than 2 cents differential, 22 cases greater than 1 cent. These estimates, however, do not take into account such elements as insurance and handling costs, which result in significant differentials (in a consistent direction) between cities on the average over the whole period. When this difference in means is factored out (and assumed constant over the period), the results are as follows: between (a) and (b) were only 2 cases of greater than 2 cent discrepancy, and 11 cases of greater than 1 cent; between (a) and (c) were 5 cases of greater than 2 cent differential, and 10 cases of greater than 1 cent. A check of the direction of price changes shows that (a) and (b) moved in the same direction 27 of 34 times (79 percent), and that (a) and (c) moved in the same direction 28 of 34 times (82 percent).

Using New Orleans prices yielded similar results:

(1) $$Y_o = \underset{}{-1.5149} + \underset{(0.1414)}{0.1884}P_{-1} + \underset{(0.0993)}{1.2533}L_{-2} \qquad R = 0.9185,\quad D\text{-}W = 0.6123$$

(2) $$S = -4.5353 + \underset{(0.7560)}{1.4549}\hat{P} + \underset{(0.1774)}{0.4806}S_{-1} \qquad R = 0.7721$$

When land sales are lagged by three years instead of two, the results were also similar:

(1) $$Y_o = -1.7477 + \underset{(0.1341)}{0.3216}P_{-1} + \underset{(0.0906)}{1.2379}L_{-3} \qquad R = 0.9286,\quad D\text{-}W = 0.9443$$

20 The results for (3) appear to show a substantially higher price elasticity, though still less than unity, when New Orleans prices are used:

$$(3) \qquad Y_2 = -0.2068 - \underset{(0.1227)}{0.9643\hat{P}} + \underset{(0.1463)}{1.5548\hat{T}} \qquad R = 0.9212 \quad D\text{-}W = 0.4968$$

But the Durbin-Watson statistic is so low that this estimate cannot be taken seriously. When the autocorrelation is corrected, a more moderate result is obtained.

For the British equation, the results are not much changed by the use of New Orleans prices:

$$(5) \qquad Y_3 = 0.0761 - \underset{(0.0957)}{0.1160\hat{P}^*} + \underset{(0.0680)}{0.8537\hat{C}} \qquad R = 0.9319 \quad D\text{-}W = 2.0066$$

21 [2, p. 156].

22 [2, p. 187].

23 The results under the revised procedure using New Orleans prices are as follows:

$$(1) \qquad Y_0 = -1.7145 + \underset{(0.1122)}{0.2812P_{-1}} + \underset{(0.0785)}{1.3085L_{-2}} - \underset{(0.0611)}{0.2752D} \qquad R = 0.9524$$

$$(2') \qquad S = -4.5551 + \underset{(0.7794)}{1.4490\hat{P}} + \underset{(0.1867)}{0.4676S_{-1}} \qquad R = 0.7701$$

$$(3) \qquad Y_2 = -1.1643 - \underset{(0.0613)}{0.5928\hat{P}} + \underset{(0.1035)}{1.4944\hat{T}} - \underset{(0.0672)}{0.4294D} \qquad R = 0.9642 \quad D\text{-}W = 1.5086$$

$$(5) \qquad Y_3 = -0.3160 - \underset{(0.0728)}{0.0941\hat{P}^*} + \underset{(0.0775)}{0.9236\hat{C}} \qquad R = 0.9343 \quad D\text{-}W = 1.8362$$

24 [9, pp. 126, 167, 192].

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