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British Industrialization Before 1841: Evidence of Slower Growth During the Industrial Revolution

C. KNICK HARLEY

New indices of industrial production show that Britain's industrial growth in the last decades of the eighteenth century and the first decades of the nineteenth century was about a third slower than currently available estimates indicate. Therefore, mid-eighteenth-century industrial output was nearly twice as high as previously assumed.

THE British industrial revolution marks the transition to the modern age. The nature of the transition remains obscure, in large part because reliable and comprehensive data do not exist prior to the mid-nineteenth century. With such paucity of data the economic historian must cultivate Sir John Clapham's "statistical sense . . . of asking . . . how large? how long? how often? how representative?" The indices of industrial production presented here attempt to attain appropriate weighting of various industries by using as a basis the first comprehensive enumeration of British economic activity—the occupation data of the 1841 Census. The growth of the indices of industrial production so derived are supported by independent estimates of the growth of demand for industrial goods. The indices indicate growth was a third lower between 1770 and 1815 than either the index estimated by Walther Hoffmann or the estimate of aggregate output proposed by Phyllis Deane and W. A. Cole.[1] In both cases the older estimates have overestimated the importance of the spectacular changes of the late eighteenth century. Hoffmann gave too much emphasis to cotton, and Deane and Cole gave too much emphasis to overseas trade.

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[1] Walther G. Hoffmann, *British Industry 1770–1950*, trans. W. O. Henderson and W. H. Chaloner (Oxford, 1955). Phyllis Deane and W. A. Cole, *British Economic Growth 1688–1959*, 2nd ed. (Cambridge, 1967), chs. 2, 5 (hereafter cited as *British Growth*).

E. J. Hobsbawm has recently written "whoever says Industrial Revolution says cotton."[2] One might want to add iron and steam. But these three industries were only a minority—less than a quarter of British manufacturing even in the 1840s—and while their technological transformations have received due attention, they must be kept in proper perspective in a study of British industrialization in the aggregate. The older textile industries of wool, linen, and silk and the agricultural processing industries of milling and baking, brewing and distilling, and leather processing certainly generated more income than the technological leaders. The diverse, dispersed, and unspectacular industries must all be given proper weight, even though the evidence is scant and fragmentary, if British industrialization is to be understood.[3]

The diversity of industrial activity was such that realistic estimation of its extent and of the relative importance of its components can only be constructed from systematic enumeration of the economy as a whole. Unfortunately no census of industrial production was conducted in Britain until 1907. It seems likely, however, that the occupational data in the population censuses can provide by 1841 relatively reliable enumeration. Two different and largely independent index numbers are constructed here to chart industrial progress before 1841. The first consists of aggregating various indicators of the growth of specific industries on the basis of weights from the 1841 Census. The second consists of estimating the demand for industrial goods from data on exports, investment, and military demand and from estimates of consumption based on controlled conjectures about real wages.

A NEW INDEX OF INDUSTRIAL PRODUCTION

The new index has been constructed from estimates of the output of various industries. Each of the series is uncertain to some degree. With a few exceptions, particularly in the metal industries, the series are very similar to the industry data used in Hoffmann's index. The novelty of the new index lies in a weighting procedure related by price and quantity movements to the occupational data of the 1841 Census. In particular the appropriate weight of cotton textiles, and of iron to a much lesser extent, dramatically influences the growth of the aggregate index. While most industries increased their output by between 40 and 200 percent from 1770 to 1815, and by between 33 and 150 percent from 1815 to 1841, cotton output increased by 2,200 percent in the first period and by

[2] E. J. Hobsbawm, *Industry and Empire* (London, 1969), p. 56.

[3] Donald N. McCloskey's useful overview in "The Industrial Revolution, 1780–1860: A Survey," ch. 6 in Roderick Floud and Donald N. McCloskey, eds., *The Economic History of Britain since 1700* (Cambridge, 1981) comes to much the same conclusion, although if the results of the present article are to be believed, his calculations for cotton before 1815 require revision. See the Appendix.

TABLE 1
WEIGHTING OF VARIOUS INDUSTRIAL SECTORS, 1841, 1815, 1770

Industry	*1841*	*1815*	*1770*
Textiles			
Cotton	.10	.08	.01
Wool	.08	.11	.15
Linen	.04	.06	.08
Silk	.03	.02	.04
Clothing	.13	.12	.11
Leather	.11	.14	.19
Metal	.11	.08	.05
Food and Drink	.04	.06	.08
Paper and Printing	.02	.02	.01
Mining	.08	.08	.05
Building	.18	.15	.12
Other	.09	.09	.12

Source: See text.

400 percent in the second, and iron production by 350 percent and by 250 percent.

The Structure of British Industry in 1841

The weighting scheme that has been employed in producing an output index (see Table 1) is a slight modification of the distribution of labor among industrial occupations as reported in the Census. The modifications consists of assigning half the weight of adult males to women, children, and youths ("under 20 years of age" in census returns). The weight roughly approximates the wage structure in cotton mills. If there is a bias in the procedure it is toward overweighting women and youths, which would in turn overweight textiles, particularly cotton, and clothing, making the results here seem closer to the traditional results than is truly warranted by the facts. The 110,031 adult males returned as "weaver (branch not specified)"—that is, handloom weavers—were also assigned half the weight of other adult males to reflect their low wages.

The data were aggregated into industrial classification by Charles Booth.[4] Since handworkers in textiles were not distributed by branch in the census, it is necessary to allocate the textile total among cotton, wool, linen, and silk on the basis of Deane and Cole's net output estimates.[5] A second adjustment to Booth's data transferred the 214,780 "Boot and Shoemakers" from "Dress" to "Fur, Leather, Glue, etc." The resulting employment weights for 1841 are presented in Table 1.

[4] Charles Booth, "Occupations of the People," *Journal of the Statistical Society* (1886), pp. 314–435. Booth's work in this regard has been carefully examined and found good by W. A. Armstrong, "The Use of Information about Occupation: Part 2. An Industrial Classification 1841–1891," in E. A. Wrigley, ed., *Nineteenth-Century Society* (Cambridge, 1972), pp. 226–310.

[5] Deane and Cole, *British Growth*, p. 212. Armstrong ("The Use of Information," p. 264) unfortunately produces separate totals for woolens, cotton and silk, and flax, hemp, and others.

If data were available, value added (which allows for interindustry differences in wages and in capital income) would provide more satisfactory weights. In the absence of comprehensive enumeration of the differences, however, there are no clear rules for adjusting the employment data. If adjustment could be made the weight of the metal industries would probably increase modestly, although the industry included the very low-paid nail makers and others in the Black Country finishing trades. The food processing industries would probably increase in weight, because milling, brewing, and distilling were among the most capital-intensive industries of the time. On the other hand, the low paid and modestly capitalized clothing and leather industries probably had smaller shares in value added than in employment, and their weights would be correspondingly lower. The weight on cotton textiles is by far the most important for the index since the growth of the cotton industry was so much more rapid than that of any other. Fortunately, there does not seem to be any reason why its relative value added should be far from its relative employment share.

Estimates of Structure for 1815 and 1770: Adjustment for Relative Price Change

A notable feature of the industrial revolution was, of course, the technological revolution in cotton and iron, radically altering their prices relative to other prices in the economy. Any comprehensive exercise at index number construction must take the price effect into account by employing varying weights in various periods. Since no comprehensive data on values of output exist for earlier periods, it is necessary for cotton and iron to use price data and the (already known) quantity data to make adjustments to the relative shares from the 1841 benchmark. The results for 1770 and 1815 are presented in Table 1.

The weights, then, reflect simple projection of the 1841 weights by the physical output indices for all industries except cotton and iron.[6] The exact magnitude of the change in the relative prices of the two cannot be precisely determined. For cotton, the 1815 relative price has been taken to be twice its 1841 level, based principally on Lars Sandberg's work. Sandberg's index of grey cloth prices falls to 29 from an 1815 base of 100.[7] Rousseaux's index of industrial prices fell to 67 on the same base,

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His procedure cannot be accepted because it involves allocating all the textile workers who were not identified by branch in the census, principally 12,988 "Spinners (branch not specified)" and 110,031 "Weavers (branch not specified)," to cotton and silk. This hardly seems appropriate given cotton's lead in factory production. Deane and Cole's shares and my weighting of women and weavers by half imply about two thirds of these workers were in wool, not cotton. This seems generally consistent with the technological history of the industry.

[6] For "other industries" the midpoint of the range of growth rates of industries other than cotton and iron has been used in the projection for earlier weights.

[7] Lars Sandberg, "Movements in the Quality of British Cotton Textile Exports, 1815–1913," this JOURNAL, 28 (March 1968), p. 8.

implying a real price decline of cotton grey cloth from 100 to 43. Grey cloth, however, was an intermediate output of the cotton textile industry and finishing roughly doubled the value added in grey cloth.[8] Technological progress in finishing was slower than in the transformation of raw cotton to grey cloth, as is apparent from the relative export value of grey and finished cloth: Sandberg finds that the average value of finished cloth rose 28 percent relative to grey cloth.[9] Interpreted as a relative price movement, this implies that the price of finished cotton goods relative to other manufactured goods was 55 percent of its 1815 level in 1841.

Price information for cotton goods prior to the 1790s is very scarce. Unfortunately the substantive difference between the index number analysis and earlier work depends on the relative weight of cotton textiles in the index for the late eighteenth century. Since there is no disagreement on quantity trends, the issue resolves into one of differences in relative prices in the late eighteenth century and in the nineteenth century. Although precision is unattainable, various strands of evidence all point to essentially the same conclusion. Fragmentary price quotations and the available evidence on yarn and weaving cost both indicate that the nominal price of standard quality cotton goods was about the same in 1815 as it had been in 1770 and, if anything, was at least as likely to have been higher as lower. The prices of other manufactured goods, in contrast, seem to have risen by about 50 percent. The price movements are so important to the analysis that details of the evidence are presented in the appendix. The conclusion that cotton prices in 1770 were some 50 percent higher than their 1815 level and three times higher than their 1841 level has been used in the construction of the index numbers.

Fortunately, although alternative price assumptions do affect the values of the index they do not alter the general conclusions of the analysis. If prices are assumed to have been 50 percent higher in 1815 than in 1841 rather than 100 percent higher, the growth of the index (with 1815 weights) changes by less than one-tenth of one percent a year between 1815 and 1841 or 1790 and 1815. If the 1815 weights assume that the relative price of cotton was three times the 1841 price, the growth rates are increased by one- or two-tenths of one percent per year, from 1.5 or 1.6 percent a year from 1770 to 1815 to 1.6 or 1.7, and for 1815 to 1841 from 3.2 or 3.3 percent to 3.4 or 3.5. These are insignificant changes. The volume of cotton was so small by 1770 that modestly different assumptions have little effect. Even doubling the estimated price of cotton goods (to six times the 1841 price) would only increase

[8] G. N. von Tunzelmann, *Steam Power and British Industrialization to 1860* (Oxford, 1978), p. 231.

[9] Sandberg, "Movements," p. 24.

TABLE 2
INDICES OF OUTPUT BY INDUSTRY, 1770, 1815, 1841
(1841 = 100)

Industry	*1770*	*1815*
Cotton	0.8	19
Wool	46	65
Linen	47	75
Silk	28	40
Clothing	20	43
Leather	41	61
Metal	7	29
Food and Drink	47	69
Paper and Printing	17	47
Mining	15	46
Building	16	42
Other	15–50	40–60

Source: See text.

the 1815 output index by 10 percent and the annual growth rate from 1.6 or 1.7 to 1.8 or 1.9 percent per year.

The 1815 and 1770 bases also incorporate the declining price of iron. Here, just as with grey cloth, care must be taken to avoid attributing to the final product all the percentage decline in the price of an intermediate good, in this case pig or bar iron. The final stages of production of iron added a value at least equal to the value of the bar iron used in its construction. A calculation based on Charles Hyde's estimates of cost improvement in bar iron production (with a weight of one-half and assuming that the finishing processes did not fall in price relative to other manufacturing) suggests that real iron costs were not more than 1.2 times their 1841 level in 1815 nor above 1.8 times their 1841 level in 1770.[10] These values have been used in the reweighting.

Indices of Output of Various Industries

With the exception of metal production, the indices of output have been compiled from standard series. These include trade and excise data and contemporary estimates. Any particular series is subject to considerable uncertainty (the original sources should be consulted for details). Index values for 1770 and 1815 are presented in Table 2. The sources of the various series are presented in Table 3.

Clothing and metals are new. The clothing series is an index of textile production retained domestically. Each textile series has been reduced by Deane and Cole's estimate of the share of exports and combined on the basis of their 1840 weights modified to exclude exports.[11] The metal production series requires more discussion. It is based on the data for

[10] Charles Hyde, *Technological Change and the British Iron Industry 1700–1870* (Princeton, 1977), pp. 204–06 (hereafter cited as *British Iron*).

[11] Deane and Cole, *British Growth*, pp. 185, 187, 195–96, 212.

TABLE 3
SOURCES OF INDUSTRIAL OUTPUT SERIES

Series	*Construction of Series*	*Source*
Cotton	5-year centered average of retained cotton imports	Brian Mitchell, *British Historical Statistics*, pp. 177–79.
Wool	Sum of estimated domestic clip and imports	Mitchell, *British Historical Statistics*, pp. 190–92.
Linen	Deane and Cole's estimate	Deane and Cole, *British Growth*, pp. 202–205.
Silk	Deane and Cole's estimate	Deane and Cole, *British Growth*, pp. 207–10.
Clothing	Terminally weighted aggregate of textile output adjusted for exports of cotton and wool	
Leather	5-year centered average of excise data extended to 1814 by Hoffmann data	Mitchell, *British Historical Statistics*, p. 266. Hoffmann, *British Industry 1770–1950*, Table 54, series 50.
Metal	See text	
Food and Drink	Average with equal 1841 weights of population growth as an index of milling and baking and a 5-year average of the beer excise 1770–1815 and the average of the excise series for hops and malt thereafter	Lee and Schofield, "Population," in Floud and McCloskey, eds., *Economic History of Britain*.
Paper and Printing	5-year average of excise data	Mitchell, *British Historical Statistics*, p. 263.
Mining	Estimates of coal production	Sidney Pollard, "A New Estimate of British Coal Production 1750–1850," *Economic History Review*, 33 (May 1980), p. 220.
Building	Sum of Feinstein's estimates of "dwellings," "public buildings and works," " industrial and commercial buildings," "railways," "roads and bridges," "canals and waterways," "docks and harbours" and half of "agricultural investments"	Feinstein, "Capital Formation in Great Britain," in *Cambridge Economic History of Britain*, vol. 7, pt. 1, p. 40.
Other Unenumerated Industries	A range has been allowed that spans the range for the other industries except cotton and metal.	

the iron industry and attempts to estimate final output. Pig or bar iron production cannot be used without modification because these are intermediate products that were mostly imported in 1770 but domestically produced by 1815. Pig iron production and bar iron imports have been adjusted to final value from the American Census of 1840.[12]

[12] The ratio of the value of final output to raw material costs has been taken as two. The ratios in American iron-working industries were: nails, 1.7; stoves, 2.1; hardware and miscellaneous iron manufactures, 2.3; cutlery, 2.6; clocks, 2.8; blacksmiths, 3.2; guns, 4.3. *U. S. Census, 1840*, pp. 137–42.

The relative prices of pig and bar iron (combined at the conventional rates of 30 hundredweights of pig iron to produce a ton of bar iron) indicate that a ton of pig iron could be converted into two thirds of a ton of bar iron worth in money the same as 1.6 tons of pig iron. The United States Census data for the ratio of final value to raw material costs for several iron-using industries suggest that the final stages of manufacturing would double the value of the bar iron. That is to say, each ton of pig iron became worth the equivalent of 3.2 tons of pig iron after it had been transformed into manufactured iron products. Similarly, a ton of imported bar iron had a value equal to 2.4 tons of pig and the domestic manufacture of that iron added an equal value. The assumption that final output was worth twice the value of the bar iron has at least the dubious virtue of simplicity. If anything it is probably a low conversion factor. The result of a low factor on the series is to lower the estimate of output in 1770, when imports of bar iron were substantial relative to that of later years, increasing the growth rate of the series.

A substantial proportion of domestic pig iron was cast into final products, estimated at a quarter of domestic pig iron production in 1775, 40 percent in 1815, and a quarter in 1841.[13] The output is valued at 1.25 times the value of pig iron. Calculations of output for 1775, 1815, and 1841 are presented in Table 4.

Indices of Industrial Production

There is no uniquely correct method of constructing a quantity index when relative prices are changing. It seems most appropriate therefore to calculate and present a series of indices using various weights. The index numbers are presented in Table 5. The first index is based on the 1841 industrial weights extended back to 1770. Indices have been constructed for the subperiods 1815 to 1841 and 1770 to 1815 using various weights. The Laspeyres indices, using initial weights, will normally overstate growth. Conversely, the Paasche index, using terminal weights, will understate growth. Fisher's "Ideal" index number is the geometric mean of the Paasche and the Laspeyres indices. A discrete approximation of a Divisia index is also calculated, in which the growth rate of the index is the weighted sum of the growth rate of the

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An alternative aggregation procedure is possible following Deane and Cole (*British Growth*, p. 222) based on Irving's real values for exports ("Official and Real or Current Values for Imports and Exports of Great Britain to and from Ireland," *Parliamentary Papers*, 1803/4, VIII, p. 4). Irving's data for iron exports show the following values: iron bars, 20/ per hundredweight; iron nails, 35/6 per hundredweight; pig iron, £8 per ton; wrought iron, £7.19 per hundredweight; wire, £3 per hundredweight. The implied value added in converting a ton of pig iron to wrought iron—presumably various final products—is equivalent to just over 12 tons of pig iron. This seems high. An output aggregate valuing cast iron at pig iron prices and finished iron at the average of the nail and wrought iron price grows from 5.7 in 1775 to 16.8 in 1815 and 55.5 in 1841, somewhat slower growth from 1770 to 1815 than calculated in the text.

[13] Hyde, *British Iron*, pp. 127–29, 141.

TABLE 4
IRON OUTPUT IN PIG IRON EQUIVALENT UNITS: 1775, 1815, 1841

	1775		*1815*		*1841*	
Production of	*Thousands of Tons*	*Pig Iron Units*	*Thousands of Tons*	*Pig Iron Units*	*Thousands of Tons*	*Pig Iron Units*
Pig Iron	44		395		1,396	
Cast Iron	11	14	158	198	349	436
Exports as Pig, Manufactured Bar, and Iron (each expressed in pig iron units)	—	—		30		540
Manufactured Iron from Domestic Pig (Pig minus Cast minus Exports)	33 (of Pig)	105	210 (of Pig)	672	677	2,166
Manufactured Iron from Imported Bar	47	113		—		—
Total		232		900		3,142

Source: See text.

TABLE 5
VARIOUS INDICES OF INDUSTRIAL PRODUCTION

Index with 1841 Weights	*Index*	*Annual Growth Rate*
1841	100	2.9–3.0
1815	45–47	1.4–1.6
1770	22–25	
	Index	
Indices for 1815–1841	*(1815 = 100)*	*Annual Growth Rate*
Laspeyres (1951 base)	229–237	3.2–3.3
Paasche (1841 base)	212–221	2.9–3.0
Fisher's Ideal	220–229	3.0–3.2
Divisia	219–228	3.0–3.2
	Index	
Indices for 1770–1815	*(1770 = 100)*	*Annual Growth Rate*
Laspeyres (1770 base)	208–220	1.6–1.7
Paasche (1815 base)	197–206	1.5–1.6
Fisher's Ideal	202–213	1.5–1.7
Divisia	198–209	1.5–1.6
Hoffmann's Index	*Index*	*Annual Growth Rate*
1841	100	3.2
1815	43	2.6
1770	14	

Note: The range of values in the indices reflects the range of growth rates allowed for "other industries" in Table 2.
Source: See text.

components, with the weights being the geometric mean of initial and terminal weights.[14] All four indices fall within the same narrow range of values. The result appears as the Production Index in Figure 1, with other indices for comparison.

COMPARISON WITH OTHER ESTIMATES OF INDUSTRIAL GROWTH

Hoffmann's Index

Walther Hoffmann's index has since its construction in the late 1930s been the most used index of British industrial production. The index is included in Table 5 for comparison with the present indices, and in Figure 1. The indices constructed here and Hoffmann's index are in substantial agreement for the period from 1815 to 1841, but there is very substantial disagreement for the period 1770 to 1815, the period of the classical industrial revolution. The new indices estimate that the annual growth rate of industrial output was a full percentage point lower than Hoffmann calculated. Consequently, industrial output was more than 50

[14] Both the Fisher and the Divisia indices have the property of being first-order approximations of the welfare gain for a single consumer. See W. E. Diewert, "Harberger's Welfare Indicator and Revealed Preference Theory," *American Economic Review*, 66 (March 1976), 143–52.

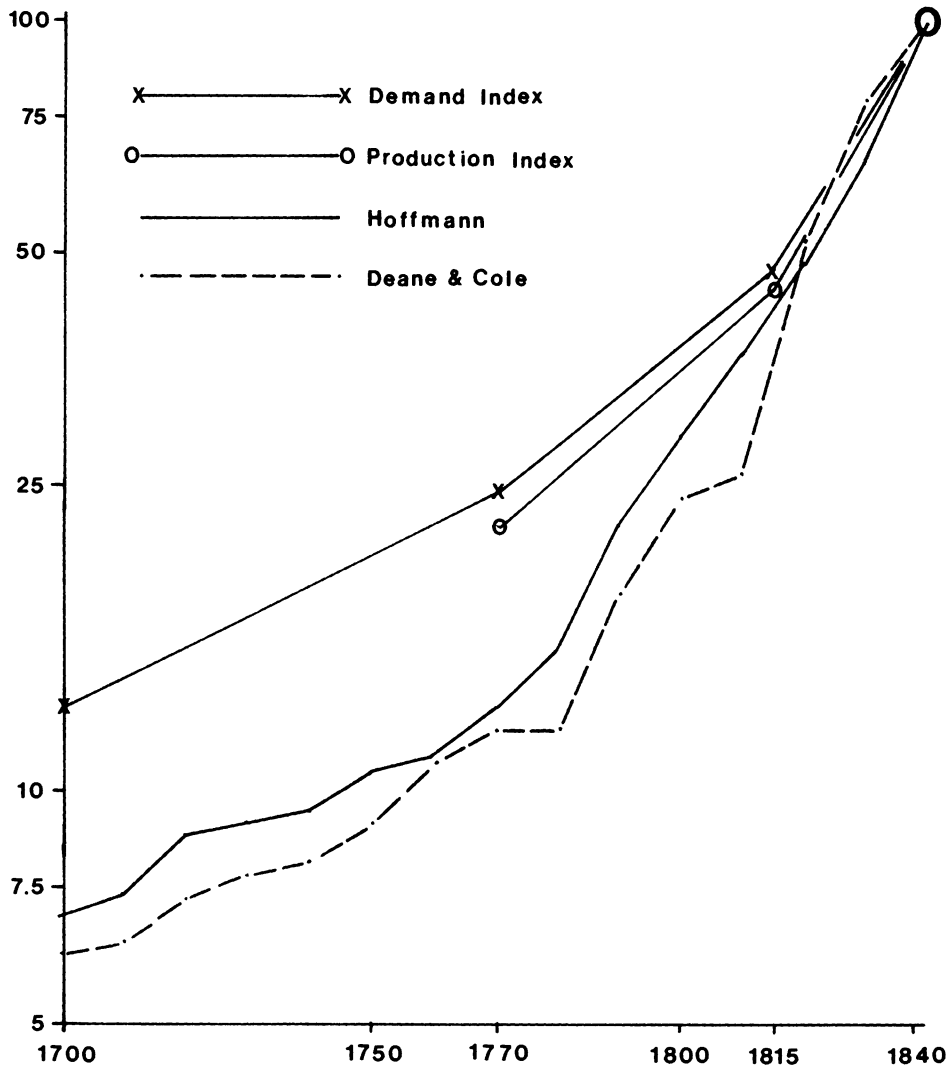

FIGURE 1
NEW AND OLD INDICES OF INDUSTRIAL GROWTH

percent greater in 1770 than Hoffmann's index indicates. A disparity of this magnitude requires exploration.

The divergence between the new industrial production indices and Hoffmann's index arises almost entirely from the excessive weight that Hoffmann assigned to cotton and iron in the base (1783) that he used for his index between 1761 and 1800. Hoffmann's data and various weighting schemes are presented in Table 6. The growth rates of the components of Hoffmann's index are not significantly different from those presented above. If the components are aggregated using the new 1815 and 1770 weightings presented in Table 1, the index would take on

TABLE 6
EXPLORATION OF HOFFMANN'S INDEX 1770–1815

Hoffmann's Output Indices (1770 = 100)					
	Cotton		*Iron*		*Other*
1783	283		196		101
1812	2,433		586		155
1815	2,600		618		172
Aggregation with Weights from Table 1					
	Weights			*Index*	*Rate of*
	Cotton	*Iron*	*Others*	*1770 = 100*	*Growth*
1770 weights	.01	.05	.94	219	1.7
1815 weights	.08	.08	.84	198	1.5
(Implied 1770 weights	.007	.03	.96)		
Hoffmann's Weights (weights inflated for missing series)					
1783 weights	.12	.12	.76	326	2.6
(Implied 1770 weights	.05	.07	.88)		
1812 weights	.16	.12	.72	223	1.8
(Implied 1770 weights	.01	.04	.95)		
Modified Hoffmann Weights (weight of missing series asigned to "other")					
1783 weights	.07	.07	.86	257	2.1
(Implied 1770 weights	.03	.04	.93)		
1812 weights	.12	.09	.79	207	1.6
(Implied 1770 weights	.01	.03	.96)		

Source: See text.

values of 198 and 219 (1770 = 100), implying annual growth rates of 1.5 and 1.7 percent, quite similar to the new indices in Table 6.

Hoffmann supposed that cotton textiles contributed 6.7 percent of industrial output and iron 6.5 percent. The cotton figure is two to three times the weight implied by the backward extrapolation of the 1841 employment data and my reading of the relative price evidence, but this is only part of the problem. A much greater weight was inadvertently assigned to cotton by Hoffmann's procedure of assuming that industries for which he had no data grew, on an average, at the weighted average of those for which he had data. This had the effect of increasing the weights of each of the included industries by the reciprocal of the sum of their weights. In the 1783 base calculation, Hoffmann estimated that the industries for which he had direct data constituted 56.4 percent of industrial value added. His treatment of excluded industries raised the weight of each included industry by a factor of 1.79 (= 1/.564). This raised the weights of cotton and iron to 12 percent of the index each.[15] Cotton and iron thus stand in Hoffmann's index for more than themselves. But they were uniquely rapid in their growth. It certainly seems unlikely that 12 percent of the uncounted industries had a growth as

[15] Hoffmann was aware of the importance of the choice of weights (*British Industry*, pp. 17–23, 34–5) but surprisingly made no investigation into the implications of his choice.

rapid as cotton and another 12 percent had growth comparable to iron. The distortion extends to the index after 1800, in which an 1812 base is used to weight the index. Here the effect is to increase the weights for cotton and iron from 12.2 percent and 9.2 percent to 15.9 percent and 12.0 percent.

An alternative to Hoffmann's procedure of increasing the weights proportionately would be to assume that excluded industries grew at the rate of the enumerated industries other than cotton and iron. Such calculations are presented in the last panel of Table 6. Hoffmann's 1783 weights still produce a considerably more rapid growth (look at the last column) than presented in Table 5, and may reasonably be regarded as upper bounds on the true industrial growth. Hoffmann's 1812 weights, it should be noted, yield results equivalent to those in Table 5.

In order to compare the various weighting schemes it is necessary to examine the weights implied for a common year. Implied weights in 1770 seem an appropriate basis for comparison and they also are presented in Table 6. Recall that the 1770 weights from Table 1 were explicitly calculated from the 1841 census employment shares, the estimates of the volume of output, and the assumptions that the price of cotton was 3.0 times as high in 1770 as in 1841 relative to other industrial prices and that iron prices were 1.8 times as high. If the 1841 shares and the volume estimates are accepted—and here Hoffmann's data are not greatly different from my own—then the weight of 5 percent that Hoffmann's index, with its 1783 base, assigns to cotton in 1770 implies that 1783 cotton prices relative to other industrial goods prices were some 16 times as high as they were in 1841. Merely comparing Hoffmann's 1812 and 1783 bases implies a relative price of cotton five times as high in 1783 as 1812. Such price movements seem at variance with the evidence (see again the appendix). It seems fair to conclude that the rapid growth that Hoffmann's industrial production index shows for the late-eighteenth century is a distortion created by the weighting procedure he employed between 1761 and 1800.[16]

Deane and Cole

Deane and Cole offer two quantitative assessments of industrial growth over the period covered by the new indices of industrial output. Surprisingly the two assessments do not seem to be consistent with one another. The basic eighteenth-century estimate in Chapter 2 of *British Economic Growth* shows much more rapid growth than those in Table 5. Their index of industrial output for the eighteenth century combines

[16] The weighting, particularly of cotton, is crucial to this issue. It is perhaps worth noting David MacPherson's estimate of industrial output for 1783 (*Annals of Congress*, vol. 4 [New York, Johnston Reprint, 1972; originally published 1805], p. 1546). His enumeration, which excludes building and food and drink (20 to 25 percent of the total) weighs cotton at just under 2 percent and iron at 23 percent of the total.

various series of goods produced exclusively for domestic consumption with a combined weight of 40 percent in 1700 and foreign trade as a proxy for "Export Industries" with a weight of the remaining 60 percent. Between 1770 and 1800 the index increased 188 points, of which 160 arise from the growth of trade.[17]

Presumably Deane and Cole used trade figures as their proxy for the output of the industries producing traded goods on the assumption that the growth of exports was a reflection of industrial development in Britain, presumably through the effect of falling prices in Britain and the availability of new goods there. The view is doubtful. The growth of British exports can be almost entirely explained by population growth in North America and naval successes that opened markets in the Spanish and Portuguese colonies to British trade. From 1730 to the end of the century three quarters of the increase in exports went to North America and the West Indies, and more than four fifths of the spectacular export growth from 1770 to the end of the century went to those markets. The growth of exports to North America was almost entirely a reflection of population growth there. Between 1710 and 1770 British exports to North America increased to 8.6 times their initial level as American population increased to seven times its initial level. From 1770 to the turn of the century exports to North America kept pace with population growth, each reaching 2.2 times its 1770 level. From 1800 to 1815 population grew more rapidly than exports.[18]

The other source of export expansion was the spurt of sales to the West Indies in the last years of the century, undoubtedly the effect of British success in selling to the Spanish colonies. The most spectacular increase—exports nearly doubled in 1798 and remained high thereafter—was the result of wartime success. The British naval victory at the Battle of Cape St. Vincent in February 1798 led to a blockade of Cadiz. The Spanish colonies in the New World were cut off from their normal sources of supply and forced to import from Britain through the British West Indies.[19]

Deane and Cole's other discussion of late-eighteenth century industrial growth occurs in their Chapter 6, "The Nineteenth-Century Staples." Here there is no attempt to combine the various industrial series into an aggregate index, but the evidence collected provides more support to the view of industrial growth presented here than to their view.[20] Their

[17] Deane and Cole, *British Growth*, pp. 75–80.

[18] Population estimates are from U.S. Bureau of Census, *Historical Statistics of the United States: Colonial Times to 1957* (Washington, D.C., 1960), pp. 757–58. The 1797/98 data include half a million for the area to become the Dominion of Canada (see Colin McEvedy and Richard Jones, *Atlas of World Population History* [London, 1978], p. 285). Exports are from Jacob M. Price, "Net Trade Series for Scotland's and Britain's Trade with the Thirteen Colonies and the States, 1740–1791," *William and Mary Quarterly*, 3 (1975), 324–25; Deane and Cole, *British Growth*, p. 87.

[19] See Frances Armytage, *The Free Port System in the British West Indies* (London, 1953), chs. 1, 6. Also see D. C. M. Platt, *Latin America and British Trade, 1806–1914* (London, 1972), ch. 1.

[20] N. F. R. Crafts of University College, Oxford has shown me an aggregate series for industrial

aggregation of the textile industries is particularly useful since it provides an aggregation of cotton with the older textiles. The series grows from 76 in 1770 to 127 in 1815 (on an 1800 base of 100) for a rate of growth of 1.1 percent per year.[21] This is considerably lower even than the rate for the textile industries in my new index (with or without clothing), which is about 1.8 percent per year with 1770 weights and 1.6 percent per year with 1815 weights. Since the cotton industry's growth is the principal source of rapid growth in any index of industrial production over the period, Deane and Cole's careful consideration of textiles supports the view that industrial growth was slow.

THE DEMAND FOR INDUSTRIAL PRODUCTS, 1700–1841

Since profitable production requires purchases for the goods produced, estimation of the growth of demand provides an independent check on an index of industrial output. The data that are used to produce the estimate are at least as imperfect as other aggregate data prior to the systematic censuses of the mid-nineteenth century. Somewhat paradoxically, the very imperfection of the data provides a rationale for the construction of a demand index. The "statistical sense" invites independent estimation of alternative measures whenever possible. The confidence that can be placed on estimates of the structure and growth of industrial production is greatly strengthened if independent estimates produce similar and mutually consistent pictures of the economy. An estimate of demand for industrial output can be projected from 1841 into the eighteenth century on the basis of estimates of investment, official data on trade and military expenditure, and inferences about consumption drawn from studies of real wages. As we shall see, an estimate so constructed shows a striking conformity with the index of industrial production presented above. In addition, between 1770 and 1815 the demand index agrees with the new indices in Table 6 by being strikingly at odds with the estimates of very rapid industrial growth produced by Hoffmann and Chapter 2 of Deane and Cole.

The Structure of Industrial Demand

The demand for industrial products arose from the final demand of consumers, demand for investment, demand for exports, and from

output constructed primarily from this data in Deane and Cole. The result, despite the choice of somewhat different time periods, is very like that in Table 5.

[21] Deane and Cole, *British Growth*, pp. 212–13. The index appears to have been constructed by aggregating the various component series on the basis of 1801 value added weights. The weights become somewhat inappropriate by the second quarter of the nineteenth century since they fail to account for the relative decline in cotton prices. Thus in 1841 cotton seems to make up three quarters of the index when its share of value added in was only about 40 percent. The growth of the textile index is thus exaggerated in the post-Napoleonic War period.

TABLE 7
STRUCTURE OF INDUSTRIAL DEMAND, 1841 AND 1770, PERCENTAGE DISTRIBUTION

	1841	*1770*
Consumption	68	77
Exports	16	13
Investment	14	7
Military	2	3

Source: See text.

military expenditure. Estimates of the relative importance of these components for 1841 and 1770 are presented in Table 7. As in construction of the industrial production index above, the benchmark based on the 1841 Census is regarded as the earliest reliable estimate of the industrial sector. Deane and Cole estimate the income originating in industry in 1841 at £155 million.[22] Since there are data on the value of exports (£50 million) and careful estimates of investment (£45 million), the share of these components can be relatively easily estimated.[23] There are, nonetheless, pitfalls. Deane and Cole's estimate is of income originating in industry while the exports and investment data are values of final product. Data from American censuses indicate value of final sales was about twice the income originating in the sector.[24] Thus exports represent 16 percent of demand, and investment 14 percent.

Military expenditures generally were quite small and could probably have been ignored had they not become a very large proportion of national income in the late years of the Napoleonic Wars. Between 1812 and 1815 military expenditures were over £55 million annually or about 18 percent of Deane and Cole's national income estimate. It is difficult without a full study of military expenditure during the war to allocate the sum to its various components.[25] A very substantial proportion, in

[22] Deane and Cole, *British Growth*, p. 166.

[23] C. H. Feinstein, "Capital Formation in Great Britain," ch. 2 in Peter Mathias and M. M. Postan, eds., *The Cambridge Economic History of Europe*, vol. 7, *The Industrial Economies: Capital, Labour, and Enterprise* (Cambridge, 1978).

[24] Robert E. Gallman's work with the nineteenth-century United States Censuses, which contain data on sales and value added, indicate value added as about 70 percent of sales. "Commodity Output, 1839–1899," in National Bureau of Economic Research, *Trends in the American Economy in the Nineteenth Century*, Studies in Income and Wealth, vol. 24 (New York, 1960), pp. 59–60; and "Gross National Product in the United States, 1834–1909," in N.B.E.R., *Output, Employment and Productivity in the United States after 1800*, Studies in Income and Wealth, No. 30 (New York, 1966), pp. 46–7 indicate that in 1839 the value of final sales of manufactured goods was $345 million and the value added in manufacturing was $250 million. Value added exceeds income originating in the sector. Twentieth-century data, *Historical Statistics of the United States*, p. 402 and Series P8 and F26, indicate between 70 and 75 of value added is income originating.

[25] This would be a major undertaking. It would start with the summary of the various parliamentary investigations in "Public Income and Expenditures from 1688," Appendix 13 to Part III: "Explanation and Historical Notices of the Several Heads of Public Income and Expenditure," pp. 669–700. *Parliamentary Papers*, 1868/9 XXXV; and also Richard Glover, *Peninsular Preparation: Reform of the British Army, 1795–1809* (Cambridge, 1963).

any event, went to the provisioning of armies overseas. In 1810 the commissary for Wellington's 35,000 troops in the Peninsula appears to have cost close to £400,000 per month.[26] These troops were about one-third of the active forces and their provisions appear to have cost about one-quarter of the army's total expenditure. It seems likely that basing calculations on an assumption that half the military expenditures were for British produced manufactured goods will if anything exaggerate the role of the military. The indices are constructed on this assumption. Fortunately, estimation of the growth of demand for industrial products over most periods is not very sensitive to modest changes in the weighting of the components. Unfortunately, the single exception to this statement occurs at the end of the Napoleonic Wars when the level of the index is quite sensitive to the weighting of the military budget.

Relative price changes will, of course, alter relative weights here as they did in the industrial production index. The important price change occurred in exports relative to other uses of manufactured goods. In 1841 cotton textiles, the good whose price had fallen most dramatically, made up 45 percent of domestic exports but only 10 percent of industrial output. The 1770 weights have been calculated using the quantity indices discussed below and the assumption that relative export prices were two thirds above their 1841 level.

Consumption was by far the largest component of demand and unfortunately the component about which we know least. An index of consumption expenditure has been constructed from plausible estimates of real wage levels and labor force size and a plausible income elasticity of demand. Real wage estimates are, of course, notoriously unreliable and controversial prior to the mid-nineteenth century. Furthermore, conversion of data on wage rates to indices of average income must assume that the earnings of nonwage earners such as independent craftsmen and agrarian smallholders moved in parallel with wages. In addition structural change in the economy involved shifts of workers among industries, presumably in many cases to higher paid occupations. Thus incomes may have grown more rapidly than wages. Certainly the shortcomings of the consumption estimate preclude drawing any strong conclusions. From 1815 to 1841 the data surveyed by M. W. Flinn and G. N. von Tunzelmann suggest an increase in average real wages of about one third.[27] The consensus seems to be that real wages were stagnant from 1770 to 1815. From 1700 to 1770, E. W. Gilboy

[26] Michael Glover, *Wellington's Army in the Peninsula, 1808–1814* (Newton Abbott, 1977), ch. 8, cf. p. 107.

[27] M. W. Flinn, "Trends in Real Wages, 1750–1850," *The Economic History Review*, 27 (Aug. 1974), 395–413. These data have recently been reanalyzed by sophisticated techniques in G. N. von Tunzelmann, "Trends in Real Wages, 1750–1850, Revisited," *The Economic History Review*, 2nd ser. 32 (1979). Von Tunzelmann's analysis reemphasizes the fragility of these data but does not contradict the assumption here.

TABLE 8
INDICES OF DEMAND FOR INDUSTRIAL GOODS, 1700–1815
(1841 = 100)

Consumption

	Real Wage	*Demand per Worker*	*Labor Force*	*Consumption*
1700	60	50	37	18
1770	75	67	45	30
1815	75	67	65	44

Other Components of Demand

	Investment	*Exports*	*Military*
1700	8	5	12
1770	13	13	39
1815	43	43	300

Indices of Industrial Demand

	1841 Base		*1770 Base*	
	Index	*Rate of Growth*	*Index*	*Rate of Growth*
1700	14	0.8	13	0.8
1770	25	1.4	24	1.6
1815	48	2.8	48	2.8

Source: For "Other Components of Demand": Investment, 1770–1841: Feinstein, "Capital Formation in Great Britain," p. 42. Year 1700 estimated as some 10 percent lower relative to income than Feinstein's 1770 estimate. For Exports, 1700–1795: Official values, Mitchell, *British Historical Statistics*, pp. 279–81; 1795–1841: Tentative volume estimate, Mitchell, *British Historical Statistics*, p. 328. For Military, Military budget, Mitchell, *British Historical Statistics*, pp. 209–91, 396–97.

suggests an average increase of one quarter.[28] Labor force growth has been assumed to follow population growth, except in 1815 when labor force is reduced by 7 percent to allow for the nearly 500,000 men serving in the military during the last years of the Napoleonic Wars.[29] The income estimates are converted to demand for industrial commodities on the assumption of an income elasticity of demand of 1.4.[30] The results are presented in the top panel of Table 8, with the other components.

[28] E. W. Gilboy, *Wages in the Eighteenth Century* (Cambridge, Massachusetts, 1934); Deane and Cole, *British Growth*, p. 19. I have used Deane and Cole's "general average."

[29] There are recent estimates presented by Ronald Lee and Roger Schofield, "British Population in the Eighteenth Century," in Floud and McCloskey, *Economic History of Britain*.

[30] For evidence of demand elasticities see, for example, H. Houthakker, "An International Comparison of Household Expenditure Patterns Commemorating the Centenary of Engel's Law," *Econometrica*, 25 (Oct. 1957), 532–51. Cross-sectional investigations also show a relationship between the level of per capita income and the size of the manufacturing sector. See Hollis B. Chenery, "Patterns of Industrial Growth," *American Economic Review*, 50 (Sept. 1960), cf. p. 634; Simon Kuznets, *Economic Growth of Nations* (Cambridge, Massachusetts, 1971), chs. 3, 4, cf. p. 111. The choice of an income elasticity of 1.4 represents the choice at the high end of the range of reasonable values, causing a more rapid growth of estimated demand (that is, a more conventional result).

Comparison with Other Indices

The indices of demand provide a gratifying degree of support to the independently estimated indices of industrial production calculated above. The demand index for 1815 is somewhat high relative to the production index, while the values for 1770 fall within the range calculated from production data. The discrepancy in 1815 is not great considering the nature of the data: it could have arisen from an overweighting of military expenditure or from modest underestimation of wage trends.

The postwar growth also agrees with Hoffmann's index. The major disagreement again arises between the demand estimate and Hoffmann's and Deane and Cole's indices between 1770 and 1815. Hoffmann's index grows at a rate of 2.6 percent a year while the demand index (1770 base) grows at a rate of only 1.6 percent. A useful consistency check can be performed on Hoffmann's index. The growth of exports, investment, and military expenditure are relatively reliable. These estimates and the relative weights for 1770 can be combined, and the consumption growth implied by Hoffmann's index can be calculated as a residual. The calculation reveals that Hoffmann's index implies a near tripling (to 280) of consumption between 1770 and 1815. Such consumption growth would represent an approximate doubling of consumption of industrial goods per member of the civilian labor force. The figure is impossible.

CONCLUSION: A REVISED PICTURE OF BRITISH GROWTH AND INDUSTRIALIZATION

The principal conclusion that emerges is that the growth of industrial production was much slower between 1770 and 1815 than either most narrative accounts of the industrial revolution or the quantitative research of Walther Hoffmann and of Phyllis Deane and W. A. Cole have suggested. The conclusion seems fairly secure, resting as it does on both output data and reasonable conjectures about demand growth. The indices imply that the industrial sector in the eighteenth century was nearly twice as large as previous estimates indicated and that its subsequent transformation was less dramatic.

As a final exercise, it seems appropriate to bring the new estimates of industrial production together with other recent revisions of Deane and Cole's estimates, principally by N. F. R. Crafts, and to produce some new conjectural estimates of income growth.[31] This is done in Table 9.

[31] N. F. R. Crafts, "English Economic Growth in the Eighteenth Century: A Re-examination of Deane and Cole's Estimates," *Economic History Review*, 2nd ser. 29 (May 1976), 226–35, and idem, "National Income Estimates and the British Standard of Living Debate: A Reappraisal of 1801–1831," *Explorations in Economic History*, 17 (April 1980), 176–88.

TABLE 9
ESTIMATE OF NATIONAL INCOME AND ITS GROWTH, 1700–1841

	Output Indices					*Growth Rate of*		
	Industry	*Agriculture*	*Services*	*Total Income*	*Income per Capita*	*Income*	*Income per Capita*	*Total Productivity*
1700	13	34	21	21	57			
1770	22	48	30	31	69	0.56	0.27	0.00
1815	44	68	59	56	80	1.31	0.33	0.25
1841	100	100	100	100	100	2.23	0.86	0.71

Notes and Sources: Industrial production: Tables 5 and 8. Agriculture: 1700–1770 assumed growth of 0.5 percent per year after Crafts, "English Growth"; 1770–1841; Deane and Cole, *British Growth*, pp. 78–170. Services: 1700–1800 assumed growth of 0.25 percent per year in excess of population; 1800–1841, assumed growth of productivity of 0.5 percent per year and Deane and Cole, *British Growth*, p. 143 employment after Crafts, "National Income."

The picture that emerges is one of steady acceleration of per capita income and total productivity. This view of the beginnings of British growth seems more plausible than Deane and Cole's, which shows a late-eighteenth century acceleration and a subsequent slowdown. It also seems better supported by the available evidence and by tests of internal consistency.

APPENDIX

THE RELATIVE PRICE OF COTTON GOODS CIRCA 1770

Much of the argument presented in this article arises from the assertion that the cotton textile industry should have a very modest weight in 1770. That conclusion emerges from fairly robust data—derived from raw cotton imports—on the physical quantity of cotton output and on the probable relative price of cotton goods. The price evidence between 1770 and 1815 is not as substantial as might be desired and requires discussion in some detail.

There is only one price series that spans the entire period. Other fragmentary evidence is available. Fairly reliable price data can be obtained for 1815 but earlier evidence is scant and its comparability to later data is difficult to ascertain amidst the bewildering array of fabrics and nomenclature in the industry.[32] The problem is further complicated by a boom in fashion demand for the new muslins after their introduction in mid- and late 1780 that raised prices and weaving costs temporarily. Price comparisons

[32] The most important distinction to make is between muslins and calicos. The muslins took four times as long to weave as calicos and seem to have been priced in roughly the same proportion. Donald McCloskey's otherwise very useful article in *The Economic History of Britain* suffers from a failure to notice that distinction. His comparison (p. 110) of "[a] piece of cloth that sold in the 1780s for 70 or 80 shillings" with one "selling in the 1850s for around 5 shillings" seems to be comparing an unprinted velveret—a new fancy weave muslin—with ordinary grey cloth calico some 70 years later, with misleading consequences for his calculations of productivity growth in the industry before 1815. Much of the literature about the industrial revolution in cotton emphasizes the muslin branch, primarily because those were new products that captured the imagination of contemporaries. This emphasis is misleading, however, since coarser calicos made up most of the industry's output. As G. N. von Tunzelmann reports, the average count of yarn in 1788 was about a 27 (*Steam Power*, p. 182) and was probably still below 40 in the 1830s (p. 184).

can be supplemented by indirect estimates based on yarn and weaving costs, on which there is somewhat greater evidence. Secondary sources may be examined. Finally, of course, since relative prices are of interest, the probable course of other industrial prices should be examined.

The only series of cotton cloth prices to span the period from 1770 to 1815 comes from Beveridge's compilation and is that of fustian purchased by the Lord Chamberlain's Department to be "supplied to the watermen to line their breeches." Unfortunately fustian was a heavy mixed fabric of flax and cotton and fell from favor as the new cottons became available. In any event, the price of fustian rose from one shilling per ell in the 1760s and 1770s to one-and-a-quarter shillings for 1797 to 1828.[33]

Another less secure price comparison is possible. Fairly good estimates of the price of standard calico grey cloth for the years at the end of the Napoleonic Wars exist. Alderman Neild presented data showing the price of a 7/8-80 Reed Printers grey cloth to have been 28 shillings per 29 yard piece. James Grimshaw before the 1833 Select Committee on Manufactures, Commerce and Shipping, stated that a 2nd 74 sold in 1815 at an average price of 19 shillings 8¾ pence.[34] Earlier quotes are much harder to find but Samuel Oldknow's correspondence indicates that in 1786 the price of "fine white calicos," "9/8 Calicos for printing," and "fine and excellent 9/8 Calicos" was 20 to 21 pence per yard and "4/4 wide" at 12½ pence per yard.[35] These convert to between 48 shillings 4 pence and 50 shillings 5 pence for 29 yards of the 9/8's and 30 shillings 3 pence for the 4/4's. Now these may well be higher quality cloth than the 1815 cloth since they are described as white and fine rather than grey and second, and they are certainly wider (7/8, 4/4, 9/8 refer to width in yards of the cloth). If a proportional adjustment is made, the 1786 prices in terms of 7/8 cloth become 37 shillings 7 pence to 39 shillings 2 pence, and 26 shillings 6 pence.[36] Other scattered data for the late 1730s and early 1740s can be extracted from Wadsworth and Mann's work. They quote correspondence showing "grey tufts 24 yds. No. 3 at 23s" for 1739, which would be 27 shillings 9 pence for 29 yards.[37] While it is impossible to draw any very precise conclusion, the data seem to support a conclusion that prices, in nominal terms, did not alter much down to 1815.

The conclusion of relative stability of nominal prices can also be supported by cost data. Grimshaw's 1883 evidence gives the cost of grey cloth production in 1815 as follows:[38]

Warp	7/10½
Weft	6/3
Weaving	4/3
Others	1/9½
Selling Price	19/8¾

The count of yarn in these typical fabrics was probably in the upper twenties. Von Tunzelmann's data indicate that the price of 25 count warps fell in the late eighteenth century about 15 percent, and of 40 count by about a third. Weft prices, not unexpectedly, seem to have fallen less, with the 24's unchanged in price and the 40's

[33] William Beveridge, *Prices and Wages in England for the Twelfth to the Nineteenth Century: Vol. I. Price Tables: Mercantilism* (London, 1939), pp. 450, 458.

[34] Alderman Neild, "An Account of the Prices of Printing Cloth and Upland Cotton from 1812 to 1860," *Journal of the Statistical Society*, 24 (Dec. 1861), 491–97; Grimshaw, *Parliamentary Papers*, 1833 VI, p. 607.

[35] George Unwin, *Samuel Oldknow and the Arkwrights*, 2nd ed. (Manchester, 1968), pp. 60–64.

[36] Such an adjustment seems appropriate; see Neild, "An Account of the Prices," p. 491.

[37] Alfred P. Wadsworth and Julia de Lacy Mann, *The Cotton Trade and Industrial Lancashire* (Manchester, 1931), p. 266.

[38] *Parliamentary Papers*, 1833 VI, p. 607.

down by just over 10 percent.[39] Weaving costs are somewhat more difficult to pin down. Various estimates may be put together. These indicate the cost of weaving a piece of standard calico to have been somewhere in the neighborhood of 2 or 2½ shillings per piece in 1770.[40] In 1815 the weaving cost per piece appears to have been between 3 and 3½ shillings per piece.[41] The indicated cost of a piece of cloth, on the relatively generous assumptions that warp fell by 25 percent, weft by 5 percent, and weaving costs rose by 50 percent between 1770 and 1815, would show a decline in grey cloth prices of under 10 percent. Since finishing certainly did not share the technological advance of spinning it seems likely that the cost of finished cloth in fact rose.[42]

Finally, it seems appropriate to draw attention to the prices of finished cotton implied in Deane and Cole's study of the industry.[43] Their table, derived largely from various contemporary estimates, implies a value of cotton goods produced from a pound of raw cotton of £0.21 in 1772/74 when the value of raw cotton is included or £0.14 when the cost of the raw cotton is deducted. These values per pound of raw cotton consumed rise to £0.43 and £0.35 in 1811/13, and £0.30 and £0.22 in 1815/17. This in fact is a somewhat steeper rise than the evidence above suggests, but may be due in part to a reduction of the waste of cotton in manufacturing.

The evidence presented above seems to justify the statement in the text that the nominal price of cotton goods changed little between 1770 and 1815 and if anything was likely to have been slightly higher at the end than at the beginning of the period. To adjust the weights for the industrial production estimate, however, is only half the task, since the movement must be compared with that of other industrial goods. I have undertaken no extensive new research here. The available indices may provide a guide. The Schumpeter/Gilboy index excluding cereals is 50 or 60 percent higher in 1800/01 than in 1770. The Rousseaux index for animal products and for industrial products shows little change, possibly a slight decline, between 1800/01 and 1815. This would seem to indicate a general index increase of about 50 percent between 1770 and 1815. This value for the price movement of industrial goods other than cotton is not inconsistent with data from Beveridge's study of prices. The average movement of six series of woolen cloth is an increase of just about 30 percent; of two series of shoes, an

[39] Von Tunzelmann, *Steam Power*, p. 181. Thomas Ellison, *The Cotton Trade of Great Britain* (London, 1886), p. 55 shows a much sharper decline in the price of 40 yarn than does von Tunzelmann, 40 yarns falling from 16/0 in 1779 to 2/10 in 1812. But Ellison also quotes 20 to 24 count yarn in 1743 at 3/4 to 4/6 (p. 16), as do Wadsworth and Mann (*The Cotton Trade and Industrial Lancashire*, pp. 173, 177, 269, 436, 438).

[40] This estimate derives from earnings per week of 5 shillings 6 pence to 7 shillings a week reported by Arthur Young in his *Northern Tour* (1769) and 8 shillings to 10 shillings a week in 1770, reported by William Radcliff (both reported in G. H. Wood, *The History of Wages in the Cotton Trade during the Past Hundred Years* [London, 1910], p. 105); the observation that weekly earnings of the weavers employed by Samuel Oldknow were 12 shillings for calico weavers and 16 shillings for plain muslin weavers in 1787; and the statement that they had increased about 50 percent since 1784 (Unwin, *Samuel Oldknow*, pp. 113–14). These can be converted to rates per piece at the conventional ratio of full employment being equivalent to 4 pieces of calico per week.

[41] There are several sources here. The most accessible compilation is in Duncan Bythell, *The Handloom Weavers: A Study of the English Cotton Textile Industry during the Industrial Revolution* (Cambridge, 1969), p. 99. Also see the interesting table of earnings of weavers (after deducting estimated costs) in Manchester, reproduced in G. W. Daniels, "The Cotton Trade at the Close of the Napoleonic War," *Transactions of the Manchester Statistical Society* (1917–18), Appendix II.

[42] Nield, "An Account of the Prices," p. 492, indicated a printed cloth sold at 44 shillings 6 pence when grey cloth sold at 25 shillings in 1813, or 63 shillings and 49 shillings in 1814. There is some evidence of improvement in finishing, but few would argue it was comparable to the improvements in spinning.

[43] Deane and Cole, *British Growth*, p. 185.

increase of 40 percent; six series of candles, an increase of just over 45 percent; five series of bricks and tiles, the largest increase, of nearly 130 percent.

It seems safe therefore to assume a stable price for cotton manufactures and an increase of 50 percent in other industrial good prices between 1770 and 1815. The upshot is that the price of cotton manufactures was 50 percent higher relative to other industrial products in 1770 than it was in 1815. This, if anything, overstates the change. Any such overstatement is of course present in my 1770 base for industrial output and results in an overestimate of industrial growth.