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SURVEYS AND SPECULATIONS, XVIII

*British Economic Growth, 1700-1831: A Review of the Evidence**

By N. F. R. CRAFTS

All students of the British industrialization process owe an enormous debt to Deane and Cole.¹ Indeed, descriptive statistical accounts of the industrial revolution commonly rely on estimates of national income derived from Deane and Cole in order to calculate ratios of exports² or investment³ to national product, statistics which are important to an understanding of the mechanisms of economic growth.

In recent years, however, a substantial amount of work has been done to refine and extend Deane and Cole's data. As a result, Deane and Cole's work now appears to be out of date in several key respects. In particular, Feinstein has provided new estimates of capital formation,⁴ Lindert and Williamson have used new estimates of occupational data to revise the social tables of King and Massie,⁵ Harley has made a tentative revision of Hoffmann's industrial output index,⁶ and Wrigley and Schofield have produced new estimates of

* Earlier versions of this paper were presented to the New Economic History Workshop at Oxford University and the Social Science History Workshop at Stanford University, and I am grateful to the participants for their comments. I have also had the benefit of very helpful and detailed comments from W. A. Cole, Paul A. David, S. L. Engerman, C. H. Feinstein, C. K. Harley, P. H. Lindert and especially P. K. O'Brien. The editors have made several useful suggestions. All mistakes are mine alone.

¹ P. Deane and W. A. Cole, *British Economic Growth, 1688-1959* (Cambridge, 1962).

² F. Crouzet, 'Towards an Export Economy: British Exports during the Industrial Revolution', *Explorations in Economic History*, 17 (1980), pp. 48-93.

³ C. H. Feinstein, 'Capital Formation in Great Britain', in P. Mathias and M. M. Postan, eds. *Cambridge Economic History of Europe*, VII, pt. 1 (Cambridge, 1978), pp. 28-96.

⁴ *Ibid.*

⁵ P. H. Lindert and J. G. Williamson, 'Revising England's Social Tables, 1688-1867', (mimeo, University of Wisconsin, 1981).

⁶ C. K. Harley, 'British Industrialization before 1841: Evidence of Slower Growth during the Industrial Revolution', *Journal of Economic History*, XLII (1982), pp. 267-89.

eighteenth-century population.⁷ In addition, Crafts has argued that Deane and Cole made implausible assumptions in dealing with eighteenth-century agricultural growth⁸ and that they used misleading price indices in calculating early nineteenth-century industrial and services output.⁹

The piecemeal nature of this new research serves potentially to confuse the general reader. The aims of this paper are to present some further revisions in respect of industrial output growth from 1700 to 1831 and of agricultural output growth after 1760 and, perhaps more importantly, to integrate the revisions of various authors to reveal their implications for the description of macroeconomic growth during the classic industrialization phase.

The main results of the paper are as follows. In section I revised estimates of industrial output growth are presented which indicate that Deane and Cole's estimates are in need of revision and that particular care needs to be taken in examining the timing of the acceleration in industrial output growth during the period 1770-1831. In section II these industrial output growth estimates are used in conjunction with the reformulated social tables of Lindert and Williamson, the new population figures of Wrigley and Schofield, the work of Crafts on eighteenth-century agriculture, and new estimates of nineteenth century services to present revised estimates of overall economic growth. The resulting patterns diverge from those presented in Deane and Cole or even in Cole.¹⁰ In section III the new estimates are combined with Feinstein's work on capital formation to provide revised estimates of the sources of growth and the investment ratio. It is shown that the acceleration in growth resulting from increased total factor productivity occurs later and more slowly than argued by Feinstein,¹¹ whilst the qualitative account of gradual rises in the investment ratio proffered by Deane and Cole¹² seems preferable to the pattern of more rapid advance suggested by Feinstein. Rostow's take-off ideas¹³ are not supported. In section IV the implications of the new figures for export ratios and personal consumption are examined. It is argued that Crouzet¹⁴ substantially underestimated the share of incremental output going to exports in the eighteenth century, and that a more pessimistic view of personal consumption during the classic industrial revolution period seems to be indicated than is suggested by either Feinstein¹⁵ or Williams.¹⁶

I

Deane and Cole's measurement of industrial output growth for the period 1801-31 has already been challenged in an earlier paper on the grounds that

⁷ E. A. Wrigley and R. S. Schofield, *The Population History of England, 1541-1871* (1981).

⁸ 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. XXIX (1976), pp. 226-35.

⁹ N. F. R. Crafts, 'National Income Estimates and the British Standard of Living Debate: A Re-appraisal of 1801-1831', *Expl. Econ. Hist.*, 17 (1980), pp. 176-88.

¹⁰ Deane and Cole, *British Economic Growth*, pp. 78, 166; W. A. Cole, 'Factors in Demand, 1700-80', in R. C. Floud and D. N. McCloskey, eds. *The Economic History of Britain since 1700*, I (Cambridge, 1981), p. 64.

¹¹ Feinstein, 'Capital Formation', p. 86.

¹² Deane and Cole, *British Economic Growth*, pp. 263-4.

¹³ W. W. Rostow, *The Stages of Economic Growth*, (Cambridge, 1960), pp. 36-41.

¹⁴ Crouzet, 'Towards an Export Economy', pp. 79-82.

¹⁵ C. H. Feinstein, 'Capital Accumulation and the Industrial Revolution', in Floud and McCloskey, *Economic History of Britain*, I, p. 136.

¹⁶ J. E. Williams, 'The British Standard of Living, 1750-1850', *Econ. Hist. Rev.*, 2nd ser. XIX (1966), pp. 581-9.

figures for current income were incorrectly deflated.¹⁷ In this section their procedure for the eighteenth century is re-examined and new indices are constructed for 1700-1760 and for individual decades thereafter until 1831. This seems worth while in view of the considerable uncertainty in the literature that still surrounds the timing of changes in the rate of growth of industrial output.¹⁸ A major reason for this uncertainty lies, as Harley has shown,¹⁹ in the index number problems of weighting sectoral growth rates during the late eighteenth century—problems which are created by the rapidly changing share of cotton in industrial value-added.

Additional difficulties arise in Deane and Cole's approach to the measurement of the growth of industry and commerce in chapter 2 of *British Economic Growth*, which deals with the eighteenth century. They divided industry and commerce into "export industries", with a 60 per cent weight, whose growth was taken as equal to foreign trade growth, and "home industries" with a 40 per cent weight whose growth was based on a weighted average of excise data for beer, hides and skins, candles and soap.²⁰ Index numbers were presented for the end of each decade. "Commerce" was not presented as a separate sector.

There are several problems with this procedure. Trade growth during the eighteenth century was erratic, as Deane and Cole themselves stress,²¹ and exports and output often grew at different rates in the three key export trades, woollens, cotton, and iron.²² Thus trade growth is not necessarily always a good guide to output growth in "export industries"; in particular this is likely to be a problem in the 1770s and 1780s, when the American war has a large impact on trade.²³ The use of trade statistics is also an arbitrary solution to the index number problem of measuring industrial output growth. Implicitly the approach is to attach weights to the growth of various sectors, but the weights are neither explicit nor necessarily related to particular sectors' importance in manufacturing activity. Finally, the procedure is very indirect with regard to "commerce" or "trade and transport" as the sector is called with reference to the nineteenth century in chapter 5 of *British Economic Growth*. There is no particular reason to suppose that this sector's growth is adequately reflected by the rather selective "home industry" index or by trade statistics. Yet it is clearly a large item in national income; Lindert and Williamson's revised social tables indicate that "commerce" accounted for about one fifth of national income in 1688.²⁴

In the circumstances it is desirable to deal separately with industry and commerce. For commerce the revised social tables of Lindert and Williamson can be used. For industry it seems best to return to data on physical quantities of inputs and outputs and to confront the weighting problem squarely. In

¹⁷ Crafts, 'National Income Estimates', pp. 179-80.

¹⁸ See, for example, the recent textbook discussion in A. E. Musson, *The Growth of British Industry* (1978), p. 64.

¹⁹ Harley, 'British Industrialization', p. 17.

²⁰ Deane and Cole, *Brit. Econ. Growth*, pp. 76-9.

²¹ *Ibid.* pp. 48-9.

²² *Ibid.* pp. 185, 196, 225.

²³ Deane and Cole accept in the text that this is so (*ibid.* p. 95), but do not modify the presentation of their key Table 19 to allow for the distorting effects of the war.

²⁴ Lindert and Williamson, 'Social Tables', pp. 11-13.

doing so, reliance is placed largely on the standard data reported in Deane and Cole and in Mitchell and Deane.²⁵ However, subsequent research has provided some extra information, particularly from Hyde²⁶ and Riden²⁷ on iron output, Feinstein and Harley on building,²⁸ and Pollard on coal output.²⁹

Table I. *Value Added in Industry (£m current)*

	1770	1801	1831
Cotton	0.6	9.2	25.3
Wool	7.0	10.1	15.9
Linen	1.9	2.6	5.0
Silk	1.0	2.0	5.8
Building	2.4	9.3	26.5
Iron	1.5	4.0	7.6
Copper	0.2	0.9	0.8
Beer	1.3	2.5	5.2
Leather	5.1	8.4	9.8
Soap	0.3	0.8	1.2
Candles	0.5	1.0	1.2
Coal	0.9	2.7	7.9
Paper	0.1	0.6	0.8
	<hr/>	<hr/>	<hr/>
	22.9	54.1	113.0

Sources:

Cotton: Deane and Cole, *British Economic Growth*, pp. 185, 187, 212.

Wool: P. Deane, 'The Output of the British Woollen Industry', *Journal of Economic History*, 17 (1957), p. 220; Deane and Cole, *British Economic Growth*, pp. 195-6, 212.

Linen: Deane and Cole, *British Economic Growth*, pp. 203-4, 212.

Silk: Deane and Cole, *British Economic Growth*, pp. 210, 212.

Building: following Harley, 'British Industrialization', p. 11, building is taken as the sum of Feinstein's estimates for investment in dwellings, public building and works, industrial and commercial buildings, railways, roads and bridges, canals and waterways, docks and harbours plus half of agricultural investments, 'Capital Formation', p. 41.

Iron: Value added is computed using prices of pig iron from Hyde and outputs of pig and bar iron also from Hyde, *Technological Change*, pp. 66, 111, 113, 139-40 together with Harley's conversion factors for bar iron into pig iron equivalents, 'British Industrialization', p. 14. The figure is an overstatement as is Deane and Cole's since it really reflects gross output.

Copper: C. Lemon, 'The Statistics of the Copper Mines of Cornwall', *Journal of the Statistical Society*, 1 (1838), p. 70 and, for 1801, J. R. Harris, *The Copper King* (Liverpool, 1964), p. 115.

Beer: derived from P. Mathias, *The Brewing Industry in England, 1700-1830* (1959) p. xxiii and p. 546 and excise data in Mitchell and Deane, *Abstract*, pp. 251-2.

Leather: derived from the discussion in Deane and Cole, *British Economic Growth*, pp. 76-9 and the figures for beer in 1801, extrapolated backwards and forwards using the excise series for hides and skins in Mitchell and Deane, *Abstract*, p. 266 and price data from W. H. Beveridge, *Prices and Wages in England from the Twelfth to the Nineteenth Century*, I (1939), pp. 296-7, 457.

Soap: derived from the discussion in Deane and Cole, *British Economic Growth*, pp. 76-9 and the figures for beer in 1801, extrapolated backwards and forwards using the excise series for soap in Mitchell and Deane, *Abstract*, p. 265, and price data on candles from Beveridge, *Prices and Wages*, pp. 145-7, 313.

Candles: As for soap, but using the excise series for candles in Mitchell and Deane, *Abstract*, p. 262.

Coal: derived from Pollard, 'A New Estimate', pp. 216, 229 adjusted as suggested by Deane and Cole, *British Economic Growth*, p. 218 and using price data from Beveridge, *Prices and Wages*, pp. 577-8 for the 1770 figure.

Paper: derived from excise figures in Mitchell and Deane, *Abstract*, p. 263 together with data on prices and costs from D. C. Coleman, *The British Paper Industry, 1495-1860* (Oxford, 1958) pp. 140-1, 169 and 203-4.

²⁵ B. R. Mitchell and P. Deane, *Abstract of British Historical Statistics* (Cambridge, 1962).

²⁶ C. K. Hyde, *Technological Change and the British Iron Industry, 1700-1870* (Princeton, 1977).

²⁷ P. Riden, 'The Output of the British Iron Industry before 1870', *Econ. Hist. Rev.*, 2nd ser. xxx (1977), pp. 442-59.

²⁸ Feinstein, 'Capital Information', p. 41 and Harley, 'British Industrialization', p. 11.

²⁹ S. Pollard, 'A New Estimate of British Coal Production, 1750-1850', *Econ. Hist. Rev.*, 2nd ser. xxxiii (1980), p. 212-35.

The basic data on industrial output are given in Tables 1 and 2. Obviously not all sectors of industry are represented and in some cases there is also the difficulty in measuring value added as opposed to gross output, and value added may be slightly too high. Nevertheless the omitted sectors must be of only very minor importance; for example, the figure for value added in industry in 1801 given in Table 1 is £54.1 m as opposed to total income originating in manufacturing, mining, and building of £54.3 m.³⁰

A number of interesting points emerge from Tables 1 and 2. In Table 1, which is mainly a reconstruction of Deane and Cole's own work, it is important to note the high weight of wool, leather, and building in 1770, when together

Table 2. Sectoral Growth Rates of Real Output (% per annum)

	<i>Cotton</i>	<i>Wool</i>	<i>Linen</i>	<i>Silk</i>	<i>Building</i>	<i>Iron</i>	<i>Copper</i>
1700-60	1.37	0.97	1.25	0.67	0.74	0.60	2.62
1760-70	4.59	1.30	2.68	3.40	0.34	1.65	5.61
1770-80	6.20		3.42	-0.03	4.24	4.47	2.40
1780-90	12.76	0.54	-0.34	1.13	3.22	3.79	4.14
1790-1801	6.73		0.00	-0.67	2.01	6.48	-0.85
1801-11	4.49	1.64	1.07	1.65	2.05	7.45	-0.88
1811-21	5.59		3.40	6.04	3.61	-0.28	3.22
1821-31	6.82	2.03	3.03	6.08	3.14	6.47	3.43
	<i>Beer</i>	<i>Leather</i>	<i>Soap</i>	<i>Candles</i>	<i>Coal</i>	<i>Paper</i>	
1700-60	0.21	0.25	0.28	0.49	0.64	1.51	
1760-70	-0.10	-0.10	0.62	0.71	2.19	2.09	
1770-80	1.10	0.82	1.32	1.15	2.48	0.00	
1780-90	0.82	0.95	1.34	0.43	2.36	5.62	
1790-1801	1.54	0.63	2.19	2.19	3.21	1.02	
1801-11	0.79	2.13	2.63	1.34	2.53	3.34	
1811-21	-0.47	-0.94	2.42	1.80	2.76	1.73	
1821-31	0.66	1.15	2.41	2.27	3.68	2.21	

Sources:

Cotton: growth rate of retained cotton imports, Deane and Cole, *British Economic Growth*, p. 51 and Mitchell and Deane, *Abstract*, pp. 177-9.

Wool: derived from wool clip in Deane, 'British Woollen Industry', p. 220 and raw wool consumed in Deane and Cole, *British Economic Growth*, p. 196.

Linen: rate of growth of linen yarn imports to 1801 from Deane and Cole, *British Economic Growth*, p. 51 and then based on Deane and Cole's linen output index, *British Economic Growth*, p. 204.

Silk: rate of growth of raw silk imports in Mitchell and Deane, *Abstract*, pp. 206-7.

Building: derived following the method described in Table 1 but using Feinstein's Constant Price series, 'Capital Formation', p. 40 for 1760 onwards. For 1700-60 based on imports of timber, Deane and Cole, *British Economic Growth*, p. 51.

Iron: rate of growth of pig iron output derived from Riden, 'British Iron Industry', pp. 443, 448, 455.

Copper: derived from Lemon, 'Copper Mines', p. 70 for Cornwall adjusted for Anglesey output using Mitchell and Deane, *Abstract*, p. 151 and Harris, *Copper King*, p. 115. For 1700-60 growth is assumed to equal that of 1725-60.

Beer: growth rate of production of barrels of strong beer subject to excise duty; Mitchell and Deane, *Abstract*, pp. 251-2.

Leather: growth rate of excise figures for hides and skins, Mitchell and Deane, *Abstract*, p. 266. For 1700-60 growth is assumed equal to that of 1725-60.

Soap: growth rate of excise figures for soap, Mitchell and Deane, *Abstract*, p. 265. For 1700-60 the growth rate is assumed to equal that of 1720-60.

Candles: growth rate of excise figures for candles, Mitchell and Deane, *Abstract*, p. 262. For 1700-60 the growth rate is assumed to equal that of 1720-60.

Paper: growth rate of excise series for paper, Mitchell and Deane, *Abstract*, p. 263. For 1700-60 the growth rate is assumed equal to that of 1720-60.

³⁰ Deane and Cole, *British Economic Growth*, p. 166.

they represent 63 per cent of value added and can be thought of as traditional industries. Also notable is the dramatic change in the weight of cotton textiles which takes place between 1770 and 1801, with a rise from 2.6 to 17 per cent of value added in industry. Less spectacular, but nonetheless noteworthy, is that the combined share of leather and wool falls from 53 per cent of value added in industry in 1770 to 34 per cent in 1801.

From this data the late eighteenth century appears as an era of radical change in the structure of industrial output. The significance of changing shares in value-added between 1770 and 1801 becomes still more obvious in the context of Table 2 where the very exceptional growth of cotton textiles is evident.

Table 2 also shows why opinions have differed about the pace of industrial advance. Whilst the period at the end of the eighteenth century demonstrates structural change and a move to very rapid growth in cotton and to a lesser extent in iron, it is also true that there was industrial output growth in the earlier period and that the advance in the median sectoral growth rate is more muted. This statistic is 0.67 per cent per annum in 1700-60, varies between 1.32 and 1.65 per cent in the next four decades and then climbs steadily to a figure of 3.03 per cent in 1821-31.

Harley has shown that Hoffmann's index of industrial production for the period 1770-1815 is unreliable because Hoffmann inadvertently gave cotton a very high weight in the index. On the basis of weights derived from the distribution of occupations in 1841 coupled with adjustments to the weights of cotton and iron to allow for price changes, Harley has argued that both Deane and Cole and Hoffmann overestimated industrial output growth during 1770-1815. For the periods he chose with his weighting procedure, Harley found that the index numbers using base or terminal weights were fairly similar.³¹

It is generally agreed, however, that in the construction of industrial output indices the use of weights based on value-added is preferable to weights based on employment.³² Table 3 presents estimates of industrial growth based on the growth of sectors as reported in Table 2, adopting data very similar to that used by Harley, but using value added weights.

Table 3 indicates that there are quite serious index number problems involved in measuring industrial growth during the period 1780-1831. This is not surprising, given the large changes in relative prices which took place at this time. One approach is to calculate growth rates from quantity indices based on the data underlying Tables 1 and 2. It will be noted that this gives relatively similar results using initial and terminal weights in 1780-1801, but that the terminal weights show much lower growth in 1801-31. This is especially a result of falling cotton prices in this period but it is, of course, generally the case that terminal weights give lower growth as fast-growing sectors experience relative price falls. Where tastes remain unchanged, the Laspeyres measure can be expected to overestimate growth, possibly substantially; the Fisher Ideal measure is appropriate if utility functions are homothetic but otherwise has an unknown amount of bias; the Paasche measure can generally be expected to underestimate growth.

³¹ Harley, 'British Industrialization', pp. 276, 278, 280-1.

³² For example, Harley, 'British Industrialization', p. 270, and W. G. Hoffmann, *British Industry, 1700-1950* (Oxford, 1955), p. 16.

Table 3. *Industrial Output Growth* (% per annum)

	(1) Weighted Average Based on 1770	(2) Weighted Average Based on 1801	(3) Weighted Average Based on 1831	(4) Divisia
1700-60	0.71			
1760-70	1.23			
1770-80	1.79			
1780-90	1.60	3.68		2.40
1790-1801	1.38	2.49		1.83
1801-11		2.70	2.76	2.72
1811-21		2.42	2.89	2.63
1821-31		3.54	3.83	3.65
	(5) Laspeyres Quantity	(6) Paasche Quantity	(7) Fisher Ideal	(8) Divisia
1780-1801	2.34	2.14	2.24	2.11
1801-31	3.57	2.81	3.17	3.00

Source: derived from Tables 1 and 2. Columns (1) to (3) are weighted averages of sectoral growth rates using shares of value added as weights. As is clear from Table 1, these weights are different in 1770, 1801 and 1831. Under these circumstances an often used 'compromise' way of measuring growth rates is to take a geometric average of the weights at the beginning and end of a period and recompute the weighted average of sectoral growth rates with the new (average) weights. This approximation to a Divisia Index is reported in columns (4) and (8) using averages of 1770 and 1801 or 1801 and 1831 shares in value added as weights, as appropriate. Column (5) is based on the growth rate of a quantity index using initial year prices in each period as weights, and column (6) is based on the growth rate of quantity index using terminal year prices in each period as weights. Column (7) is a geometric average of Columns (5) and (6). For further discussion of the properties and pros and cons of various indices, see D. Usher, *The Measurement of Economic Growth* (Oxford, 1980) chs. 2 and 9.

Table 3 also shows that there is great sensitivity of the weighted average of growth rates of sectoral industrial output to the year from which value-added weights are chosen. In particular, this is an acute problem in the late eighteenth century, when cotton's share in value-added leaps up. Hoffmann was aware of this problem and attempted to cope with it by calculating an approximation to a Divisia index for 1760-1800 and, indeed, each of the periods he examined. Unfortunately, for the late eighteenth century Hoffmann failed to implement his procedure correctly.³³ The growth rates labelled Divisia in Table 3 can be thought of as "Revised Hoffmann", avoiding his inadvertent errors and using more up-to-date data. Columns (1) to (3) illustrate the potential seriousness of the index number problem confronting Hoffmann and others using the late eighteenth-century data. It should be noted that the Divisia index is a good measure where utility functions are homothetic but can be unreliable otherwise.

Whilst it is obviously important that weights reflect the importance of sectors, it must be emphasized that there is no "right" answer to the index number problems revealed by Table 3. It is important that the reader is aware of the difficulty and has a sense of the range of possible answers. For 1781-1801 the closeness of the Laspeyres and Paasche quantity indices narrows the

³³ The main problem arises with regard to Hoffmann's estimates for 1760-1800, which are based on 1783 weights. The use of 1783 weights is intended as an approximation to an average of initial and terminal weights and hence to a Divisia index. Hoffmann had data for only 56.4% of the shares in industrial output, however, of which cotton was 6.7%. Unfortunately Hoffmann took the 56.4% as representative of the whole of industry, thus in effect giving cotton a weight of $6.7/56.4 = 11.9\%$. Since the missing sectors obviously did not grow as fast as cotton, the result was an overall exaggeration.

range of possibilities, but for 1801-31 the range remains wide and it could be that the bias in the Laspeyres measure is large. Accordingly, this article will throughout use the Divisia and Fisher Ideal indices but it must be accepted that others may prefer different solutions to the problem.

As the discussion of Table 4 below indicates, the growth rates of Divisia and Fisher Ideal Indices of Table 3 produce results much closer to Harley than to earlier writers and largely support his claim that the growth of industry and commerce has been exaggerated. In particular, it is worth noting that Table 4 shows that Deane and Cole's figures for "Industry and Commerce" in 1780-1801 and for manufacturing in 1801-31 are well in excess of the Laspeyres measure of industrial output growth in Table 3, which is itself an overestimate.

"Trade and Transport" or "Commerce" is a problematical sector but it nonetheless appears possible to improve on Deane and Cole's work. For the eighteenth century it will be assumed that growth in this sector was at the same rate as national output as a whole. The chief support for this proposition comes from Lindert and Williamson's work on the social tables of King, Massie, and Colquhoun. They give estimates indicating that income originating in commerce was more or less a constant proportion of national income in each of the years covered, namely 20.1 per cent in 1688, 19.6 per cent in 1759 and 19.7 per cent in 1801/3.³⁴ Neither the price evidence from the late eighteenth century nor the experience of the United States during the industrialization phase suggests that changes in relative prices would vitiate the broad conclusion that trade and transport grew with national income in the eighteenth century.³⁵

For the early nineteenth century Deane and Cole provide estimates of income in current prices originating in trade and transport, but their method of converting this into real terms is clearly inadequate.³⁶ For transport it is possible to obtain some evidence on growth of output. From Hawke we learn that real output on the Leeds-Liverpool canal grew at 2.34 per cent per annum between 1801 and 1831,³⁷ and from excise statistics we find that stage carriage travel grew at 3.88 per cent per annum in the same period.³⁸ If we take these figures as representative of the different branches of transport, and weight them according to Baxter's figures for transport income in 1834,³⁹ this gives an estimate of the growth of transport output at 3.02 per cent per annum for 1801-31.

For trade it is assumed that output growth is best proxied by employment growth. Deane and Cole give figures for employment growth in trade and transport combined for 1801-31 and separately for 1841. On the assumption that labour productivity growth was as high in transport as it was in industry

³⁴ Lindert and Williamson, 'Social Tables', pp. 11-13, 18-20, 23-6.

³⁵ For the British price evidence see n. 66 below. On the United States, see R. E. Gallmann and T. J. Weiss, 'The Service Industries in the Nineteenth Century', in V. R. Fuchs, ed. *Production and Productivity in the Service Industries* (Columbia, 1969), p. 295.

³⁶ Crafts, 'National Income Estimates', pp. 181-2.

³⁷ Derived from G. R. Hawke, *Railways and Economic Growth in England and Wales, 1840-70* (1970), pp. 81-2.

³⁸ Derived from statistics for the growth in duty on stage coaches in *Parliamentary Papers* (1857) IV, App. 23.

³⁹ R. D. Baxter, 'Railway Extension and Its Results', *Journal of the Statistical Society*, 29 (1866), p. 562.

(presumably an over-estimate), employment in transport can be deduced and hence employment growth in trade can be inferred. The result would be growth of employment at 1.83 per cent per annum in trade, which will, of course, also tend to be an overestimate.⁴⁰

Table 4. *Comparisons of Estimates of Growth in Industry and Commerce*
(% per annum)

	(1) <i>Deane and Cole: Industry and Commerce</i>	(2) <i>Deane and Cole: Manufacturing</i>	(3) <i>Deane and Cole: Trade and Transport</i>	(4) <i>Crafts: Industry</i>	(5) <i>Crafts: Commerce</i>	(6) <i>Crafts: Industry & Commerce</i>
1700-60	0.98			0.71	0.69	0.70
1760-80	0.49			1.51	0.70	1.05
1780-1801	3.43			2.11	1.32	1.81
1801-31	3.97	4.44	3.02	3.00	2.13	2.71
	(7) <i>Hoffmann: Industry</i>	(8) <i>Harley: Industry</i>	(9) <i>Deane and Cole: Industry and Commerce</i>	(10) <i>Crafts: Industry</i>	(11) <i>Crafts: Industry and Commerce</i>	
1770-1815	2.59	1.5-1.7	2.92	2.15	1.85	

Sources: Column (1) from Deane and Cole, *British Economic Growth*, p. 78; columns (2) and (3) *ibid.* p. 166 using appropriate Rousseaux price indices; columns (4), (5) and (6) see text; column (7) derived from Hoffmann, 'British Industry', end tables; column (8) is Harley's Fisher Ideal estimate, 'British Industrialization', p. 278; column (9) derived from columns (2), (3) and (1); columns (10) and (11) derived from Table 3 and column (5).

Taking trade and transport together, growth for the sector is estimated at 2.13 per cent per annum for 1801-31.⁴¹ This is a tentative figure and may be slightly too high. On the other hand it seems unlikely that growth would be less than employment in the combined sector which was 1.97 per cent per annum over the period. The present estimate gives labour productivity growth for the whole sector at about one third the rate for industry, and output growth a little higher than that of national income. This seems plausible both in terms of a general picture of relatively rapid progress in transport in the early nineteenth century⁴² and the growth of trade and transport *pari passu* with national income in the eighteenth century.

Although it has not been possible to estimate the growth of trade and transport with great precision, two points should be noted. First, this sector has a weight of 16 per cent in national product in the period 1801-31 and therefore the possible small overestimate in its growth will not have any major effect on estimates of overall growth. Second, it does appear that Deane and Cole's procedure was seriously misleading in that they estimate growth for

⁴⁰ Deane and Cole, *British Economic Growth*, p. 143 give the employment figures. These figures give employment growth in manufacturing at 2.6% per annum; using Table 3 this gives an estimate of 0.4% for labour productivity growth with the Divisia index. Transport employment is then calculated by assuming that the labour force in that sector grew at 2.6% for 1801-41. The discussion in the text indicates that this may be too low; if this is the case, trade employment growth would be lower than the present estimate.

⁴¹ Baxter, 'Railway Extension', p. 562, estimates transport income in 1834 at £14.25 m, roughly a quarter of Deane and Cole's figure for income in transport and trade in 1831 (*British Economic Growth*, p. 166). Overall growth in trade and transport is estimated at $(3.02 \times 0.25) + (1.83 \times 0.75) = 2.13\%$.

⁴² P. S. Bagwell, *The Transport Revolution from 1770* (1974), chs. 2-3.

trade and transport at 3.02 per cent, a figure which implies that labour productivity growth was more than two and a half times as fast as in industry.⁴³

The preceding work is drawn together and compared with earlier estimates in Table 4.

The estimates in this paper, together with Harley's work, argue very strongly that previous writers have exaggerated the growth of industry and commerce. Hoffmann's estimates relate only to industry and are badly misleading for the late eighteenth century. Deane and Cole's deflation procedure appears to have led them seriously astray in the early nineteenth century. For the eighteenth century their reliance on the trade statistics seems to lead them to overestimate the growth of industry and commerce on average by about 0.3 per cent per annum. The Table also reflects the distortion to Deane and Cole's figures produced by the American War, with the result that their estimates tend to exaggerate the acceleration of growth in the last two decades of the eighteenth century.

Finally, the statistical results can now be related to the controversy over the timing of industrial advance. The new figures do not support the idea of a general spectacular acceleration in the growth of industrial output starting in the 1780s. At the same time there is a considerable variety of experience in the late eighteenth century, and there appears to be rapid structural change which *can* be seen as a discontinuity. Given the index number problems involved in looking at the late eighteenth century, however, those in search of an overall summary would be safest with the statement that industrial growth in the first quarter of the nineteenth century was more than four times as fast as a century earlier; for every major sector other than beer the growth rate was at least twice as high.

II

In this section a new picture of national output growth is developed based on the recent research listed in the introduction and the results of Section I. The patterns of growth obtained are considerably different from those suggested by Deane and Cole, as will be obvious from the results summarized in Table 5.

The derivation of the new estimates is described in detail below, but an immediate warning is required. The periodization of Table 5 is an outcome primarily of exigencies of the data and it should not be given any undue weight. The quality of the data for national income is not good enough to permit an accurate computation of growth rates over periods as short as a decade, and attempts to pinpoint turning points should *not* be made.

As is noted below, data on the growth of industrial output are too fragile to permit very certain comparison between sub-periods within the period 1700-1760. Accordingly, it is not possible to evaluate fully Deane and Cole's claim of a turning point in economic growth in 1740. It should be noted, however, that the revisions to agricultural growth noted below would make a 1740 turning point in overall per capita income growth seem very questionable.

It is important also to bear in mind the difference between Deane and Cole's work on the eighteenth and on the nineteenth centuries. For the eighteenth century they used proxy variables to estimate growth in real output. For the nineteenth century they compiled estimates of current incomes by sectors and

⁴³ This arises solely from Deane and Cole's deflation procedure. See Crafts, 'National Income Estimates', pp. 181-2.

then used price indices to deflate their figures into real income estimates. A revision of Deane and Cole's work involves an evaluation of the proxy variables for the eighteenth century and of the outcome of the deflation procedure for the nineteenth century. Thus the discussion of Table 5 is undertaken chronologically.

a) 1700-60

In their work on the eighteenth century Deane and Cole divided the economy into four major sectors. For three of these the new research requires changes, though "government and defence" remains unaltered. "Rent and services" was taken by Deane and Cole to grow at the rate of population growth,⁴⁴ and revision is needed in the light of Wrigley and Schofield's new estimates.⁴⁵ The assumption that rent and services move with population is, of course, questionable but no superior alternative has been suggested. Cole's figures in panel (iii) are adjusted for the new population figures.

For "industry and commerce" the evidence of Section I is preferred in the new estimates. It is, of course, possible to argue that some of the data used relates to 1720-60 and thus that the industrial output growth figures used in panel (a) are somewhat shaky. On the other hand, it is unlikely that this criticism would account for the difference from Deane and Cole's figures since they consider growth to have been faster from 1720-60 than from 1700-20.

Table 5. *Growth in Real National Output (% per annum)*

(a) Eighteenth Century	Agriculture	Industry	Commerce	Rent and Services	Government & Defence	National Output	National Output/Head	
<i>(i) New Estimates</i>								
1700-60	0.60	0.71	0.69	0.38	1.91	0.69	0.31	
1760-80	0.13	1.51	0.70	0.69	1.29	0.70	0.01	
1780-1801	0.75	2.11	1.32	0.97	2.11	1.32	0.35	
<i>(ii) Deane and Cole's Estimates</i>								
1700-60	0.24		0.98	0.21	1.91	0.66	0.45	
1760-80	0.47		0.49	0.68	1.29	0.65	-0.04	
1780-1800	0.65		3.43	0.98	2.11	2.06	1.08	
<i>(iii) Cole's Revision of Deane and Cole's Estimates</i>								
1700-60	0.64		0.98		0.93	0.84	0.46	
1760-80	0.44		0.43		0.96	0.60	-0.09	
1780-1800	0.71		3.24		1.56	1.98	1.00	
<i>(b) 1801-1831</i>								
	Agriculture	Industry	Trade and Transport	Housing	Domestic & Personal	Government Professional & Rest	National Output	National Output/Head
<i>(iv) New Estimates</i>								
	1.18	3.00	2.13	1.53	1.37	1.37	1.97	0.52
<i>(v) Deane and Cole's Estimates</i>								
	1.64	4.44	3.02	3.75	3.12	1.97	3.06	1.61

Sources: New Estimates, see text; Deane and Cole's Estimates derived from *British Economic Growth*, pp. 78 and 166; Cole's revision derived from 'Factors in Demand', p. 64.

⁴⁴ Deane and Cole, *British Economic Growth*, p. 77.

⁴⁵ Wrigley and Schofield, *Population History*, pp. 533-4.

Agricultural growth has to be inferred as there is no direct evidence. Crafts pointed out that Deane and Cole's assumption that during the eighteenth century agricultural consumption grew with population is implausible because incomes were growing, and only if price and income elasticities were zero could Deane and Cole's assumption hold good.⁴⁶ Cole accepted this criticism and adjusted Deane and Cole's figures, as suggested by Crafts's 1976 paper, and also to take account of the implications of the new population estimates. The agricultural estimates for a period such as 1700-60, when prices were the same at both the beginning and the end of the period⁴⁷ and when imports were unimportant, can be obtained by noting that home supply growth must equal home demand growth, which can be taken as equal to the sum of population growth plus the growth of incomes per head times the income elasticity of demand for food: $\Delta Q_{ag}/Q_{ag} = \Delta \text{pop}/\text{pop} + e \cdot (\Delta Y/\text{pop})/(Y/\text{pop})$.

Further adjustments to the figures for agricultural output growth now need to be made because Crafts has subsequently shown that the income elasticity of demand for food was about 0.7⁴⁸ and because the new estimates of industrial growth affect estimates of income growth. The results are presented for 1700-60, which is convenient because of price behaviour, the possibility of checks with King and Massie and because some of the industrial output data is frail before 1720. The periodization should not be taken to deny the message of Crafts's paper that agricultural growth would have been faster in 1710-40, the period of price falls,⁴⁹ a finding which appears to be strengthened by Overton's work on probate records which finds rapid increases in cereal yields from 1700 to 1730.⁵⁰

In order to estimate the overall rate of economic growth it is necessary to assign weights to the various sectors. Deane and Cole assigned weights on the basis of evidence provided by contemporaries, especially Gregory King.⁵¹ Recently Lindert has shown that King underestimated the importance of occupations in manufacturing and commercial activities and overestimated the importance of agriculture.⁵² As Lindert makes clear,⁵³ the description of occupational data in eighteenth-century records does not make the division of incomes into Deane and Cole's categories particularly easy. Nevertheless, Lindert and Williamson's revision of the social tables of King and Massie indicates that Deane and Cole's weights need revision.

In both 1688 and 1759 Lindert and Williamson's estimates suggest that industry and commerce together accounted for about 37 per cent of national income, with rather more than half this total in commerce. On examining some of the categories involved in commerce it seems that adjustments are required, particularly in terms of income accruing to tradesmen, and weights

⁴⁶ Crafts, 'English Economic Growth', pp. 231-3.

⁴⁷ See, for example, P. K. O'Brien, 'The Terms of Trade in European Agriculture, 1660-1820', (Oxford, mimeo 1982), App. 1.

⁴⁸ N. F. R. Crafts, 'Income Elasticities of Demand and the Release of Labour by Agriculture during the British Industrial Revolution', *Journal of European Economic History*, 9 (1980), pp. 156-9.

⁴⁹ Crafts, 'English Economic Growth', pp. 232-3.

⁵⁰ M. Overton, 'Estimating Crop Yields from Probate Inventories: An Example from East Anglia, 1585-1735', *Journal of Economic History*, 39 (1979), p. 35.

⁵¹ Deane and Cole, *British Economic Growth*, p. 77.

⁵² P. H. Lindert, 'English Occupations, 1670-1811', *Jnl. Econ. Hist.*, 40 (1980), pp. 685-712.

⁵³ *Ibid.* pp. 691-2.

of 20 per cent for industry and 16 per cent for commerce have been chosen for the period 1700-60.⁵⁴ These are, of course, higher weights than Deane and Cole chose using King: they assigned 30 per cent to industry and commerce.⁵⁵

Deane and Cole used 7 per cent and 20 per cent respectively as weights for "government and defence" and "rent and services". These have been retained, though it is possible that future research may modify them. Such weights would be reasonable for the end of the century,⁵⁶ but the social tables do not enable measurement of rent or of domestic service.

This leaves a weight of 37 per cent for agriculture, whereas Deane and Cole allowed 43 per cent.⁵⁷ The 37 per cent weight is probably acceptable, though the evidence of the social tables is slightly ambiguous. Income clearly attributable to agriculture is 34 per cent of national income in 1688 and 28 per cent in 1759. In addition, however, there are rents which accrue to the well-off. In 1688 Lords, Baronets, Knights, and Esquires received 8.4 per cent of income and in 1758 7.1 per cent; Gentlemen received 9.4 and 7.7 per cent respectively; the number of yeomen suffered a substantial decline during this period.⁵⁸ Obviously the crude data understate agricultural income but there is some doubt about the exact amount.

There is some scope for debate and for slight readjustments to the sectoral weights. It should be clear from Table 5, however, that any adjustments are unlikely to change the basic picture of growth between 1700 and 1760 very much.

Moreover, the new estimates are reasonably consistent with evidence from the social tables on national income for England and Wales. If we take prices to be the same in 1700 and 1759,⁵⁹ then the growth rates from the new estimates in Table 5 would put the national income of England and Wales at £48.0 m based on extrapolation of Lindert and Williamson's revised figure for Massie's national income of £71.4 m in 1759. This is the same as the £48.0 m which Deane and Cole took to be national income in Gregory King's year of 1688.⁶⁰

(b) 1760-1801

We have already seen that the new estimates of industrial output diverge significantly from those of Deane and Cole for the reasons discussed in Section I. On the other hand, the population growth-rate figures used to measure the

⁵⁴ Lindert and Williamson, 'Social Tables', pp. 11-13 and 18-20. The commerce category includes income from bakers and other tradesmen who can be thought of as involved in food processing, i.e. manufacturing, and who account for perhaps 3.5% of income. It is possible that the weight attaching to industry is still a little low; extrapolation backwards of the value-added figures for Table 1, using the growth rate of Table 3, suggests a weight for industry of 24%. Also, as Lindert, 'English Occupations', p. 692 notes, some capitalists are probably omitted from the social tables category 'industry' and are recorded as receiving income as 'gentlemen'.

⁵⁵ Deane and Cole, *British Economic Growth*, p. 78.

⁵⁶ *Ibid.* p. 166.

⁵⁷ *Ibid.* p. 78.

⁵⁸ Lindert and Williamson, 'Social Tables', pp. 11-13 and 18-20; for the decline in yeomen see Lindert, 'English Occupations', p. 702.

⁵⁹ O'Brien, 'Terms of Trade', App. 1, Tables 1 and 2.

⁶⁰ Deane and Cole, *British Economic Growth*, p. 2. Lindert and Williamson argue for a figure of £54.4 m for 1688, 'Social Tables', p. 13. This is based on acceptance of a total of 5.5 m for the population of England and Wales in 1688. Wrigley and Schofield, *Population History*, p. 571 (adjusted to include Wales) would give a population for England and Wales of 5.20 m. Adjusting their head counts accordingly, this would lower Lindert and Williamson's national income estimate to £51.4 m in 1688.

growth of rent and services are virtually the same as those of Deane and Cole. For the latter half of the period some further adjustments to sectoral weights are required; but the main discussion for this period concerns agriculture.

The same objections still apply to Deane and Cole's original work, but the application of the demand growth equation to provide estimates of output growth in agriculture becomes hazardous in this period because we know that relative prices were changing, especially after 1780.⁶¹ Unfortunately, information on the extent of these changes is imperfect.

A two-part approach has therefore been used to estimate agricultural output growth. As it turns out, this yields consistent estimates for the period 1760-1801 as a whole. The first part uses estimates of agricultural income in current prices, and O'Brien's agricultural price index, to yield an estimate of growth in real agricultural incomes. The details are as follows. Starting from a share of agricultural output of 37 per cent of £48.0 m in 1700, the new estimate for the growth rate of agricultural output in Table 5 was used to derive a figure for agricultural output of £25.2 m for England and Wales in 1760. Deane and Cole's work gives the current agricultural income of Great Britain in 1801 as £75.5 m. This was adjusted to a figure for England and Wales in 1801 at 1760 prices of £30.1 m by multiplying by 200/232 (the ratio of the national incomes)⁶² and deflating by O'Brien's smoothed agricultural price index.⁶³ This indicates a growth rate of home agricultural output of 0.44 per cent per annum. (This is much lower than the growth of population at 0.83 per cent and thus lower than Deane and Cole's estimate for agricultural output growth.) Agricultural consumption would have grown at 0.50 per cent per year allowing for imports.⁶⁴

The second part of the approach involves the application of the demand growth equation. This is a tedious iterative procedure in view of the difficulties of price information. Estimates of changes in other sectors' prices were obtained by using the national income estimates for 1759 and 1801 to give current income originating by sector, which was combined with the new estimates of growth at constant prices (including the provisional estimates for agriculture obtained above)⁶⁵ to give estimates of price increases. The results gave industrial prices rising at 0.52 per cent per year and commerce and services at 1.86 per cent,⁶⁶ which, combined with O'Brien's data on agriculture, produce a rise in the relative price of agricultural goods of 0.59 per cent per year. The new estimates for national income and population growth would give growth

⁶¹ O'Brien's index, 'Terms of Trade', App. I, shows a 13 year moving average of agricultural prices (1720-44 = 100) at 111 in 1760, 131 in 1780 and 221 in 1801, but O'Brien does not have evidence on services and his industrial prices data are sparse.

⁶² Using Deane and Cole, *British Economic Growth*, p. 166 and Cole, 'Factors in Demand', p. 65.

⁶³ O'Brien, 'Terms of Trade', App. 1; the index used was a five-year moving average of agricultural prices.

⁶⁴ Import figures are given in current prices for 1784/6 and after in R. Davis, *The Industrial Revolution and British Overseas Trade* (Leicester, 1979), pp. 102-114, and in official values, which are acceptable for 1760, in idem, 'English Overseas Trade, 1700-1774', in W. E. Minchinton, ed. *The Growth of English Overseas Trade in the Seventeenth and Eighteenth Centuries* (1969), pp. 119-20. Using these sources, agricultural consumption becomes £28.2 m in 1760 and £34.4 m in 1801, both at 1760 prices.

⁶⁵ These estimates take agricultural output to be growing at 0.44% and allow for this in the estimate for the growth of commerce. They also use the weights described below.

⁶⁶ A further result is that overall inflation is estimated at 1.52% per year and commerce price increases at 1.47% per year. This is consistent with the treatment of commerce in section I, see n. 35.

of demand at 0.97 per cent per year, which, with a price effect of (-0.8×0.59) ,⁶⁷ would give predicted consumption growth for agricultural goods at 0.50 per cent per year. This happens to be the same as the result arrived at in the first part of the calculation.

Growth of home agricultural output is therefore estimated to be 0.44 per cent per year. This is consistent with the predicted growth of demand based on changes in income and relative prices, and is also the outcome of deflating current income estimates for agriculture. The same approach, when applied to the two sub-periods, results in a growth of home agricultural output at 0.13 per cent for 1760-80 and 0.75 per cent for 1780-1801.

Finally, in computing results for national income growth in 1760-1801, it was necessary to adjust the sectoral weights for the second sub-period. The sectoral output estimates suggest that by 1780 agriculture's share had fallen to about 32 per cent. Given constant shares for commerce, rent and services, and government and defence, as assumed, this fall in agriculture's share would raise industry's share to 25 per cent.

(c) 1801-1831

As was noted earlier, for this period Deane and Cole's work relied on estimates in current income by sector,⁶⁸ deflated by using Rousseaux price indices to obtain constant price estimates. The price indices used are not well suited to this purpose, apart from the agricultural prices index, and the results for other sectors reported in Table 5 (v) seem to exaggerate output and productivity growth.⁶⁹

The "trade and transport" data have already been discussed in detail, and Table 3 established a range of 3.00 per cent to 3.17 per cent per year for industrial growth based on the Divisia or Fisher Ideal indices of that Table. A check was performed in an earlier paper by constructing a crude index of manufacturing prices more suitable than that of Rousseaux to deflate the current price series; this yielded a rate of growth of manufacturing output of 3.3 per cent for 1801-31.⁷⁰ That procedure was inferior to the one adopted in this paper but it nevertheless offers support for the view that Deane and Cole's estimates for industrial growth are considerably higher than is justified.

As with commerce, it is not possible to construct a price index to deflate the income data of other service sectors, either because they were non-marketed or because information on prices is deficient. Similar problems beset attempts to measure present-day national income, of course. Accordingly there has to be a resort to proxy variables. For "housing" use has been made of Feinstein's estimates of the stock of houses, and it has been assumed that real output grew at the same rate as the value in constant prices of the stock of houses.⁷¹ Growth at 1.53 per cent is slightly higher than population (1.45 per cent) but is close enough to offer some support to the earlier treatment of eighteenth-century

⁶⁷ Using the same reasoning applied in Crafts, 'English Economic Growth', p. 230, the price elasticity of demand for agricultural goods is taken to be -0.8 .

⁶⁸ Deane and Cole, *British Economic Growth*, p. 166.

⁶⁹ Crafts, 'National Income Estimates', pp. 179-82.

⁷⁰ *Ibid.* p. 180.

⁷¹ I am indebted to Professor Feinstein for this suggestion; the series is reported in Feinstein, 'Capital Formation', p. 42.

housing. For "domestic and personal" growth of output has been assumed to be at the rate of growth of employment in the sector, at 1.37 per cent per year,⁷² again similar to the rate of population growth.

The "government, professional and other" series is also based on employment. Deane and Cole's series for "public and professional" employment⁷³ shows zero growth over 1801-31 as a result of the decline in government activity after the wars. In fact the period 1801-31 seems to have been one of considerable expansion in professional employment. To take account of this development, use has been made of Williamson's paper for information on relative earnings and employment levels among low-paid public employees and among solicitors. Weighting the former's real productivity as worth a quarter of the latter's, a growth rate of 1.37 per cent for this sector is obtained.⁷⁴

Inevitably, estimates of services sector output can be no more than tentative. The new estimates seem more plausible than those of Deane and Cole, nevertheless. For example, as with "trade and transport" their estimate for "domestic and personal" output growth implies a very high rate of growth of labour productivity (in this case 1.75 per cent per year). The present estimates confirm Crafts's earlier argument that the growth of labour productivity in services and commerce together would be in the range 0.1 to 0.5 per cent per year,⁷⁵ and give a figure of 0.31 per cent. It is worth remembering, however, that there were other services not specifically measured here; this may be an area where future research will modify the findings of the present article.⁷⁶

For agricultural growth the new estimates are actually very similar to Deane and Cole's results for 1801/11-1831/41, although rather lower than are obtained by using Deane and Cole's procedure for 1801-31. The new estimates have been made by deflating Deane and Cole's current income figures by a five-year moving average of O'Brien's price index, extended to 1831.⁷⁷ It is important to note that the 1.18 per cent growth rate is low compared with what would be predicted using the demand equation.⁷⁸ This approach would yield a

⁷² Derived from Deane and Cole, *British Economic Growth*, p. 143.

⁷³ *Ibid.* p. 143.

⁷⁴ Data were obtained from J. G. Williamson, 'The Structure of Pay in Britain, 1710-1911', in P. Uselding, ed. *Research in Economic History*, 7 (New York, 1982), pp. 1-54. For 1801 there are estimated to be $(260,000 \times 0.25) + (40,000 \times 1) = 105,500$ worker equivalents; for 1831 $(190,000 \times 0.25) + (110,000 \times 1) = 157,500$ worker equivalents.

⁷⁵ Crafts, 'National Income Estimates', p. 182.

⁷⁶ Even so, the missing sectors may not all be fast growing even where intuition suggests they should be. A crude attempt to measure growth of financial services by looking at growth of real means of payment other than specie is instructive in this regard (if also unreliable). The estimated growth rate of real output obtained from the data in R. Cameron, ed. *Banking in the Early Stages of Industrialization* (1967), p. 42, is 0.54% per year.

⁷⁷ The extension of O'Brien's index to 1831 was based on data taken from Mitchell and Deane, *Abstract*, pp. 88, 495 for wool and grain prices, and from Beveridge, *Prices and Wages*, pp. 425, 426, 429 for milk, pork, mutton, and beef. Weights of 60% and 40% were given to arable and meat respectively. It should be noted that the growth rate for agriculture is much lower than that in Crafts, 'National Income Estimates', p. 179 because the 1801 figure is deflated by a five-year moving average here in order to be consistent with the treatment of 1760-1801, whereas in the previous paper 1801-31 was taken in isolation. It should also be noted that in computing the 1.64% figure for the Deane and Cole agricultural output growth estimate the Rousseaux index was adjusted to a "five-year moving average" for 1801 by comparison with the difference between O'Brien's index and its five-year moving average. By 1831, the predicted agricultural consumption growth rate would be 1.78% rather than 2.21%.

⁷⁸ Changes in the prices of industrial and services output were again estimated using the current income figures compared with real output growth estimates. Real agricultural prices were estimated to fall at 0.50% per year in 1801-31.

predicted figure of 2.21 per cent consumption growth compared with an estimated figure of 1.51 per cent (including imports) and would predict home agricultural output growth to be 1.88 per cent per year. It is not possible at the moment to resolve this discrepancy fully. A possible, incomplete, explanation may be as follows. Lindert and Williamson's work shows a significant shift in favour of the top 10 per cent of income receivers between 1801/3 and 1867. If that occurred by 1831, which is not known, and if the top 10 per cent had a very low income elasticity of demand for food, perhaps about half the discrepancy could be explained.⁷⁹

It should be accepted therefore that the true rate of growth of agricultural output during the period 1801-31 may be 1.88 per cent rather than the 1.18 per cent given in Table 5 (iv). For the present the estimate of 1.18 per cent is retained; if the estimate of 1.88 per cent were preferred, then national income growth would be raised by 0.18 per cent per year to 2.15 per cent for 1801-31.⁸⁰ If one also wished to use the Fisher Ideal of the quantity indices to represent industrial output growth with a 3.17 per cent rate, then the overall rate of economic growth would rise to 2.21 per cent.

For this period the weights used are taken from the current price income data of Deane and Cole⁸¹ and are representative of the whole period. They are: agriculture 26 per cent, industry 32 per cent, trade and transport 16 per cent, housing 6 per cent, domestic and personal 6 per cent, government, professional and other 14 per cent.

The detailed description of how the estimates were constructed indicates that many assumptions are required and that the data are far from being fully adequate. It remains true, as Deane and Cole observed, that we have "a set of hypotheses" . . . rather than a set of conclusions".⁸² Nevertheless, I have argued that the new evidence now provides the basis for a more plausible set of hypotheses than when Deane and Cole wrote. It is worth noting that the pattern of growth contained in the new estimates for the eighteenth century is essentially consistent with contemporary estimates, excluding the obviously unreliable Young, which is not the case with Deane and Cole's figures.⁸³

The main features of the new set of hypotheses as compared with those of Deane and Cole and Cole are revealed in Table 5. They can be summarized as follows:

⁷⁹ Lindert and Williamson, 'Social Tables', p. 34 find that the share of the top 10% was 45.4% in 1801-3 and 52.7% in 1867. If these income receivers had a zero income elasticity of demand for food and their increased share had accrued entirely by 1831, the predicted agricultural consumption growth rate would be 1.78%, rather than 2.21%.

⁸⁰ This would still not fully resolve the difficulties of the data. Not only would the higher income growth raise demand growth and thus require further iterations of the demand equation, but unless Deane and Cole's estimates of current agricultural income in 1801 and/or 1831 were changed it would have to be accepted that relative agricultural prices were falling faster than the 0.50% reported in n. 78 (and that agricultural prices were falling faster than the O'Brien/Beveridge data suggest). Indeed this price effect added to the income effect means that the gap between estimated and predicted consumption growth is hardly reduced in each iteration. The implication of preferring the 1.88% agricultural output growth rate is almost certainly to reject at least one of Deane and Cole's current income figures; until evidence to justify this is forthcoming the author prefers to retain the 1.18% figure of the text, whilst accepting that more doubt attaches to this figure than is desirable.

⁸¹ Deane and Cole, *British Economic Growth*, p. 166.

⁸² *Ibid.*, p. 78.

⁸³ *Ibid.* p. 81.

(i) For the period as a whole per capita real income growth is lower in the new estimates—by 0.4 per cent per year for 1700-1831 as compared with Deane and Cole, and 0.5 per cent per year as compared with Cole.

(ii) The acceleration in growth is much more gradual in the new estimates, whether industrial output or national product is considered. Industrial output growth at 3 per cent per year is postponed to the 1820s and is not achieved in the 1780s, with the result that Rostow's case for take-off in 1783-1802 is considerably weakened.

(iii) Agricultural growth is slower after 1760 than is estimated by Deane and Cole, or by Cole, and is faster than Deane and Cole estimated before 1760.

The new estimates have other important implications for the literature on the industrial revolution which have so far gone unrecognized. These are explored in the next two sections.

III

There has been much interest in the share of gross national expenditure devoted to investment during the industrial revolution. Deane and Cole's work seemed to refute the Lewis-Rostow hypothesis, and in 1972 Crouzet summarized the conventional wisdom as follows: "most recent writers have agreed that at present there is little theoretical or historical justification for assuming that the industrial revolution was the result of a notable acceleration in capital accumulation, and that a high investment proportion was required for the starting of 'modern growth'".⁸⁴

Since Crouzet wrote, Feinstein has produced improved estimates of capital formation. By combining these with Deane and Cole's national income estimates, he argued that "Contrary to the view tentatively advanced by Deane and Cole and now widely (and sometimes dogmatically) accepted, the investment ratio did rise during the eighteenth century, and by quite a substantial margin".⁸⁵ In addition, Feinstein used a growth accounting framework to suggest that 62.5 per cent of the increase in growth in the period 1801-30, compared with the period 1761-1800, was attributable to total factor productivity growth and 22 per cent to faster capital growth.⁸⁶

In calculating gross domestic investment ratios, Feinstein employs his constant price estimates for capital formation and calculates national income in constant prices working backwards from 1851-60, using Deane⁸⁷ and also Deane and Cole's estimates of growth. The new estimates presented in Section II make it clear that this procedure will give incorrect answers for the years before 1831 because Deane and Cole overestimated growth in constant prices.

⁸⁴ F. Crouzet, 'Introduction', in F. Crouzet, ed. *Capital Formation in the Industrial Revolution* (1972), p. 19.

⁸⁵ Feinstein, 'Capital Formation', p. 90.

⁸⁶ *Ibid.* p. 86.

⁸⁷ P. Deane, 'New Estimates of Gross National Product for the United Kingdom, 1830-1914', *Review of Income and Wealth*, 14 (1968), pp. 95-112

As a result, Feinstein used underestimates for national income. Table 6 sets out corrected estimates for the investment ratio. The new estimates for 1801-31 are obtained by using Deane and Cole's current income figures. (The present paper accepts the current price estimates for 1801-31 and only changes the constant price series). Thus, for this period Feinstein would have arrived at the same answer had he worked in current prices, as would have been preferable.⁸⁸

The revised figures of Table 6 do much qualitatively to restore the picture drawn by Deane and Cole. In particular, the sharp jump in the investment ratio between the 1770s and the 1780s recorded by Feinstein is smoothed out and a rise of 5 percentage points in the investment ratio takes about sixty years rather than thirty years. On the other hand, Feinstein is apparently right to draw attention to significant rises in the investment ratio in the first half of the eighteenth century.⁸⁹

Table 6. *Gross Domestic Investment as a proportion of Gross Domestic Product (%)*

	<i>New Estimates</i>		<i>Feinstein</i>
1700	4.0	1761-70	8
1760	5.7	1771-80	9
1780	7.0	1781-90	12
1801	7.9	1791-1800	13
1811	8.5	1801-10	11
1821	11.2	1811-20	11
1831	11.7	1821-30	12

Sources: Feinstein: figures for gross domestic capital formation plus stockbuilding divided by Deane and Cole's national income estimates in 1851-60 prices; Feinstein, 'Capital Information', p. 91.

New Estimates: Figures for gross domestic capital formation plus stockbuilding in current prices (Feinstein, 'Capital Formation', pp. 41, 69), divided by national income estimates in current prices from Deane and Cole, *British Economic Growth*, p. 166 for 1801-31. For 1760 the national income figure is 232/200 times Lindert and Williamson's corrected figure for Massie's national income for England and Wales. For 1780 the national income figure is derived by using the 1759 estimate and increasing it to allow for growth as in the new estimates in Table 5, and inflation according to the Schumpeter-Gilboy price index, Mitchell and Deane, *Abstract*, p. 469 and then multiplying by 232/200 to obtain a figure for Great Britain. For 1700 the estimate is derived from the argument that the capital to output ratio was constant from 1700-60. This is consistent with the view in P. Deane, 'The Role of Capital in the Industrial Revolution', *Explorations in Economic History*, 10 (1973), p. 355, and with the proposition that the growth of the capital stock is the gross investment ratio/the gross capital to output ratio. This last was calculated as 5.8 for 1760 using Feinstein's capital stock estimates and capital to output ratio for 1830 ('Capital Formation', pp. 84, 86) and the new estimates for economic growth.

It is also necessary to adjust Feinstein's sources of growth accounting in the light of lower estimates of economic growth. This is done in Table 7, in which the weights assigned to capital and labour allow a share to pure rent for the fixed factor of production, land, in contrast to Feinstein's approach but following Crafts and McCloskey.⁹⁰

⁸⁸ It should be noted that the lower values obtained, as compared with Feinstein's constant price estimates, confirm the argument that Deane and Cole overestimated early nineteenth-century economic growth in constant prices.

⁸⁹ C. H. Feinstein, 'Capital Accumulation and the Industrial Revolution', in Floud and McCloskey, *Economic History of Britain*, 1, p. 135. It should be noted that the 4.0% figure for the gross investment ratio supports Crouzet's view that capital was long-lived in the eighteenth century and that the gross investment ratio was much lower than writers such as Kuznets had surmised: Crouzet, 'Introduction', p. 21.

⁹⁰ Feinstein, 'Capital Formation', p. 86 gives weights of 0.5 to both capital and labour. N. F. R. Crafts, 'The Eighteenth Century: A Survey', p. 8 and D. N. McCloskey, 'The Industrial Revolution, 1780-1860', p. 127, both in Floud and McCloskey, *Economic History of Britain*, use 0.15 and 0.13 respectively for land. The weights follow Crafts.

Table 7. *Growth Accounting with the New Estimates*

	$\Delta Y/Y$	Due to Capital	Due to Labour	Residual	Feinstein's Residual
1700-60	0.69	0.35×0.7	0.5×0.4	0.25	} 0.3
1760-80	0.70	0.35×0.8	0.5×0.7	0.1	
1780-1801	1.32	0.35×1.2	0.5×1.0	0.4	} 1.3
1801-31	1.97	0.35×1.5	0.5×1.4	0.75	
1831-60	2.5	0.35×2.0	0.5×1.4	1.1	

Sources: Values for input growth and Feinstein's residual from 'Capital Formation', p. 86, together with output growth for 1831-60. Weights for 1831-60 differ from Feinstein. Otherwise derived from the new estimates given in this text.

There are very well known limitations to growth accounting exercises, and these are ably summarized by Feinstein.⁹¹ For what it is worth, however, it should be noted that the revisions of Table 7 indicate a rather less dominant role for productivity growth than Feinstein suggested. In general, productivity growth accounts for less than half the increases in growth between periods; only 39 per cent of the faster growth of 1801-31, for example, as compared with the period 1700-60.

A further important point to emerge from Table 7 is that the impact of productivity growth on economic growth is modest in the eighteenth century, including the "take-off" decades when capital formation contributes virtually as much to the acceleration in growth. Productivity growth reaches a more impressive level much later, in the second quarter of the nineteenth century. It is only then that growth peaks, and McCloskey's claim that "ingenuity rather than abstinence governed the industrial revolution"⁹² becomes fully apposite.

Tables 6 and 7 together also point to the importance of rises in the investment ratio in a fashion recognized by Ashton,⁹³ namely to cope with demographic pressure. It is noteworthy that the six percentage points rise in the investment ratio between 1760 and 1831 were only just sufficient to keep capital per head rising in the context of increasing population growth. Yet in 1831 the investment ratio was three times its level in 1700.

IV

There has been much controversy over changes in living standards during the industrial revolution. Obviously, macro-economic data cannot resolve the debate, but trends in personal consumption expenditure have been used as an important piece of evidence⁹⁴ and it is worth considering the implications of the new estimates for consumption. Consumption experience is also relevant to the question of the sources of demand for the extra output coming from the growth process. In particular, there has been much discussion of the relative contribution of exports.

This last issue has been extensively reviewed by Crouzet.⁹⁵ He concludes

⁹¹ Feinstein, 'Capital Accumulation', pp. 140-2.

⁹² McCloskey, 'The Industrial Revolution, 1780-1860', p. 108.

⁹³ T. S. Ashton, *The Industrial Revolution, 1760-1830* (1948), p. 5.

⁹⁴ See, for example, Williams, 'The British Standard of Living', and Feinstein, 'Capital Accumulation'.

⁹⁵ Crouzet, 'Towards an Export Economy'.

that "during most of the century up to 1780s, the ratio of domestic exports to national income was quite modest and remained under 10%",⁹⁶ whilst "During the decisive stage of the Industrial Revolution, in the twenty years which followed the peace of 1783, the incremental ratio of exports to national income seems to have been as high as 40% . . .".⁹⁷ In making his calculations Crouzet used Deane and Cole's figures for national income. The picture obtained by using the new estimates presented in this paper is somewhat different, as Table 8 shows.

Table 8 reveals that the proportion of extra output going to exports varied between periods. Crouzet does seem to have understated the share of exports in the pre-industrial period; in fact, for the period 1700-80 as a whole the incremental export-output ratio is 13 per cent, double the figure given by Crouzet and Bairoch.⁹⁸ Furthermore, it appears that Crouzet's figures dramatically exaggerate the role of exports during what he calls "the decisive stage of the Industrial Revolution",⁹⁹ the last two decades of the eighteenth century.

The differences arise principally from the national income statistics, since the data for exports are essentially the same (except for 1801). Crouzet uses a figure of £160 m for the national income of Great Britain in 1783 (compared with £232 m in 1801). This is clearly unacceptable; the present paper would estimate national income in current prices at £105 m for Great Britain in 1780.

Other writers have considered exports as a share of industrial output to be a more interesting ratio. Cole gives figures which indicate that between 1700 and 1760, and between 1780 and 1800, the incremental export-industrial output ratio was 44 per cent and 42 per cent respectively for England and Wales. For the eighteenth century as a whole he reckons the ratio to be 40 per cent.¹⁰⁰

The new industrial output growth figures in Table 4 suggest that while Cole's finding for the eighteenth century as a whole is little changed—the 40

Table 8. *Exports as a Proportion of National Income in the Eighteenth Century (%)*

	New Estimates		Crouzet's Estimates	
	Exports/ Nat. Inc.	Incremental Exports/ Nat. Inc.	Exports/ Nat. Inc.	Incremental Exports/ Nat. Inc.
1700	8.3	1700-60 21.2	1700	8.5
1760	12.4	1760-80 3.5	1759	11.6
1780	10.5	1780-1801 19.3	1783	7.8
1801	15.3		1801	17.8
			1700-59	16.6
			1759-83	3.3
			1783-1801	40.3

Sources: Crouzet's Estimates: Crouzet, 'Towards an Export Economy', p. 78.

New Estimates: National income figures, see text. Exports; for 1700, from Davis, 'English Foreign Trade', p. 120 adjusted by the ratio of Great Britain/England and Wales exports in 1775-84 from Deane and Cole, *British Economic Growth*, p. 48; for 1760 from *ibid.*; for 1780 and 1801, Deane and Cole's figures for exports in official values, *British Economic Growth*, p. 48 adjusted by the ratio of current/official values, computed by Davis, *The Industrial Revolution*, p. 86.

⁹⁶ *Ibid.* p. 77.

⁹⁷ *Ibid.* p. 82.

⁹⁸ *Ibid.* p. 82 and P. Bairoch, 'Commerce internationale et genèse de la révolution industrielle anglaise', *Annales*, xxvii (1973), p. 558.

⁹⁹ Crouzet, 'Towards an Export Economy', p. 82.

¹⁰⁰ Cole, 'Factors in Demand', p. 40

per cent contribution of exports is raised to 43 per cent—the results for 1700-60 and 1780-1800 show higher ratios because the new estimates reveal that industrial output grew more slowly during these periods. The incremental export-industrial output ratios for both sub-periods become 58 per cent.¹⁰¹

Thus the new estimates indicate that the contribution of export growth to industrial and overall growth was higher before 1760 than Crouzet and Cole thought. For the last two decades of the century the new estimates suggest that the contribution of exports to overall growth was much lower than Crouzet thought, but indicate that their importance to industrial growth may have been even greater than Cole argued.

The very high fraction of extra industrial output being exported in the late eighteenth century directs our attention back to the behaviour of personal consumption. Feinstein has produced a series for real per capita consumption using Deane and Cole's national income figures and deducting government spending and home and foreign investment.¹⁰² Table 9 compares the growth of consumption according to Feinstein with the new income growth estimates.

Table 9. *Real Private Consumption per Head* (1760=100)

	<i>New Estimates</i>		<i>Feinstein's Estimates</i>
1760	100.0	1761-70	100.0
1780	97.4	1781-90	99.0
1801	101.2	1801-10	109.4
1821	108.0	1811-20	117.7
1831	122.7	1821-30	152.1

Sources: Feinstein: 'Capital Accumulation', p. 136.

New Estimates: the new estimates of growth in Table 5 adjusted for the same items as Feinstein.

The new estimates are more pessimistic than Feinstein's. They suggest that the increase in per capita consumption in 1830 over 1760 was less than half Feinstein's estimate. Nevertheless, the new estimates serve to reinforce Feinstein's conclusion concerning "the absence of any marked improvement or deterioration before the 1820s, the relatively small influence of increased domestic investment, and the substantial measure of progress after the 1820s . . .".¹⁰³

V

The preceding sections contain a mass of detail on the dimensions of economic growth during the British industrial revolution. In this final section the aim is simply to recapitulate and to underline several key features of the broad outlines of the growth process as revealed by the new estimates presented above. It must always be remembered that in so doing we are in the realm of controlled conjectures rather than very firm evidence.

The main points to note about growth during the industrial revolution era are as follows.

¹⁰¹ Derived using the export figures in Cole, 'Factors in Demand', p. 40 and his figure for the gross value of industrial output in 1800 extrapolated back using the industrial output growth figures in Table 4 above. Note that exports as a proportion of industrial output fell between 1760 and 1780.

¹⁰² Feinstein, 'Capital Accumulation', p. 136.

¹⁰³ *Ibid.* p. 137.

(1) Growth was substantially slower during the years 1780-1831 than is believed by conventional wisdom. The best guesses for the growth rates of real national product are 1.32 per cent per year for 1780-1801 and 1.97 per cent for 1801-31, rather than the 2.06 per cent and 3.06 per cent respectively estimated by Deane and Cole. The economy did not reach a sustained rate of growth of 2 per cent per year until the 1820s.

(2) The economy did not experience a "take-off" in the last two decades of the eighteenth century. The pace of growth quickened at that time, but not dramatically so.¹⁰⁴ The investment ratio rose by about 1 per cent of national income and total factor productivity growth rose by about 0.15 per cent per year compared with 1700-60. Consumption per head rose by only about 4 per cent in two decades.

(3) The last part of the eighteenth century does see quite marked changes in the composition of industrial output, most notably the rise in the weight of cotton from about 2 per cent of industrial value added in 1770 to about 10 per cent in 1801. The fast growth of cotton and iron is not typical, however, and the growth of industrial output as a whole in 1780-1801 is only just over half of the rate achieved in the 1820s.

(4) Living standards, as measured by personal consumption, were little changed between 1760 and 1820. This is mainly because growth was not particularly rapid and, in particular, the high rate of growth of productivity, which ultimately overcame Malthusian problems, was a nineteenth- and not an eighteenth-century phenomenon. The experience of cotton textiles is not typical, nor does it loom very large statistically in the overall growth process.

(5) The domestic investment ratio rose steadily between 1700 and 1811 but in doing so was mainly combatting demographic pressure on living standards.

(6) Exports at no time accounted for a major part of increases in national income, which is not surprising given the substantial part of the economy involved in the production of non-traded goods. It should be recognized, however, that in the last two decades of the eighteenth century (the early rather than the decisive phase of the industrial revolution), almost 60 per cent of additional industrial output was exported.

Finally, it should be remembered that the picture presented in this paper is essentially a refinement of that constructed by Deane and Cole. Certainly, the view of economic growth it contains is much closer to that of Deane and Cole than to that held by previous generations of economic historians.

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¹⁰⁴ In addition to the revisions suggested in the present article it seems that 1740 is probably better not looked upon as a turning point in per capita income. See Crafts, 'English Economic Growth', pp. 232-4.