COMPARATIVE PRODUCTIVITY IN BRITISH AND AMERICAN MANUFACTURING
DURING THE NINETEENTH CENTURY

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ABSTRACT

Conventional accounts of comparative Anglo-American economic performance, based on national accounts data see Britain as the labour productivity leader until the 1890s. However, figures for the manufacturing sector suggest that US labour productivity was already substantially higher than in Britain by the early nineteenth century. The US rise to overall productivity leadership was thus due to a combination of trends in non-manufacturing sectors and distributional shifts into the high productivity manufacturing sector rather than due to trends within manufacturing. Although labour productivity differences were smaller in agriculture, Britain still had a comparative advantage in manufacturing on account of resource endowments.

I. INTRODUCTION

The earliest reliable estimates of comparative US/UK labour productivity in manufacturing are for the mid-1930s from the pioneering study of Rostas (1948). Rostas used time series on output and employment in manufacturing in the two countries to indicate the pattern of comparative productivity back to 1907. Rostas suggested a monotonically widening gap from 1907 through to the 1920s and 1930s. Building upon this picture, Frankel (1957) extrapolated back further, making assumptions about productivity growth in the two countries, to arrive at the conclusion that in manufacturing labour productivity, the US probably overtook Britain in about 1830.

This picture of the UK as productivity leader at the start of the nineteenth century, being caught up and overtaken by the US, appears to receive confirmation from Maddison (1982, 1991) using data on productivity for the whole economy. Using GDP per worker, Maddison finds the US overtaking the UK in about 1890.

In this paper, however, it is shown that comparative trends in manufacturing labour productivity were very different from comparative trends in labour productivity for the whole economy. A new benchmark estimate of labour productivity in manufacturing is presented for 1907 and time series of output and employment in both countries are used to establish the pattern of comparative productivity during the nineteenth century. Already by 1850 US labour productivity was about twice the British level. Britain never was the productivity leader in manufacturing; New World productivity levels were always substantially higher. Although the US productivity lead increased from about 1880 through to the First World War, this was after a substantial narrowing of the gap during the American Civil War. Although labour productivity differences were smaller in agriculture, Britain still had a comparative advantage in manufacturing and the US in agriculture on account of natural resource endowments.

II. A BENCHMARK ESTIMATE FOR 1907

1. Data Sources and Methods

The primary sources of data for the benchmark estimate are the 1909 US Census of Manufactures and the 1907 UK Census of Production. For the US, supplementary information on output was obtained from Fabricant (1940), while Rostas (1948) provided supplementary information for a number of industries in both countries.

It was possible to obtain estimates of comparative productivity for 29 industries covering 41.6 percent of British manufacturing employment in 1907 and 36.6 percent of American employment in 1909. This is similar to Rostas' (1948) coverage of 42.4 percent of British employment in 1935 and 39.1 percent of American employment in 1937.

The approach followed for the majority of the 29 industries was relatively straightforward. The physical quantity of output was obtained directly from the Census, usually recorded by weight. However, since in some cases quantity data were not available for the whole output of the trade, the estimate of operatives in the trade was reduced in proportion to the ratio of the value of covered items to the value of total gross output in the trade.

In cases where a number of rather different items were grouped together (e.g. cars, cycles and motorcyles) outputs were weighted according to relative factory gate prices or unit values. Since these price ratios differed between the two countries, the geometric mean of US and UK price-weighted outputs was taken.

Since both price and quantity data were generally available, the ratio of US/UK factory gate prices or unit value ratios (UVRs) could be calculated. The weighted average of the UVRs provides an alternative to the market exchange rate for comparing net output per worker between the two countries. The results using physical output per operative and net output per worker were extremely close. The average UVR of £1 = $5.47 suggests that for manufacturing as a whole, sterling was undervalued by about 13 percent. If the average UVR is used to compare net output per worker between the two countries, a ratio of 208.1 is obtained, which is satisfactorily close to the result with physical outputs.

2. Results

Results for 29 industries are presented in Table 1. The comparison for 1909/07 yields an overall productivity ratio of 208.5 percent, but allowance has to be made for the different years. Using data on output and employment in US manufacturing from Kendrick (1961, p.465), the 1909/07 benchmark must be multiplied by the ratio of US productivity in 1909 to US productivity in 1907. This yields an estimate for 1907 of 201.9.

TABLE 1 : US/UK Comparative Labour Productivity 1909/07

1.	Coke	128.8
2.	Seedcrushing	110.3
3.	Soap	220.7
4.	Fertilisers	177.5
I.	CHEMICALS AND ALLIED	156.4
5.	Iron and Steel	282.5
6.	Tinplate	328.5
7.	Wire	321.2
8.	Copper	424.9
9.	Lead and Zinc	102.0
II.	METALS	288.0
10.	Cars, Bicycles and Motorcyles	434.7
11.	Shipbuilding	95.2
12.	Machinery	202.1
III.	ENGINEERING	202.3
13.	Cotton	151.1
14.	Woolen and Worsted	111.9
15.	Hosiery	230.2
16.	Rope and Twine	194.6
17.	Boots and Shoes	170.0
IV.	TEXTILES AND CLOTHING	150.7
18.	Grain Milling	134.2
19.	Butter and Cheese	196.3
20.	Fish Curing	219.0
21.	Manufactured Ice	150.2
22.	Sugar	109.7
23.	Brewing	146.3
24.	Spirit Distilling	167.1
25.	Tobacco	108.3
V.	FOOD, DRINK AND TOBACCO	137.2
26.	Cement	218.7
27.	Bricks	217.3
28.	Paper	261.5
29.	Musical Instruments	153.1
VI.	MISCELLANEOUS	227.2
	TOTAL MANUFACTURING	208.5

Source: See text.

Although the US had higher productivity in 26 of the 29 industries, there was considerable variation in the size of the productivity ratio. Dividing the sample into six broad sectors, it is clear that Britain's performance was rather better in the textiles and clothing and food, drink and tobacco sectors, and correspondingly worse in the metals and engineering sectors. This is broadly in line with the findings of Broadberry and Crafts (1990) for the mid-1930s, and confirms established trends in revealed comparative advantage (Crafts and Thomas, 1986).

3. Some Examples

In this section the methods of calculation are illustrated with two examples. Fuller details are given in the data appendices. Table 2 presents data on the tinplate industry. In the first column, physical output is taken directly from the census, together with the value of this output, recorded in the second column. This information is sufficient to calculate the unit value in the third column. The value of total output for the trade is given in the fourth column. The ratio of the second to the fourth column gives the proportion of the trade covered, and this ratio is then used to deflate the number of operatives in the trade to obtain the estimated number of operatives producing the main output in the sixth column. Dividing output from the first column by estimated operatives from the sixth column yields output per operative in the final column. The comparative productivity ratio for tinplate is thus 328.5. The unit value ratio of £1 = $5.98 can also be obtained from the third column.

TABLE 2 : The Tinplate Industry

	(tons) Quantity	Value	(per ton) Unit Value	Value of Total Output	Operatives in the Trade	Estimated Operatives	(tons) Output per Operative
UK 1907	672,000	£8,745,000	£13.01	£9,167,000	20,059	19,136	35.1
US 1909	595,854	$46,335,611	$77.76	$47,969,645	5,352	5,170	115.3

Source: See text.

Table 3 presents information on the cars, cycles and motorcycles industry. Since the output shown in part (a) is very heterogeneous, it needs to be converted to car equivalents using the relative unit values. This can be done using UK or US prices. Output per operative is thus calculated at UK and at US prices in part (b). Taking the geometric mean of the two estimates yields an overall US/UK productivity ratio of 434.7 for cars, cycles and motorcycles.

TABLE 3 : The Cars, Cycles and Motorcycles Industry

(a) Output

	UK £1000			US $1000		
	Number	Value	£ Unit Value	Number	Value	$ Unit Value
Cars	10,300	3,585	348.06	126,593	164,269	1297.62
Bicycles	615,300	3,396	5.519	168,824	2,437	14.35
Motorcycles	3,700	137	37.03	18,628	3,016	161.91

(b) Productivity

	(car Equivalents) Output				Output per Operative	
	UK Prices	US Prices	Operatives in Trade	Estimated Operatives	UK Prices	US Prices
UK 1907	21,248	17,607	47,666	29,299	0.725	0.600
US 1909	131,433	130,795	47,874	45,735	2.874	2.860

Source: See text.

The biggest exception to the above methodology is that for machinery, following Rostas (1948), the value of net output has been used rather than physical output, which was not available in the censuses. However, the weighted average unit value ratio of £1 = $5.47 has been used rather than the market exchange rate which Rostas used and which is now widely regarded as inappropriate (Gilbert and Kravis, 1954; Maddison and Van Ark, 1988; Paige and Bombach, 1959; Smith et al, 1982).

4. Previous Estimates

Although the scale of Britain's productivity gap in manufacturing as early as 1907 may seem surprising at first sight to anyone familiar with Maddison's (1982; 1989; 1991) figures on GDP per worker, there is an older literature which accepted the idea of a US lead of the order of two-to-one at this time, but which lacked a firm quantitative basis. Although Flux (1933) published comparisons of British and American productivity in manufacturing for 1909/07, 1925/24 and 1929/30, his calculations were based on net output converted at the market exchange rate, with a single allowance for deviation from purchasing power parity in 1925. All workers on productivity comparisons now regard the use of a market exchange rate as seriously misleading, particularly at a disaggregated level. Differences in the value of net output could be due to differences in prices or quantities. The use of a single market exchange rate thus imposes that all the differences are due to quantity differences, an unwarranted assumption (Gilbert and Kravis, 1954; Paige and Bombach, 1959; Smith et al, 1982; Maddison and Van Ark, 1988; Summers and Heston, 1988).

In fairness to Flux, it should be noted that he was aware of the problem and indeed he experimented with comparisons of physical output per worker for a number of industries. These figures were made available to and published by Taussig (1924). The results, mainly for a number of metals and food industries, appeared to be consistent with a substantial US productivity lead, but the unrepresentativeness of the sample meant that this conclusion could not be firmly established.

III. COMPARATIVE PRODUCTIVITY 1840-1907

1. US Time Series of Output and Employment

Time series back to 1839 are readily available for the US. For the period 1869-1909, the output index is taken from Kendrick (1961), building upon the work of Fabricant (1940) and the Census Bureau. This is essentially an index of the physical volume of gross industry output, using value added weights. For the period 1839-69, a series on manufacturing value added in 1879 prices from Gallman (1960) has been used. However, for the period 1860-69, use has been made of the Frickey (1947) index which formed the basis of Kendrick's (1961) series from 1869, and is conceptually closer to the British output series, which is based on physical volumes for the whole period.

Employment data for the period 1869-1909 are taken from Kendrick (1961), again based upon the work of Fabricant (1942) and the Census Bureau. For 1839-1869 the series constructed by Lebergott (1966) has been used. The chosen series of US output and employment back to 1839 are shown in the first two columns of Table 4. In the third column, output per employee derived from these estimates is shown.

2. UK Time Series of Output and Employment

For the UK, the output index for the period 1861-1911 is taken from Feinstein (1972). For the period 1841-1861 the Hoffmann (1955) index of industrial production has been recalculated so as to include only manufacturing production. Thus the British index of output is based on physical volumes for the whole period.

TABLE 4 : Output and Employment in US Manufacturing (1907=100)

	Output	Employees	Output per Employee
1839	2.27	5.53	41.1
1849	5.84	13.3	43.9
1859	10.3	16.9	61.0
1869	16.9	27.3	61.9
1879	24.2	36.5	66.3
1889	43.5	52.6	82.7
1899	65.3	69.8	93.6
1907	100.0	100.0	100.0
1909	103.1	99.9	103.2

Source: See text.

For employment 1861-1911, Feinstein's (1972) estimates, based on the Population Census are used. These estimates can be extended back to 1841, using the data available in Mitchell (1988). The decennial estimates have been linked to 1907 using Feinstein's (1972) series on total employment for interpolation. The series on UK output and employment are shown in Table 5, together with the resulting series for output per employee.

TABLE 5 : Output and Employment in UK Manufacturing (1907=100)

	Output	Employees	Output per Employee
1841	19.0	41.1	46.2
1851	25.8	60.4	42.7
1861	35.1	68.0	51.6
1871	48.4	74.4	65.1
1881	58.2	77.8	74.8
1891	71.5	87.3	81.9
1901	86.9	94.8	91.7
1907	100.0	100.0	100.0
1911	101.6	103.6	98.1

Source: See text.

3. Comparative Productivity 1840-1910

Table 6 takes the US and UK labour productivity indices from

Tables 4 and 5 respectively. Strictly speaking, the dates of comparison are 1839/41, 1849/51, ..., which have been represented here by the central date 1840, 1850, ..., in the table.

TABLE 6 : US/UK Manufacturing Labour Productivity (Y/L)

	1907=100			UK=100
	US Y/L	UK Y/L	US/UK Y/L	US/UK Y/L
1840	41.1	46.2	88.9	179.4
1850	43.9	42.7	102.8	207.6
1860	61.0	51.6	118.1	238.5
1870	61.9	65.1	95.1	192.0
1880	66.3	74.8	88.6	178.9
1890	82.7	81.9	101.0	203.9
1900	93.6	91.7	102.1	206.1
1907	100.0	100.0	100.0	201.9
1910	103.2	98.1	105.2	212.4

Source: See text.

American labour productivity was already twice the British level by 1850. The conventional view of faster productivity growth in the US from 1880 is borne out by Table 6, but it needs to be seen in the context of the fall in America's relative position during the Civil War period.

It should be noted that the fall in America's relative productivity position across the Civil War would be much greater if the Gallman (1960) real value added series were used rather than Frickey's (1947) volume index of production. However, the Gallman series suggests a substantial fall in absolute as well as relative labour productivity during the Civil War decade, which seems to go too far in revising the Beard-Hacker thesis that the Civil War stimulated industrialisation. Indeed, Cochran (1969) and Engerman (1971), both sympathetic to the revisionist position, cite the Frickey index approvingly.

4. A Cross-Sectional Check

The use of time series for extrapolation over long periods necessarily raises index number problems. Thus it is important to guage the plausibility of the extrapolated results with a cross-sectional check. Clearly, since there was no British Census of Production during the nineteenth century, it is not possible to produce a full benchmark estimate for 1850. Nevertheless, it is worth comparing Deane and Cole's (1967) estimate of value added in manufacturing with the US Census of Manufactures estimates, as in James and Skinner (1985).

James and Skinner (1985, table 4) report value added per worker in US manufacturing in 1849 as $488. For Britain in 1851, the corresponding figure is $244, converted at the market exchange rate. This yields a comparative US/UK productivity ratio of 200, which is reassuringly close to the figure of 207.6 in table 6. Too much weight should not be put on the precise magnitude of this estimate, particularly since the market exchange rate has been used. However, the estimate does at least serve to suggest that there is no large discrepancy between the time series and cross-sectional evidence.

IV. TRENDS BEFORE 1840

1. Output and Employment Data 1800-1840

Trends in labour productivity before 1840 are necessarily much more speculative. However, estimates are reliable enough to establish that the US still had a considerable productivity lead in the early years of the nineteenth century.

For the US, Sokoloff's (1986) work on manufacturing productivity in the American Northeast is used, rather than extrapolating further with national indices. Thus estimates of American labour productivity back to 1820 can be obtained.

For the UK, the series reported in Section III can be extended back to the beginning of the nineteenth century. For output, the Hoffman index was recalculated for manufacturing only back to 1801. For employment, the population census data are less reliable before 1841, although Wrigley (1986) uses them to extract useful information on agricultural employment. For the period 1831-41 the data refer to males 20 or over, while for the period 1811-31 the data are reported in terms of number of families (Mitchell, 1988, p.103). Clearly, this can only be expected to give a very rough indication of employment trends in the UK.

In Table 7, the first column presents US manufacturing labour productivity, with the Sokoloff index spliced to the US productivity index from Table 6 in 1850. The second and third columns give British output and employment, which can be used to obtain British labour productivity in the fourth column. The fifth column gives US/UK comparative productivity in index number form, while the final column presents US productivity as a proportion of UK productivity. The results indicate that US labour productivity in manufacturing was substantially above the UK level even in the early years of the nineteenth century.

TABLE 7 : US/UK Manufacturing Labour Productivity Before 1840

	1907=100					UK=100
	US Y/L	UK Y	UK L	UK Y/L	US/UK Y/L	US/UK Y/L
1820	22.8	9.18	29.7	30.9	73.7	148.8
1840	41.1	19.0	41.1	46.2	88.9	179.4
1907	100.0	100.0	100.0	100.0	100.0	201.9

Source: See text.

V. INTERPRETATION

1. Long Run Productivity Trends in Manufacturing

The estimates in tables 6 and 7 indicate a substantial US productivity lead over the UK as early as 1820. By 1850, this productivity lead was of the order of two-to-one. Between 1850 and 1910, there was no trend in comparative US/UK manufacturing productivity, although there were substantial swings in productivity, particularly during the Civil War decade.

Extending the analysis into the twentieth century, table 8 presents estimates of comparative US/UK labour productivity in manufacturing during the twentieth century, taken from Broadberry (1992). These estimates are obtained by extrapolation of time series from the 1937 benchmark of Rostas (1948), with checks for 1987 from Van Ark (1992) and for 1907 from the present study. The extrapolated estimate of 192.0 for 1907 in table 8 is close to the benchmark estimate of 201.9 from table 6. Indeed, inconsistencies between time series extrapolations and benchmark estimates are often much greater than this over much shorter time periods (Krijnse Locker and Faerber, 1984;

Szilagyi, 1984; Smith et al., 1982).

From the evidence of tables 6 to 8, it seems clear that in the manufacturing sector, at least, comparative labour productivity has been stationary, displaying no clear trend, over the last century-and-a-half, although it seems likely that the US lead grew substantially in the first half of the nineteenth century. These trends are relatively easy to square with the Habakkuk (1962) thesis for the mid-nineteenth century. However, they do not sit easily with the generally pessimistic view of British industrial performance from the late nineteenth century to the

TABLE 8 : US/UK Manufacturing Labour Productivity in the Twentieth Century

	UK = 100 US/UK Y/L
1907	192.0
1913	212.9
1920	222.8
1925	234.2
1929	249.9
1937	208.3
1950	262.6
1958	250.0
1968	242.6
1975	207.5
1980	192.8
1987	188.8

Source: Broadberry (1992) table 2

1970s and the generally optimistic view of American performance over the same period (Chandler, 1977, 1990; Elbaum and Lazonick, 1986; Aldcroft, 1968; Levine, 1967). Clearly, since 1850 there have been short periods of rather poor British productivity performance and short bursts of rapid American progress, but these have generally been followed by reversion towards the two-to-one American lead.

It is possible to interpret this experience as consistent with the catch-up hypothesis (Abramovitz, 1979; 1986) since a period of widening of the productivity gap is followed by a period of narrowing. However, wars have played a very important role here. The Civil War provided the US with a major set back and opportunity for subsequent growth, while the two World Wars had a similar effect on the UK. The interpretation here is thus more consistent with Dumke's (1990) reconstruction thesis than with the productivity gap analysis of Abramovitz.

Furthermore, the persistence of a large productivity gap over two centuries is clearly inconsistent with a stronger version of the catch-up hypothesis, which sees convergence of productivity levels among the industrialised nations to the same steady state path (Baumol, 1986; Dowrick and Nguyen, 1989). This stronger convergence thesis has been developed from a consideration of data on productivity for the whole economy (GDP per worker). However, the argument has usually been cast in terms of technology transfer in manufacturing (Cornwall, 1977; Gomulka, 1971). The evidence of this paper suggests that if the stronger convergence thesis is to be rescued at the level of the whole economy, the emphasis will have to be switched away from technology transfer in manufacturing to a more general view of borrowing from the leader. This would be consistent with Feinstein's (1990) emphasis on the possibility of borrowing from the leader across a wide range of activities.

2. Manufacturing and the Whole Economy

The conventional account of Anglo-American productivity based on the work of Maddison (1982, 1989, 1991) using data on GDP per capita or GDP per worker, is that during the nineteenth century Britain was replaced as productivity leader by the US. The data in Table 9 are for GDP per head of population before 1870, since reliable estimates of GDP per hour worked can only be obtained back to 1870. The work of Rostas (1948) and Frankel (1957) has encouraged the belief that a similar change of leadership occurred in manufacturing. The estimates in this paper, however, paint a very different picture, with the US already the

TABLE 9 : Comparative US/UK Productivity in the Whole Economy
(UK = 100)

	GDP per head of population	GDP per hour worked
1820	74.6	
1870	86.1	96.2
1913	120.6	128.2
1950	150.4	175.4

Source: Maddison (1991) tables 1.1 and 3.4

clear labour productivity leader in manufacturing during the early nineteenth century.

The implication of this must be that the rise of the US to overall productivity leadership was not primarily the result of faster productivity growth in manufacturing. Clearly, there was impressive productivity growth in US manufacturing, but this was matched by Britain. The emergence of the US as overall productivity leader, then, must be attributed to advances in non-manufacturing sectors and to intersectoral redistribution effects. It is not surprising that the settling of the prairies and transport improvements were important (Lee and Passell, 1979, ch.13; Lebergott, 1984, ch.22-23), and given the scale of the US productivity lead in manufacturing, the growth in the relative size of

US manufacturing must have been of some considerable importance (Lebergott, 1966).

3. Comparative Advantage

One remaining puzzle is how Britain managed to become the 'workshop of the world' if labour productivity in manufacturing was much higher in America. As Crafts (1989) notes, given much closer levels of labour productivity in agriculture between Britain and America, it may be tempting to ask why Britain didn't become the 'granary of the world'. Bairoch (1965), for example, has US labour productivity in agriculture in 1840 only 23 percent above the British level. Clark (1960), even has British agriculture slightly ahead in 1860. One possible answer to this might be to draw a distinction between the modernised and unmodernised sectors of manufacturing, as indeed Crafts (1985; 1989) does. Perhaps, it may be argued, Britain was the productivity leader in cotton textiles, which so dominated British exports in the nineteenth century. However, some crude calculations can be made, which at least cast doubt on this possibility.

In Table 10, data on raw cotton consumed are used as a proxy for output (Robson, 1957). UK data are taken from Mitchell (1988), while US data are from Montgomery (1840). For 1831 the data cover twelve states, while for 1837 only Massachusetts is covered. Employment data for the UK add together factory workers and handloom weavers from Mitchell (1988). US employment data are also taken from Montgomery. Simply taking the US/UK ratio of cotton consumption per worker, the American cotton industry was approximately twice as productive as the British cotton industry in the 1830s.

In fact, the above calculation is probably biased against Britain. A similar calculation for 1909/07 yields a US/UK ratio of 183.4, which compares with a ratio of 151.1 based on separate calculations for spinning and weaving, reported in Table 1. A similar overstatement of about 30% occurs in 1929/30. It seems unlikely, then, that the scale of the bias introduced by using cotton consumption as a proxy for output could be sufficient to overturn the finding of a substantial US productivity lead in the 1830s.

TABLE 10 : Labour Productivity in Cotton Textiles

	(m lb) Consumption of Cotton	Employment	(lb) Cotton Processed per Worker
UK, 1831	263	427,000	616
12 American States, 1831	77.5	62,208	1,245
US/UK, 1831			202.1
UK, 1837	366	400,000	915
Massachusetts, 1837	37.3	19,754	1,887
US/UK, 1837			206.2

Source: Mitchell (1988), Table 2, 30.
Montgomery (1840) pp.157, 160-161.

In fact a substantial productivity advantage in favour of the American cotton industry in the 1830s should not be altogether surprising given the literature on labour scarcity (Habakkuk, 1962). Indeed, in an explicit comparison of the British and American textile industries, Jeremy (1981, part IV) notes the adaptation of imported British cotton technology to the conditions of labour scarcity in America between 1790 and the 1830s. Von Tunzelman (1978, Ch.10) confirms the higher speeds of American machinery in cotton textiles.

Thus although comparative labour productivity is a good guide to comparative advantage when comparing Britain with other European countries (Crafts, 1989), this is not the case when comparing Britain with America. The difference must surely be due to natural resources. This is most obvious with respect to US agricultural exports, but Wright (1990) argues that it applies equally to US manufacturing exports in the late nineteenth century, with the US having a comparative advantage in resource intensive products.

VI. CONCLUDING COMMENTS

This paper presents figures for comparative US/UK labour productivity in manufacturing during the nineteenth century. Labour productivity was already substantially higher in America by 1820, attaining a two-to-one superiority by 1850. Since 1850, this comparative productivity ratio has fluctuated without displaying any clear trend. These findings are consistent with the Habakkuk thesis, but more difficult to square with the generally pessimistic interpretation of British industrial performance from the late nineteenth century to the 1970s and the generally optimistic view of American performance over the same period.

For these figures to be consistent with the conventional picture of productivity trends, based on historical national accounts, the US rise to productivity leadership must be due to a combination of trends in non-manufacturing sectors and distributional shifts to the high productivity manufacturing sector.

Some calculations for cotton textiles indicate that US labour productivity was substantially higher in this sector too. Given evidence of smaller labour productivity differences in agriculture, this suggests that in Anglo-America comparisons, comparative advantage can only be understood when natural resources are brought into the picture.

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APPENDICES I - VI

Information is presented on quantities, values and employment for individual industries, based on the US Census of Manufactures for 1909 and the UK Census of Production for 1907. Note that rounding errors result in some minor discrepancies.

APPENDIX I : CHEMICALS AND ALLIED INDUSTRIES

Industry	Country	Unit	(thousands) Quantity	(thousands) Value	Unit Value	(thousands) Value of Total Output	Operatives in Trade	Estimated Operatives	Output per Operative
1. Coke	UK	tons	11,344	£9,516	£0.8389	£10,140	10,631	9,977	1137
	US	short tons	39,315						
		tons	35,103	$89,965	$2.563	$98,078	29,273	26,852	1307
2. Seedcrushing	UK	tons	1,371	£12,940	£9.44	£12,961	6,805	6,794	201.8
	US	tons[1/]	1,626	$91,100	$56.0	$147,868	17,071	10,517	154.6
3. Soap	UK	cwt	7,440	£8,564	£1.151	£12,218	15,596	10,932	680.6
	US	lb	1,780,793						
		curt	15,900	$89,495	$5.629	$114,448	13,538	10,583	1502.4
4. Fertilisers	UK	tons	1,185	£3,542	£2.99	£5,861	10,802	6,528	181.5
	US	short tons	5,240						
		tons	4,679	$92,370	$19.74	$103,960	18,310	16,269	287.6

Notes: [1/]US output data for oil, cottonseed and coke from Fabricant (1940), pp.494-495. For later years, this data source is consistent with the Census estimates.

APPENDIX II : CHEMICALS AND ALLIED INDUSTRIES

Industry	Country	Unit	(thousands) Quantity	(thousands) Value	Unit Value	(thousands) Value of Total Output	Operatives in Trade	Estimated Operatives	Output per Operative
5. Iron & Steel	UK	tons	17,245	£97,446	£5.65	£104,958	247,404	229,697	75.08
	US1/	tons	53,614	$1269,337	$23.68	$1377,152	278,505	252,770	212.10
6. Tinplate	UK	tons	672	£8,745	£13.01	£9,167	20,059	19,136	35.1
	US	lbs	1,334,714						
		tons	596	$46,336	$77.76	$47,970	5,352	5,170	115.3
7. Wire	UK	tons	179.3	£2,608	£14.55	£6,588	17,016	6,736	26.62
	US2/	short tons	2,472						
		tons	2,207	$120,586	$54.64	$84.486	18,084	25,811	85.51
8. Copper	UK	tons	91.5	£8,303	£90.7	£17,160	19,956	9,656	9.48
	US2/	lbs	1,410,000						
		tons	629.5	$378,806	$601.8	$378,806	15,628	15,628	40.28
9. Lead & Zinc									
Lead	UK	tons	159	£3,191	£20.07				
Zinc	UK	tons	48	£1,161	£24.19				
Lead & Zinc	UK	tons	207	£4,352		£8,878	7,409	3,632	56.99
Lead	US	short tons	447	$167,406					
Zinc	US	short tons	256	$34,206					
Lead & Zinc	US4/	tons	628	$201,612		$201,612	12,092	12,092	51.91

Notes: 1/US output data given in long tons in the Census. US employment data calculated using separate information on coverage and employment for pig iron and for steel works and rolling mills.

2/The value of covered products is greater than the value of total output since the latter excludes iron and steel rolling mills.

3/US output data from Fabricant (1940), p.558. The value data include some secondary output of gold and silver.

4/US output data from Fabricant (1940), pp.559 and 565. The value data includes some secondary output of gold and silver. Because of this it is not possible to obtain meaningful unit prices for the US.

10. Cars, Bicycles and Motorcycles

[See table 3 in main text]

11. Shipbuilding

Country	Unit	(thousands) Quantity	(thousands) Value	Unit Value	(thousands) Value of Total Output	Operatives in Trade	Estimated Operatives	Output per Operative
UK1/	gross tons	1,614	$24,178	£14.98	£42,556	178,510	101,420	15.91
US	gross tons	467	$37,680	$80.69	$37,680	30,855	101,420	15.14

Notes: 1/UK data in the Census is for vessels worked on during the year, not necessarily launched during the year. However, this corresponds closely with the figure of 1,608,000 gross tons launched during the year from Lloyds' Register. US data is for gross tonnage launched. US employment data are provided separately for work on shipbuilding and repairing. US value data are from Fabricant (1940), p.590.

12. Machinery

Country	(thousands) Net Output	Operatives	Net Output per Operative
UK1/	£50,495	422,427	£119.54
US2/	$1,106,083	836,955	$1321.563/

Notes: 1/UK net output for mechanical engineering and electrical engineering.

2/US net output for Iron and Steel Products : industries making more highly elaborated products; Miscellaneous Industries : agricultural implements; electrical machinery apparatus and supplies; phonographs and graphophones; washing machines and clothes wringers.

3/The overall unit value ratio is £1 = $5.47.

APPENDIX IV : TEXTILES AND CLOTHING

Industry	Country	Unit	(thousands) Quantity	(thousands) Value	Unit Value	(thousands) Value of Total Output	Operatives in Trade	Estimated Operatives	Output per Operative
13. Cotton[3]									
(a) Spinning	UK	lb	1,487,367	£78,304	£0.053	£174,601	559,573	250,954	5,927
	US[1]	lb	470,380	$109,315	$0.232	$628,392	378,880	65,910	7,137
(b) Weaving	UK[2]	lin. yds.	7,019,729						
		sq.yds.	7,567,268	£81,313	£0.011	£174,601	559,573	260,597	29,038
	US	sq.yds.	6,348,569	$456,089	$0.072	$628,392	378,880	120,236	52,801
14. Woollen & Worsted									
Intermediate products	UK	lb	291,087	£26,720	£0.092				
Final products	UK[4]	lin.yds.	364,599						
		sq.yds.	506,428	£32,426	£0.064				
Total products	UK[5]	sq.yds.	895,400	£59,146		£75,905	254,378	198,214	4,517
Intermediate products	US	lb	172,852	$111,508	$0.645				
Final products	US	sq.yds.	570,744	$296,448	$0.519				
Total products	US	sq.yds.	801,808	$407,955		$419,744	163,192	158,609	5,055
15. Hosiery	UK	doz.pairs	14,389	£4,402	£0.306	£8,966	47,687	23,413	614.6
	US	doz.pairs	62,825	$68,722	$1.094	$200,144	129,275	44,388	1415.4
16. Rope and Twine	UK	cwt	1,413	£3,289	£2.328	£3,953	13,323	11,085	127.5
	US	lb	504,020						
		cwt	4,500	$42,865	$9.525	$61,020	25,820	18,138	248.1
17. Boots and shoes	UK	pairs	99,387	£20,225	£0.204	£20,957	117,565	113,459	845.4
	US[6]	pairs	285,017	£442,631	$1.553	$442,631	185,116	198,297	1437.3

Notes: 1/US spinning is for independent mills only. For US weaving, spinners from integrated concerns have been subtracted, on the basis of Rostas' (1948, p.130) estimate of the ratio of integrated to independent spinners for 1939 to 2.348.

2/UK weaving data converted to square yards from data for the 1924 Census, which suggests a conversion factor of 1.078.

3/The comparative productivity ratio for spinning and weaving combined has been calculated on the basis of UK value weights of 0.5 for both sectors.

4/UK output for final products has been converted from linear yards to square yards using the ratio from the 1924 Census of 1.389.

5/Intermediate products have been converted to final product equivalents at UK and US relative prices. The figure reported is the geometric mean of these two estimates.

6/US labour force includes cut stock and findings, since these were bought by footwear firms from specialist firms. UK output per operative has been calculated on the basis of operatives in the trade to match the US situation.

APPENDIX V : FOOD, DRINK AND TOBACCO

Industry	Country	Unit	(thousands) Quantity	(thousands) Value	Unit Value	(thousands) Value of Total Output	Operatives in Trade	Estimated Operatives	Output per Operative
18. Grain Milling	UK	cwt	153,874						
		tons	7,694	£65,291	£8.49	£65,697	29,112	28,932	265.9
	US[1]/	tons	21,698	$926,345	$42.69	$938,700	46,467	45,855	473.2
19. Butter & Cheese									
Butter	UK	cwt	1,100	£5,840	£5.31				
Cheese	UK	cwt	75	£193	£2.57				
Butter & Cheese[2]/	UK	cwt	1,136	£6,033		£10,164	7,754	4,603	246.8
Butter	US	lb	624,765						
		cwt	5,579	$179,511	$32.18				
Cheese	US	lb	311,126						
		cwt	2,778	$43,240	$15.57				
Butter & Cheese	US	cwt	6,911	$222,751		$274,558	18,431	14,267	484.5
20. Fish Curing	UK	cwt	2,925	£3,682	£1.26	£3,723	24,532	24,262	120.6
	US	lb	168,354						
		cwt	1,503	$10,075	$6.70	$17,573	9,926	5,691	264.1
21. Manufactured Ice	UK	tons	609	£389	£0.639	£390	1,085	1,082	562.8
	US	short tons	12,648						
		tons	11,293	$39,889	$3.532	$42,953	16,114	14,965	754.6
22. Sugar									
Sugar, Total	UK	cwt	14,610						
		tons	731	£10,922	£14.95	£12,315	5,836	5,176	141.1
Sugar, excluding cane sugar refining	US[3]/	short tons	829						
		tons	740	$72,033	$97.37	$78.743	11,331	10,394	71.2

Industry	Country	Unit	(thousands) Quantity	(thousands) Value	Unit Value	(thousands) Value of Total Output	Operatives in Trade	Estimated Operatives	Output per Operative
23. Brewing	UK4/	36 gal. barrels	34,505	£58,580	£1.698	67,250	85,743	68,320	505.0
	US5/	barrels 31 US gals.	56,400						
		36 gal. barrels	40,310	$374,730	$9.296	$374,730	54,579	54,579	738.6
24. Spirit Distilling	UK	gals.	48,086	£3,709	£0.077	£4,833	5,632	4,322	11,126
	US6/	gals.	119,571	$204,699		$204,699	6,430	6,430	18,596
25. Tobacco	UK	cwt	970	£23,452		£23,870	33,880	33,287	29.14
	US7/	cwt	5,262	$416,695		$416,695	166,810	166,810	31.55

Notes: 1/US output is measured in a variety of units. It has been assumed that a barrel is 200 lb, as in the 1939 Census.

2/Butter and cheese in butter equivalents, geometric mean of UK and US relative prices. US employment from sub-totals in Census.

3/No quantity data are available for US cane sugar refining. However, Taussig (1924) reports a US/UK output per worker ratio of 172.4 to 206.9 in cane sugar refining. We take the average value of 189.7 for cane sugar refining and combine it with the ratio of 50.5 for beet and cane sugar from the Census data, using net output weights from the US Census.

4/Operatives in the UK includes 16,753 from bottling.

5/US output figures from Fabricant (1940), p.412.

6/US output from Fabricant (1940), p.411, excludes distilled spirits produced by wine manufacturers. Using the 1914 ratio (Census, p.166) output excluding wine manufacturers is multiplied by a ratio of 1.766. US value data are seriously distorted by taxation, so a unit value ratio is not calculated for this sector.

7/US output is given in the number of cigarettes and cigars and the weight of other products, from Fabricant (1940), pp.414-415. Cigars and cigarettes were converted to weights using conversion factors from Rostas (1948), p.202.

APPENDIX VI : MISCELLANEOUS INDUSTRIES

Industry	Country	Unit	(thousands) Quantity	(thousands) Value	Unit Value	(thousands) Value of Total Output	Operatives in Trade	Estimated Operatives	Output per Operative
26. Cement	UK	tons	2,877	£3,439	£1.20	£3,735	13,860	12,762	225.4
	US 1/	barrels	66,690						
		tons	11,195	$53,611	$4.79	$63,205	26,775	22,710	493.0
27. Bricks	UK 2/	thousands	4,760	£6,329	£1.33	£8,316	65,866	50,128	95.0
	US 3/	thousands	15,738	$92,777	$5.90	$92,777	76,298	76,298	206.3
28. Paper	UK	cwt	17,342						
		tons	867	£13,026	£15.02	£13,621	38,642	36,954	23.46
	US	short tons	5,128						
		tons	4,578	$262,918	$57.43	$267,657	75,978	74,633	61.34
29. Musical Instruments									
Organs	UK	number	4.3	£30	£6.98				
Pianos	UK	number	58.1	£972	£16.73				
Pianolas	UK	number	0.5	£23	£46.00				
Total (piano equivalents)	UK	number	61.3	£1,025		£1,707	9,340	5,608	10.93
Organs	US	number	65.3	$5,309	$81.26				
Pianos	US	number	339.7	$50,226	$147.87				
Pianolas	US	number	45.4	$10,750	$236.81				
Total (piano equivalents)	US	number	469.5	$66,285		$89,790	38,020	28,067	16.73

Notes

1/US output data from the Census in barrels, in tonnage from Rostas (1948), p.10.

2/Output in thousands, thus quantity for UK is 4,760,000,000. Unit values are reported per 1,000 bricks.

3/US output in common brick equivalents from Rostas (1948), p.118.