MANUFACTURING AND THE CONVERGENCE HYPOTHESIS : WHAT THE
LONG RUN DATA SHOW

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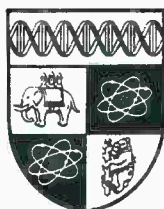
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I.   INTRODUCTION

This paper presents estimates of relative levels of labour productivity in manufacturing since 1870 for three of the major manufacturing economies. Comparative labour productivity trends in manufacturing for Britain, the US and Germany are very different from the trends in comparative GDP per employee, which inform most accounts of long run productivity performance (Maddison, 1982, 1991; Feinstein, 1988a; Baumol, 1986). First, the whole economy evidence suggests that the US overtook Britain as labour productivity leader in the early 1890s, then forged substantially ahead to 1950, with Britain pulling back close to American levels of labour productivity by the late 1980s. However, the evidence from manufacturing suggests that the US labour productivity levels were already about twice the British level in 1870, that the US superiority was still close to this two-to-one level in the late 1980s, although there had been substantial swings in comparative labour productivity in the intervening years, particularly across the two World Wars. Second, the whole economy evidence suggests that German labour productivity levels were substantially below the British level in 1870 and caught up only by the 1970s. However, the evidence from manufacturing suggests that German labour productivity levels were already close to British levels in the late nineteenth century, and pulled substantially ahead after the Second World War, particularly during the 1970s, although the gap narrowed substantially during the 1980s.

Although these trends are consistent with a form of catching-up (Abramovitz, 1986), since a period when one country widens its labour productivity lead is followed by a period when the gap narrows, they do

not suggest that the three countries should be seen as converging on the same level of labour productivity (Baumol, 1986). Thus rather than suggesting global convergence, they are consistent with a process of local convergence between Britain and Germany, but a persistent large gap between both European economies and the United States.

Section II sets out the details of the calculations, which involve matching time series data on labour productivity growth with benchmark estimates of comparative labour productivity levels. Section III considers the implications of the manufacturing results for the whole economy estimates of Maddison (1991). It is suggested that the broad trends of the two series are reconcilable. Section IV considers the implications for the convergence hypothesis, while Section V looks at the role of capital, providing estimates of total factor productivity to complement the figures on labour productivity. Section VI examines the implications of technological choice for productivity estimates by manufacturing branch.

II.   LABOUR PRODUCTIVITY IN MANUFACTURING

1.   Introduction

Time series on labour productivity in manufacturing can be obtained for the countries considered in this paper for the period since 1870. These time series can be linked to benchmark estimates of comparative labour productivity levels to provide a reconciliation of evidence on levels and rates of growth of labour productivity.

The extrapolation of benchmark comparisons to other years on

the basis of time series does not necessarily yield identical results compared to actual benchmark year comparisons because of traditional index number problems (Krijnse Locker and Faerber, 1984; Szilagyi, 1984). The existence of a number of benchmark comparisons between Britain and the US and between Britain and Germany thus provides a useful check on the extrapolations. It should be noted that since prewar benchmark estimates exist only for manufacturing and not for the rest of the economy, this check of consistency between time series and cross-sectional evidence is not possible for Maddison's (1982; 1991) extrapolations based on GDP per worker, which form the basis of the standard literature on long run productivity performance.

2.   Benchmark Estimates of Comparative Productivity Levels
      in Manufacturing

Table 1 presents an overview of the available benchmark estimates of manufacturing output per person employed. All comparisons are made on a binary basis with the UK. Prewar estimates are based on direct comparison of physical output per worker, following the methodology of Rostas (1948).

Postwar estimates of comparative labour productivity are based on comparisons of prices for individual products, following the methodology set out in Paige and Bombach (1959). The average price ratio is used to convert the output value in different countries to a common currency. In general the price ratios are unit value ratios (UVRs) which are obtained from the production censuses in each country as the quotient of the ex-factory sales value and the corresponding quantities (Maddison and van Ark, 1988). However, for the Germany/UK

1950 comparison, the price ratios are proxy PPPs (purchasing power
parities) for expenditure on manufactures from Gilbert and Kravis
(1954).

3.   Time Series of Labour Productivity in Manufacturing

Although table 1 provides useful information, the benchmark
estimates leave too many gaps to analyse long term comparative
productivity performance in detail. Other authors have provided long
time series of per capita income and labour productivity for the whole
economy by linking national time series of GDP and population or labour
input to benchmark estimates for a particular year (Maddison, 1982;
1991). In a similar way this study combines the benchmark results from
table 1 with time series on output and employment in manufacturing for
the years for which there are no benchmark estimates. In table 2, the
starting point for the extrapolations is the mid-1930s, or roughly
halfway through the sample period. This is preferred to the use of very
recent benchmarks, which would require extrapolations of more than a
hundred years to obtain estimates for the 1870s.

In table 2 it is useful to compare the extrapolations from the
mid-1930s benchmarks to the other direct benchmark comparisons, which
are reported in brackets. The results are in general reassuringly
close. The time series in Table 2 are presented in detail in an
appendix, but it will be useful to point out here some of the general
principles followed. First, it is important to ensure that the series
are collected on the same basis for different countries. For the post-
1950 period the time series generally refer to production census
information on net output and employment, with net output deflated by a

postwar price index for manufactures. However, for the pre-war period, given the general unavailability of reliable time series on real net output, industrial production indices have been used. For all three countries these indices are based on gross output indicators for individual industries, weighted by net output or employment shares (Fabricant, 1940; Carter et al, 1948). These series have the added advantage of being consistent with the pre-war benchmark comparisons, which are also based on gross output.

Second, time series of productivity can be strongly affected by using different sources for output and employment, which provides another reason to use production census data. Third, in some cases, time series for 'industry' need to be purged of mining, public utilities and construction. For Germany, the prewar output and employment series had to be recalculated for manufacturing only.

4.   Long Term Trends of Comparative Productivity in Manufacturing

The first conclusion to be drawn from Table 2 is that there has been a substantial US lead in manufacturing labour productivity going right back to 1869. Indeed, Broadberry (1992) suggests that the US had a two-to-one productivity advantage even in the mid-nineteenth century. The estimates in Table 2 suggest a widening of the gap between Britain and the USA across the First World War, followed by a narrowing of the gap during the Depression of the 1930s, which hit the US more severely than Britain. A further widening of the gap occurred across the Second World War, to be followed by a narrowing through to the 1980s. This time series evidence suggests that the US/UK labour productivity gap in 1987 was roughly equal to the gap in 1879, nearly 120 years

earlier.

The second conclusion apparent from Table 2 is that labour productivity in Germany was close to British levels in the 1870s to 1890s and although Germany pulled ahead somewhat by 1913, the First World War provided a setback and between the wars labour productivity in Germany remained close to the British level. After the Second World War, rapid labour productivity growth propelled Germany into a lead over the UK of nearly fifty percentage points by 1980, but the 1980s has seen a dramatic reversal of this, with a German lead of under ten percentage points by the late 1980s.

The above results suggest a long run stationarity of comparative labour productivity levels in manufacturing over a period of about 120 years. This is in marked contrast to the findings of convergence among the major industrialised countries, using data on GDP per worker. Thus it will be necessary to consider the issue of the reconciliation of the results for manufacturing and the whole economy in the next section.

First, however, note that these results are unlikely to be substantially altered by the use of hours worked rather than number of employees as the labour input. This paper concentrates on output per worker because historical information on hours worked is extremely unreliable. However, from what is known about working hours in history, it seems reasonable to conclude that hours have moved in similar ways in Britain, the US and Germany since 1870s. Maddison's (1991) figures in Table 3(a) relate to the whole economy, but for the pre-1950 period little is known about hours outside manufacturing, so they can be

regarded as representative of the manufacturing sector. However, for
the post-1950 period, it is possible to obtain more detailed estimates
for manufacturing alone. Van Ark's (1990) estimates in Table 3(b)
suggest that by 1987 differences in hours of work would lower the US/UK
productivity ratio by about 8%, and raise the Germany/UK ratio by a
similar amount. Clearly these adjustments are not trivial, but equally
they do not substantially change the overall picture of the productivity
rankings between the three economies.

III.   RECONCILING PRODUCTIVITY ESTIMATES FOR MANUFACTURING AND THE
        WHOLE ECONOMY

Table 4 shows estimates of GDP per employee for the whole
economy based on figures derived from Maddison (1991). These estimates
are obtained using time series on real GDP and employment for each
country, with a benchmark estimate of comparative levels of GDP per
worker based on 1985 purchasing power parities (PPPs). Maddison uses
binary 'Paasche'-type PPPs of national currencies compared to US
dollars, so that he obtains comparisons in terms of US relative prices.
These figures are shown on the left of Table 4 and provide the
quantitative basis of the conventional chronology of long run
comparative productivity performance outlined earlier; the US is seen as
overtaking Britain as the labour productivity leader in the early 1890s,
forging ahead to a substantial lead by 1950, followed by a closing of
the gap from 1950 to the 1980s; Germany is seen as coming from a labour
productivity level of less than half the British level in 1870 to a
small lead over Britain by the 1970s. Labour productivity levels in all
three economies are seen as fairly close by 1987, particularly in
comparison with the position in 1950. Thus the Maddison figures are

usually seen as consistent with the idea of convergence of labour productivity levels among the major industrialised countries (Baumol, 1986).

Note however that the use of binary Paasche-type PPPs exaggerates the convergence process. If in the US/UK comparison, for example, the US is relatively good at producing cars and the UK relatively bad, the relative price of cars will tend to be low in the US and high in the UK. Thus if output is valued at US prices, the high volume of US cars has a low value. However, if output is valued at UK prices, the high volume of US cars will have a high value. One common approach to the problem is to take the geometric mean of output valued at US and UK prices. Thus Table 4 also presents an adjustment to the Maddison figures using binary 'Fisher'-type PPPs. Note that this has the effect of substantially raising the level of productivity in the US relative to Britain and Germany. In particular, it should be noted that with the Fisher-type PPPs the US was already the labour productivity leader by 1870.

Comparing levels of GDP per worker from Table 4 with levels of manufacturing output per worker from Table 2, there are a number of striking differences. First, at the cross-sectional level, labour productivity gaps are always very different in manufacturing from those for the whole economy. In general, British performance is far worse in manufacturing than for the whole economy. Second, the time series reveal rather different patterns. For the whole economy, the US comes from behind, overtakes Britain and builds up a substantial lead which is then eroded from 1950, while Germany comes from labour productivity levels less than half the British level to a slight lead by the 1970s.

For the manufacturing sector, however, the US lead over Britain has remained of the order of two-to-one over the whole period, albeit with substantial fluctuations over sustained periods of a decade or more. Similarly, over the period as a whole, there is little trend in the Germany/UK relative labour productivity position in manufacturing, but again substantial fluctuations over sustained periods. Thus the issue of the reconciliation of this evidence from manufacturing and the whole economy is now addressed.

2.   Manufacturing and the Whole Economy : Cross-Sectional Evidence

British labour productivity performance over the whole period from 1870 has been substantially worse in manufacturing than for the whole economy. This applies to both the US/UK and Germany/UK comparisons, and raises questions about the compatibility of the manufacturing and whole economy estimates. Feinstein (1988a, p.3), for example, referring to the work of Smith et al (1982), uses the whole economy estimates to suggest that "the true gap in manufacturing... must be smaller than these 'industry of origin' calculations suggest". In fact, the two sets of estimates need not be inconsistent.

Paige and Bombach (1959) and Rostas (1948) worked up to estimates of comparative labour productivity for the whole economy on an industry-of-origin basis for the US and the UK. Their results for 1950 and 1937/35, respectively, suggest that the manufacturing and GDP estimates can be reconciled. Referring to Table 5, we see that for 1950, the productivity ratio of 273 for manufacturing is consistent with a substantially lower ratio of 193 for GDP because the American superiority was much smaller in the other sectors, particularly

agriculture, construction, distribution and services. A similar picture emerges from Rostas' (1948) estimates for major sectors in the USA (in 1937) compared to the UK (in 1935).

However, it should be noted that in some of the non-commodity sectors where output is not marketed (such as public administration, education, health, defence and research) price information does not exist, so the relative real output between countries is estimated on the basis of relative employment. Hence comparative output per employee is equal to 100 by construction. For the Paige and Bombach study, about 25 percent of GDP is affected in this way although this is not apparent from the table because of the level of aggregation. Thus it is possible that the comparisons using GDP per worker understate the productivity gap, rather than that the manufacturing estimates overstate it. Recent work on the measurement of real output in services suggests that progress can be made in this area (Pilat, 1991; Levitt and Joyce, 1987).

3.   Manufacturing and the Whole Economy : Time-Series Evidence

As well as a substantial difference in the level of comparative labour productivity between manufacturing and the whole economy at any point in time, however, there are very different trends over time. For these different trends to be reconcilable, it is required either that trends in other sectors offset the trends in manufacturing, or that the expansion and contraction in relative importance of sectors had substantial composition effects on overall labour productivity. In fact, both seem likely. As Broadberry (1992) notes, both effects can be seen at work in explaining the single biggest discrepancy between the manufacturing and GDP trends. In manufacturing

US labour productivity was substantially higher than in Britain throughout the nineteenth century, while for the whole economy, the US rose to leadership only in the 1890s. This US rise to leadership depended on the settling of the prairies and transport improvements outside manufacturing (Lee and Passell, 1979, Ch.13; Lebergott, 1983, Ch.22-23), and also on the growth in the relative size of US manufacturing from about 3% of employment in 1810 to nearly 20% by 1900 (Lebergott, 1966).

The catching-up by Germany and other European countries on British levels of GDP per worker since the late nineteenth century has been accompanied by a reduction in the share of economic activity accounted for by agriculture. Indeed, Dumke (1990) finds the share of the labour force in agriculture to be a highly significant variable in regressions explaining growth in a cross-section of countries for the postwar period. He concludes that the shift out of agriculture, which was already a very small sector in Britain by the late nineteenth century, was a very important part of the catching-up process in Europe. This view can also be found in Kaldor's (1966) explanation of slow productivity growth in postwar Britain as a result of 'premature maturity' and in Denison's (1967) assessment of the contribution of agricultural contraction to differences in growth rates in nine western countries.

However, before reaching the conclusion that all discrepancies can be swept away, it is necessary to discuss the choice of time series for the post-1950 period. For the US and UK, the time series for real output are based on production census net output deflated by a price index for manufactures. These series have been preferred to alternative

series produced for the national accounts. The problem is that in disaggregating GDP, the national accounts in the US and UK use rather idiosynchratic methods. The UK national accounts use indices of industrial production (CSO, 1968), while the US use a double-deflation procedure, with nominal inputs calculated as the difference between gross output and value added, the latter from the income side (Mishel, 1988).

The difference that this makes can be seen in Table 6, which presents output data from the production censuses and the national accounts, based on 1970 = 100. For the US, there is little difference between the two series for the period as a whole. Taking 1950 = 100, the Census series takes a value of 333.3 in 1987, while the national accounts series takes a value of 325.3. However, the time profiles of the series are very different; the Census series grows more rapidly between 1950 and 1970 (Gottsegen and Ziemer, 1968), while the national accounts series grows more rapidly between 1970 and 1987 (Lawrence, 1991; Mishel, 1988). For the UK, the two series are fairly close for the period from 1970 to 1987, but the Census series grows faster for the period 1950 to 1970 (Godley and Gillion, 1964a, 1964b; Ross, 1964).

The effect of using the national accounts series for both countries is thus to substantially reduce the extent of the closing of the gap between Britain and the US from 1950 to 1987, which, it should be noted, would strengthen the principal findings of this paper. However, in this study the census data have been preferred for a number of reasons. First, there is no reason to believe that the benchmark estimates reported in Table 1 are biased on the scale that would be implied by the national accounts series. Second, in a study of

productivity it is preferable to use output and input data from the same
source. With the production census, it is clear that the output and
employment refer to the same firms. And third, as has already been
pointed out, there are serious methodological differences in the way the
output series have been constructed in the US and the UK.

It should be noted, however, that rejection of the national
accounts series for real output in manufacturing does not imply
rejection of the national accounts aggregates built up from the
expenditure side. It is simly that within each country the aggregate
has been decomposed in different ways on the output side.

IV.   THE CONVERGENCE HYPOTHESIS

Most authors conclude that there has been convergence of GDP
per worker among the major industrialised countries since 1870
(Abramovitz, 1986; Baumol, 1986; De Long, 1988; Baumol and Wolff, 1988;
Dowrick and Nguyen, 1989; Wolff, 1991). Furthermore, this is usually
explained in terms of technology transfer in manufacturing (Gomulka,
1971; Cornwall, 1977; Nelson and Wright, 1992).

Within manufacturing, however, there is a persistent large
labour productivity gap between the United States on the one hand and
Britain and Germany on the other hand. Nevertheless, periods of one
country altering its comparative labour productivity position are
generally followed by periods of 'catching-up', restoring the long run
comparative position. To use the terminology of Durlauf and Johnson
(1992) there is evidence of local convergence but without global
convergence.

If, as has been argued in this paper, the results for manufacturing are consistent with the results for the whole economy, this suggests that the global gonvergence of GDP per worker cannot be explained in terms of technology transfer in manufacturing. This, in turn, suggests the need for a more general view of the catching-up process. In addition to composition effects through structural change, productivity trends in sectors other than manufacturing have a role to play, and this suggests a more general view of how following countries borrow from the leader in the process of catching up. Feinstein (1990, p.290) argues that borrowing from the leader can occur across a wide range of activities, including "property rights and legal procedures, corporate structures and management hierarchies, banking systems and intermediate sources of finance, forms of taxation and of insurance, industrial relations and personnel management".

V.   THE ROLE OF CAPITAL

It has been suggested in much of the literature on Anglo-American comparisons that at least part of the difference in labour productivity levels between the two countries has been due to the use of more capital per worker in the US (Habakkuk, 1962; Rostas, 1948; Frankel, 1957; Davies and Caves, 1987). Hence it is of some interest to calculate comparative levels of total factor productivity (TFP) as well as labour productivity.

Comparative TFP levels for two countries can be calculated as the geometric weighted average of comparative capital productivity and

comparative labour productivity, according to the formula:

$$\frac{TFP^*}{TFP} = \left[\frac{Y^*/K^*}{Y/K} \right]^{\alpha} \left[\frac{Y^*/L^*}{Y/L} \right]^{1-\alpha} \tag{1}$$

where Y is output, L is employment and K is the capital stock. Variables relating to the US are indicated by an asterisk. The weights are given by the shares of capital and labour in net output. The share of wages in net output $(1 - \alpha)$ is 0.77, which is the geometric mean of US and UK shares for 1975 (van Ark, 1990). Equation (1) can be written equivalently as the ratio between comparative output levels and comparative total factor input (TFI):

$$\frac{TFP^*}{TFP} = \frac{Y^*/L}{(K^*/K)^{\alpha} \ (L^*/L)^{1-\alpha}} = \frac{Y^*/Y}{TFI^*/TFI} \tag{2}$$

The benchmark level of US/UK comparative TFP can be established for 1975 using data from van Ark (1990). Post-1950 gross capital stock series in manufacturing are available from the US and UK national accounts. Before 1950, gross capital stock series are taken from Feinstein (1972; 1988b) for the UK and from Kendrick (1961) for the US.

The results using the official estimates of the capital stock for the postwar period are shown in Table 7(a). From 1880 onwards, the TFP results are more favourable to the UK than the labour productivity results. Prior to that date, however, the capital stock estimates suggest greater capital per worker in the UK, so that the TFP results

are more favourable to the US.

Van Ark (1990) also presents some figures on standardised capital stock estimates for the postwar period, and these are used in Table 7(b). The official capital stock estimates are based on very different assumptions about asset lives in the two countries. For non-residential buildings, asset lives are assumed to be 60 years in the UK and 25 years in the US, while for industrial equipment asset lives are assumed to be 25 years in the UK and 19 years in the US. Since the capital stock estimates are obtained by cumulating investments and allowing for retirements, these assumptions tend to result in a large UK capital stock for relatively little investment, and a small US capital stock despite relatively high investment. Given that very little is actually known about asset lives, it is also useful to calculate standardised capital stocks, with the same asset life assumptions for both countries. Van Ark (1990) calculates standardised capital stocks for the UK and the US based on common asset life assumptions of 45 years for structures and 20 years for equipment. These assumptions lead to the conclusion that capital per worker was substantially greater in the US during the postwar period, so that the TFP gap between Britain and the US was substantially narrower than the labour productivity gap.

However, the prewar estimates of capital are much more heavily based on stock data rather than on cumulated investments, so that similar calculations of standardised capital stocks would be inappropriate (Creamer, 1954; Feinstein, 1988b). Thus it seems likely that the finding of greater output per worker in the US but greater capital per worker in the US during the nineteenth century is not a statistical artefact. Field (1983, p.408) explains this apparent

paradox by higher American interest/profit rates (due to land abundance) which led to the choice of "shorter lived capital goods, faster operational speeds and organisational forms that economise on inventory stocks". An alternative explanation might be to distinguish between skilled and unskilled manufacturing, with only the former being more capital intensive in the US, and the UK having greater capital intensity in manufacturing as a whole (James and Skinner, 1985).

Repeating the TFP calculations for the Germany/UK comparison in Table 8 using the official capital stock estimates, again physical capital does not at first sight play a major role in explaining labour productivity differences. However, O'Mahony (1992) shows that standardising the asset lives between the two countries implies that capital per worker in Germany was 127.3 percent of the British level in 1987 rather than 76.4 percent as in Table 8. But again, it would be inappropriate to standardise the prewar estimates, which are based largely on stock data.

Finally, it should be noted that even if it is accepted that the standard growth accounting framework gives too small a weight to capital, a large portion of the productivity level differences identified in this paper remains unexplained by capital. The standard Solow (1957) approach weights capital by its share in income, which is usually about 0.3. However, even if Romer's (1986) extreme case of constant returns to capital were accepted, and capital given a weight of unity, this would not help to reconcile the nineteenth century finding of higher labour productivity in the US and higher capital intensity in Britain.

VI. TECHNOLOGICAL CHOICE AND PRODUCTIVITY ESTIMATES BY

MANUFACTURING BRANCH

For the nineteenth century, there is an extensive literature linking the US productivity advantage in manufacturing to technological choice through resource endowments. Habakkuk's (1962) development of Rothbarth's (1946) thesis suggested that land abundance and labour scarcity in America led to high relative wages and substitution of capital for labour. However, we have seen that capital per worker was greater in Britain, so the simplest form of the Habakkuk thesis cannot be correct. A more subtle formulation by Ames and Rosenberg (1968) argued that American firms substituted cheap resources and resource-using machinery for skilled labour, thus emphasising the complementarity between machinery and resources. This substitution raised output per worker in America as firms moved towards standardised mass production. British and German firms could not initially adopt machinery which was very wasteful of resources and continued to compete on the basis of skilled labour. The wood lathe is the classic early example of a machine which was very wasteful of resources and could not be adopted in Europe where wood costs were much higher. It should be emphasised that the Ames and Rosenberg formulation is quite consistent with the finding of higher capital per worker in the UK as machinery forms only a small part of the capital stock which is dominated by structures (Field, 1985).

However, American mass production techniques could not be successfully applied at the same time in all industries. For example, in shipbuilding it was only in the 1950s with the perfection of welding and prefabrication techniques that mass production techniques could be

widely used. Furthermore, it should be emphasised that the response of the European firms in not immediately adopting American technology was perfectly consistent with rational behaviour given their different resource endowments and relative factor prices. Indeed, many studies document the rationality of the response of British entrepreneurs to the American innovations of the late nineteenth century (McCloskey, 1973; Harley, 1974; Sandberg, 1974). Often, the new American technologies improved over time or had to be adapted to local circumstances before they became profitable. In some cases British firms were able to compete successfully for some time with incremental improvements in British technology raising productivity and offsetting improvements in American technology (Sandberg, 1974; Lorenz and Wilkinson, 1986). In other cases, as the American techniques improved, British firms were forced at some point to switch to more American methods of production (Lewchuk, 1987).

In these circumstances, we should expect comparative productivity ratios to vary by industry and these patterns of comparative productivity to change over time. The figures by manufacturing branch in tables 9 and 10 can be interpreted in this light. In textiles, for example, British craft production methods with skilled labour continued to compete effectively with American methods before the Second World War, while from 1950, Britain's comparative productivity position in textiles converged toward the position for aggregate manufacturing.

The other sector where British productivity performance was relatively good before the Second World War was food, drink and tobacco (Broadberry and Crafts, 1990). This is an interesting case in that in

these process industries, Britain was quick to develop large scale
production catering for standardised demand along American lines
(Jefferys, 1954; Mathias, 1967; Vaizey, 1960; Alford, 1973). This shows
up clearly in the comparative productivity figures for the first half of
the twentieth century, in both the US/UK and Germany/UK comparisons.

Turning to the heavier industries, the comparative
productivity picture in engineering appears to have been dominated by
sectors such as motor vehicles, where a large American productivity lead
developed on the basis of mass production techniques in the first half
of the nineteenth century, but with British firms continuing to compete
on the basis of skilled labour. The adaptation of American
multinationals in motor vehicles to European conditions confirms the
rationality of different strategies of technological choice on both
sides of the Atlantic (Foreman-Peck, 1982). The eventual switch by
British firms to a more American style of production from the late 1960s
has seen a convergence of relative productivity in engineering towards
the figures for aggregate manufacturing. However, even within
engineering the picture was not uniform; we have already noted that in
shipbuilding mass production techniques did not become dominant until
the 1950s and Britain continued to compete effectively on the basis of
skilled labour until this time.

Comparative productivity trends in chemicals and basic metals
are similar to trends in engineering, with a recent improvement in
British performance removing a long-standing above-average productivity
gap in these sectors.

A number of authors have suggested that other factors besides

resources and technological choice have contributed to the US
productivity lead. Frankel (1957), Rostas (1948) and Chandler (1990)
among others, have stressed the larger market size in America, allowing
longer production runs. One of the difficulties with this argument is
that the large US productivity lead in manufacturing goes back to the
mid-nineteenth century, when US population was not substantially larger
than the British population (Maddison, 1991, table B.4). However,
Nelson and Wright (1992) argue that the basis of the American
productivity lead may have changed over time. Indeed, they now see US
leadership as having more to do with research and development than with
resources.

The R+D argument does seem to be a promising way of
integrating human capital into the explanation of productivity
differences along the lines suggested by recent work on growth theory
(Romer, 1990). This is particularly the case, given the reliance of
European countries on skilled labour, the other common way of measuring
human capital (Prais, 1989).

VII.   CONCLUDING COMMENTS

This paper suggests that the commonly accepted chronology for
comparative labour productivity levels, based on GDP data, does not
apply to the manufacturing sector. In manufacturing, although there
have been substantial swings in comparative labour productivity for
periods of a decade or so, over the long run there is evidence of a much
greater degree of stationarity of comparative labour productivity
performance. In particular, the US has continued to enjoy a substantial
labour productivity lead over Britain and Germany. This cannot be

explained simply by differences in capital intensity; these differences in labour productivity are also reflected in differences in total factor productivity. Rather, it is argued that technological choice is responsible for the large productivity gap between the US and Europe. Branch level estimates are seen to be consistent with this view. These results for manufacturing suggest that convergence of GDP per worker must have occurred through trends in other sectors and through compositional effects of structural change.

TABLE 1 : Benchmark Estimates of Manufacturing Output per Person
Employed (UK=100)

	US/UK	Germany/UK
1907	201.9	
1935		102.0
1937	208.3	
1950	273.4	99.5
1968	272.7	130.4
1975	224.7	
1977	251.0	
1987	186.6	112.7

Notes: (1) In some cases the comparisons were based on production census
data for slightly different years (e.g. 1967 for Germany and
the US compared to 1968 for the UK) and an adjustment has
been made to bring the comparison onto a single year basis.

(2) The estimates shown here are geometric averages of the
productivity ratios at each country's own weights and at UK
weights.

Sources: US/UK : 1907 from Broadberry (1991); 1937 from Rostas
(1948); 1950 from Paige and Bombach (1959); 1968
from Smith et al (1982); 1975 from Van Ark
(1990); 1977 from Smith (1985); 1987 from Van
Ark (1992).

Germany/UK : 1935 from Broadberry and Fremdling (1990); 1950,
Census data converted at 'proxy' purchasing
power parity for manufactured products from
Gilbert and Kravis (1954); 1968 from Smith et al
(1982); 1987 from O'Mahony (1992).

TABLE 2 : Manufacturing Output per Person Employed (UK=100)

	US/UK		Germany/UK	
1869	203.8			
1875			100.0	
1879	187.8			
1882			83.6	
1885			94.5	
1889	195.4		94.7	
1899	194.8		99.0	
1907	192.0	(201.9)	106.4	
1913	212.9		119.0	
1920	222.8			
1925	234.2		95.2	
1929	249.9		104.7	
1935	207.8		*102.0	(102.0)
1937	*208.3	(208.3)	99.9	
1950	262.6	(273.4)	96.0	(99.5)
1958	250.0		111.1	
1968	242.6	(272.7)	120.0	(130.4)
1975	207.5	(224.7)	132.9	
1977	229.6	(251.0)	148.6	
1980	192.8		140.2	
1984	183.3		122.7	
1987	188.8	(186.6)	107.8	(112.7)
1989	177.0		105.1	

Notes: *Benchmark year from which the time series are extrapolated.
The figures in brackets are actual benchmark comparisons from
Table 1.

Source: Time series of output and employment from Appendix Table A1.

TABLE 3 : Annual Hours Worked per Person

(a) Maddison's Estimates

	UK	US	Germany
1870	2984	2964	2941
1890	2807	2789	2765
1913	2624	2605	2584
1929	2286	2342	2284
1938	2267	2062	2316
1950	1958	1867	2316
1960	1913	1795	2081
1973	1688	1717	1804
1987	1557	1608	1620

Source: Maddison (1991) Table C9.

(b) Van Ark's Estimates, for Manufacturing Only

	UK	US	Germany
1950	2019	1965	2325
1960	2045	1933	2097
1973	1849	1930	1832
1987	1763	1911	1630

Source: Van Ark (1990), Table C1, O'Mahony (1992) table A4.

TABLE 4 : GDP per Person Employed (UK=100)

	Paasch-type PPPs		Fisher-type PPPs	
	US/UK	Germany/UK	US/UK	Germany/UK
1870	95.1	47.8	105.9	48.8
1890	98.1	52.3	109.2	53.4
1913	127.9	62.9	142.4	64.1
1929	154.0	63.1	171.4	64.4
1938	143.0	73.4	159.3	74.9
1950	167.4	62.1	186.4	63.3
1960	167.5	88.4	186.5	90.2
1973	151.6	102.6	168.8	104.7
1987	128.9	103.5	143.5	105.6

Source: 1985 GDP at national currencies, and the indices of GDP and
employment derived from Maddison (1991). In addition to the
results using Maddison's Paasche-type PPPs of national
currencies to US dollars, results using Fisher-type PPPs are
presented for comparability with Table 2.

TABLE 5 : US/UK GDP per Employee by Major Sector (UK=100)

	1937/35	1950
Agriculture	103	207
Extractive and Utilities	316	689
Manufacturing	215	273
Construction	115	150
Transport and Communications	282	323
Distribution	150	178
Services incl. Finance, Public and Professional	132	122
GDP	173	193

Source: 1937/35 Rostas (1948) with weights from Matthews et al (1982)
            1950   Paige and Bombach (1959)

TABLE 6 : Production Census and National Accounts Manufacturing
Output Data (1970=100)

	US		UK	
	Census	NA	Census	NA
1950	42.0	50.9	41.2	53.6
1970	100.0	100.0	100.0	100.0
1987	140.0	165.6	104.3	107.1

Source: Census: Appendix Table A1.
            National Accounts (NA): Van Ark (1990) Annex Table C1.

TABLE 7 : Comparative US/UK Levels of Labour Productivity, Total Factor Productivity and Capital per Worker (UK=100)

(a) Official Capital Stock Data

	Y/L	K/L	TFP
1869	203.8	93.7	204.9
1879	187.8	91.8	189.7
1889	195.5	159.0	174.0
1899	194.8	188.2	166.8
1909	208.5	183.0	179.7
1919	206.9	178.1	179.5
1929	249.9	173.1	218.2
1937	208.3	151.2	187.7
1950	262.6	155.2	235.1
1958	250.0	165.1	220.7
1968	242.7	133.1	225.1
1975	207.5	142.1	189.2
1980	192.9	120.7	183.0
1984	183.3	110.5	177.5
1987	188.8	109.9	183.1

(b) Standardised Capital Stock Data

	Y/L	K/L	TFP
1950	262.6	251.3	199.1
1958	250.0	264.1	187.4
1968	242.7	202.7	193.3
1975	207.5	206.6	166.6
1980	192.9	174.4	159.0
1984	183.3	166.7	152.7
1987	188.8	172.8	156.1

Source: Appendix Tables A1 and A2 for basic series.   Standardised estimates from van Ark (1990).

TABLE 8 : Comparative Germany/UK Levels of Labour Productivity, Total Factor Productivity and Capital per Worker (UK=100)

	Y/L	K/L	TFP
1875	100.0	60.4	116.4
1882	83.6	58.8	98.1
1889	94.7	71.2	104.9
1899	99.0	97.6	99.8
1909	117.7	98.0	118.5
1913	119.0	105.3	117.2
1925	95.2	61.0	110.5
1929	104.7	67.1	118.0
1937	99.9	73.2	109.8
1950	96.0	77.8	103.6
1958	111.1	71.5	122.8
1968	120.0	95.3	121.8
1975	132.9	107.2	130.2
1980	140.2	92.7	143.5
1984	122.7	81.2	130.7
1987	107.8	76.4	116.9

Source: Appendix Tables A1 and A2.

TABLE 9 : US/UK Manufacturing Output per Employee (UK=100)

	1909/07	1937/35	1950	1967/68	1975	1987
Chemicals and Allied	156.4	226.9	356.4	281	226.8	152.4
Basic Metals	288.0	192.0	274.4	261	251.1*	166.2*
Engineering incl. Metal Products	202.3	289.1	337.3	294	190.6*	185.8*
Textiles, Leather and Clothing	150.7	145.4	197.9	225	222.8	174.0
Food, Drink and Tobacco	137.2	203.5	215.3	246	208.4	232.9
Other, incl. Wood, Paper and Stone	227.2	210.8	284.7	276	274.8	207.5
Total Manufacturing	208.5	217.9	273.4	276	224.7	186.6

*Metal Products included with Basic Metals

Source: 1909/07 : Broadberry (1992)
 1937/35 : Rostas (1948)
 1950   : Paige and Bombach (1959)
 1967/68 : Smith et al (1982)
 1975   : van Ark (1989, 1990)
 1987   : van Ark (1992)

TABLE 10 : Germany/UK Manufacturing Output per Employee (UK=100)

	1935	1967/68	1987
Chemicals and Allied	122.9	124.0	88.5
Basic Metals	116.0	136.7	96.1
Engineering incl. Metal Products	119.7	116.8	111.6
Textiles, Leather and Clothing	97.2	107.9	109.0
Food, Drink and Tobacco	41.3	94.2	114.1
Other, incl. Wood, Paper and Stone	101.8	140.6	131.6
Total Manufacturing	102.0	118.9	112.7

Source: 1935   : Broadberry and Fremdling (1990)
 1967/68 : Smith et al (1982)
 1987   : O'Mahony (1992)

APPENDIX 1 : TIME SERIES ON OUTPUT, AND EMPLOYMENT

TABLE A1 : Real Output and Employment in Manufacturing (1929=100)

	UK		US		Germany	
	Output	Employment	Output	Employment	Output	Employment
1869	29.3	66.9	7.1	19.9		
1870	31.8	68.8			16.3	
1871	34.6	70.8			18.2	
1872	35.4	71.7			20.9	
1873	36.2	72.1			21.8	
1874	37.0	72.2			22.2	
1875	36.5	72.3			22.0	45.6
1876	36.6	71.8			22.3	
1877	37.4	71.5			22.0	
1878	36.6	70.5			22.7	
1879	34.5	67.6	10.2	26.6	23.0	
1880	40.1	72.3			22.3	
1881	41.6	74.1			23.4	
1882	44.3	75.9			23.3	50.0
1883	44.6	76.6			25.0	
1884	42.4	73.0			26.1	
1885	40.4	72.9			26.5	52.9
1886	40.1	73.0			27.0	54.5
1887	43.9	75.9			28.6	55.8
1888	46.9	79.0			30.1	57.6
1889	50.3	82.4	18.3	38.3	33.2	60.0
1890	50.7	85.5	19.7	39.9	33.5	62.1
1891	51.2	83.1	20.2	41.1	34.2	61.8
1892	47.9	81.5	21.9	43.6	35.0	61.6
1893	47.8	84.5	19.4	42.1	36.3	61.7
1894	49.4	82.4	18.8	40.0	38.4	62.3
1895	52.5	84.1	22.4	43.6	41.5	64.1
1896	59.7	86.6	20.4	42.7	43.7	67.3
1897	57.3	87.9	22.0	44.2	44.7	69.9
1898	60.6	89.1	25.1	45.4	47.4	72.3
1899	63.0	90.6	27.5	50.8	48.7	74.1
1900	62.3	90.3	27.7	52.8	48.6	75.9
1901	62.1	90.2	30.9	55.5	48.6	74.8
1902	62.3	90.4	35.5	60.4	49.6	74.5
1903	60.8	90.9	35.4	62.7	53.0	76.0
1904	61.2	90.4	34.2	59.1	55.2	78.0
1905	66.5	92.1	39.0	66.1	57.6	80.0
1906	69.6	94.3	41.6	69.6	59.7	82.2
1907	71.5	95.0	42.1	72.8	64.1	83.7
1908	65.4	91.6	33.7	65.2	64.8	82.4
1909	66.2	92.4	43.4	72.7	66.3	82.4
1910	66.9	96.2	45.1	76.0	68.9	84.9
1911	72.6	98.6	42.7	76.0	73.1	87.1
1912	75.6	99.6	51.3	79.4	78.6	89.5
1913	80.5	102.2	53.8	80.2	80.9	90.4
1914	75.0		51.1	77.4		
1915	78.9		59.9	80.9		
1916	73.9		71.2	95.4		
1917	68.4		70.6	102.0		
1918	66.4		69.8	104.0		

	UK		US		Germany	
	Output	Employment	Output	Employment	Output	Employment
1919	74.3		61.0	100.3		
1920	81.7	110.5	66.0	100.1		
1921	63.6	86.9	53.5	77.4		
1922	74.0	90.9	68.1	84.7		
1923	79.3	93.3	76.9	96.2		
1924	87.3	94.9	73.4	90.2		
1925	90.0	95.5	81.9	92.7	84.7	98.8
1926	87.1	92.8	86.2	94.7	75.9	87.0
1927	96.3	98.7	87.1	93.5	97.3	100.8
1928	96.1	98.6	90.1	93.8	98.4	103.6
1929	100.0	100.0	100.0	100.0	100.0	100.0
1930	95.7	93.0	85.6	89.2	88.4	90.3
1931	89.2	86.8	72.0	75.6	74.0	77.1
1932	89.7	88.1	53.8	63.9	64.5	65.8
1933	96.3	91.4	62.8	98.9	71.0	70.1
1934	105.1	95.6	69.1	79.9	85.6	81.9
1935	114.6	97.9	82.8	85.1	102.3	89.7
1936	125.3	103.3	96.8	92.2	112.9	96.7
1937	132.9	108.5	103.3	101.2	122.3	104.6
1938	129.0	106.9	80.9	87.4	136.3	110.4
1939			102.5	95.5		
1940			118.6	104.3		
1941			157.9	125.7		
1942			197.2	146.1		
1943			238.1	166.3		
1944			232.5	163.1		
1945			196.5	145.5		
1946	135.0		160.6	139.1		
1947	142.8		178.3	145.9		
1948	155.7	127.2	184.2	146.5		
1949	165.7	129.5	173.5	136.1		
1950	177.1	132.8	201.1	143.5	77.8	63.6
1951	184.0	144.5	206.2	151.9	89.7	71.3
1952	183.3	141.6	225.5	156.0	101.5	73.8
1953	201.2	142.9	251.6	166.1	113.2	76.9
1954	222.4	146.0	240.1	156.7	126.7	81.6
1955	234.4	150.5	273.9	163.4	148.3	89.3
1956	237.4	150.5	282.9	166.9	160.0	95.4
1957	242.4	151.4	279.9	166.2	170.9	98.7
1958	252.1	148.1	265.2	155.7	179.9	99.6
1959	270.6	148.4	300.2	161.9	196.9	100.7
1960	296.4	154.3	304.2	162.9	223.2	106.0
1961	301.0	156.0	306.0	158.7	235.9	109.1
1962	306.2	153.8	333.2	162.9	246.3	109.6
1963	321.5	151.4	358.1	164.8	249.5	108.9
1964	350.7	153.5	382.5	167.8	273.5	108.9
1965	360.7	155.0	414.0	175.0	293.7	110.8
1966	367.0	155.0	445.1	184.8	296.5	109.6
1967	369.4	150.2	460.5	187.7	287.6	103.7
1968	395.1	149.0	488.7	189.7	317.7	104.5
1969	419.3	152.1	503.9	194.7	356.2	108.9
1970	430.3	152.9	478.8	186.7	373.1	111.4

	UK		US		Germany	
	Output	Employment	Output	Employment	Output	Employment
1971	422.8	149.0	485.2	178.4	376.4	110.6
1972	443.5	143.1	527.7	184.9	388.2	108.6
1973	482.4	145.0	551.8	192.8	412.1	109.3
1974	485.8	147.6	516.1	192.8	409.8	106.8
1975	437.5	142.1	454.6	177.8	391.9	100.2
1976	448.6	139.0	502.5	182.2	422.9	98.0
1977	428.7	138.6	541.0	190.3	431.9	98.3
1978	439.0	135.3	545.0	199.2	439.4	98.2
1979	457.1	131.9	574.2	204.4	461.5	99.4
1980	416.9	124.1	520.1	200.6	451.1	100.2
1981	392.6	110.4	514.7	196.9	448.3	98.3
1982	386.0	102.4	494.9	185.5	431.9	95.5
1983	395.4	97.0	524.3	181.8	438.4	92.3
1984	404.7	96.7	570.5	185.8	451.1	91.9
1985	412.2	95.1	577.7	182.6	468.5	93.0
1986	419.7	93.2	611.4	178.5	472.3	94.6
1987	448.8	93.1	670.5	184.1	469.9	94.6
1988	477.9	94.2	694.8	186.0	484.5	94.5
1989	496.2	94.6	687.2	185.0	504.7	95.9

SOURCES FOR TABLE A1

UNITED KINGDOM

Output

1869-1950 : Feinstein (1972) Table 51.
1950-1989 : Census of Production, net output deflated by producer price index for manufacturing from Annual Abstract of Statistics. For the period 1950-70, interpolated onto an annual basis using industrial production index from the National Accounts.

Employment

1869-1950 : Feinstein (1972) Tables 59 and 60. An adjustment has been made for the exclusion of Southern Ireland from 1920, using an estimate of employment in manufacturing in the Irish Republic in 1926 from Mitchell (1988, p.110). Before 1920, annual estimates are obtained by interpolation using Feinstein's (1972, Table 57) series on civil employment.

1950-1989 : Census of Production. For the period 1950-70, annual estimates obtained by interpolation using employment data from Feinstein (1972, Table 57), British Labour Statistics Historical Abstract and British Labour Statistics Yearbook, 1976.

UNITED STATES

Output

1869-1950 : Kendrick (1961) Table D-II.
1950-1989 : Census of Manufactures, net output (census value added) deflated by producer price index for manufacturing produced by the Bureau of Labour Statistics.

Employment

1869-1950 : Kendrick (1961), Table D-II.
1950-1989 : Census of Manufactures, <u>Annual Survey of Manufactures</u>.

GERMANY

Output

1869-1950 : Hoffmann (1965) Table 76, reweighted to exclude construction and gas, water and electricity.
1950-1989 : <u>Volkswirtschaftliche Gesamtrechnungen Fachserie 18, Reihe S.15</u>. Revidierte Ergebnisse, 1950 bis 1990, Statistisches Bundesamt, 1991.

Employment

1989-1950 : Hoffmann (1965) Table 15, excluding construction and gas, water and electricity.
1950-1960 : <u>Lange Reihen zur Wirtschaftsentwicklung</u>, 1988.
1960-1989 : <u>Volkswirtschaftliche Gesamtrechnungen, Fachserie 18, Reihe S.15, Revidierte Ergebnisse, 1950 bis 1990</u>, Statistisches Bundesamt, 1991.

APPENDIX 2 : TIME SERIES ON CAPITAL

TABLE A2 : Gross Reproducible Capital Stock at Constant Replacement Cost in Manufacturing (1929=100)

	UK	US	Germany
1869	27.0	4.4	
1875	32.3		18.4
1879	36.3	7.6	
1882	38.4		22.2
1889	41.2	17.6	31.9
1899	48.1	29.3	57.2
1909	65.4	54.4	85.1
1913	72.6		100.8
1919	91.0	92.9	
1925	97.7		91.8
1929	100.0	100.0	100.0
1937	104.8	85.4	110.2
1950	140.8	136.5	78.2
1958	184.4	185.0	132.2
1968	268.2	262.8	267.1
1975	322.5	344.9	374.6
1980	368.5	415.7	411.3
1984	376.5	461.9	433.3
1987	384.8	483.0	445.7

SOURCES FOR TABLE A2

United Kingdom

1869-1920 : Feinstein (1988) Table XI.
1920-1950 : Feinstein (1972) Table 45.
1950-1987 : C.S.O., National Income and Expenditure (The 'Blue Book').

United States

1869-1950 : Kendrick (1961) Table D-I.
1950-1982 : US Department of Commerce, National Income and Product Accounts.
1982-1987 : Survey of Current Business.

Germany

1875-1959 : Hoffmann (1965) Table 39.
1959-1987 : Statistisches Bundesamt, Volkswirtschaftliche Gesamtrechnungen, Fachserie 18, Reihe S.15, Revidierte Ergebnisse, 1950 bis 1990.

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