The coat of arms of the University of Groningen is a complex heraldic shield. It features a central figure holding a staff, surrounded by various symbols including a lion, a bear, and a ship. The shield is divided into several sections with different patterns and colors. The text 'VER BYM DNI' and 'LV CER NA' is visible on the shield.

**A Comparison of Real Output and Productivity for British  
and American Manufacturing in 1935**

Research Memorandum GD-108

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# **A Comparison of Real Output and Productivity for British and American Manufacturing in 1935<sup>1</sup>**

March 2009

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## **Abstract:**

The manufacturing productivity gap between the U.S. and the U.K. became much larger during the interwar period than existing estimates suggest. This paper presents a new estimate based on real value added and hours worked. First, a detailed benchmark comparison for 1935 is constructed using official industrial census reports. Second, structural shift methodology is applied to analyse productivity movements for industrial branches in the period 1900-1957. U.S. manufacturing shows high comparative levels and growth rates for chemicals and engineering. These results support revisionist accounts of Robert Gordon and Alexander Field on the Depression's strengthening of American productivity leadership.

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<sup>1</sup> We have received helpful comments and suggestions from Steve Broadberry, Stanley Engerman, Knick Harley, Angus Maddison, Patrick O'Brien, and participants of the 2007 EHES conference in Lund, the Hi-Stat workshop on Historical Comparisons of International Income and Productivities, 26 September 2007 in Tokyo and the conference 'Economic Structure and Performance of Nations' 21-22 February 2008 in Groningen. We are responsible for all errors. Pieter Woltjer's research was supported by a grant from the Netherlands Organisation for Scientific Research (NWO).

## ***A Comparison of Real Output and Productivity for British and American Manufacturing in 1935***

The large productivity lead that the United States achieved over Western Europe by the mid-twentieth century is one of the most characteristic long term aspects of American economic development. Whether it was created by ‘good fortune, Yankee ingenuity, or European stupidity’, however, still remains an open question.<sup>2</sup> The present study contributes to the issue of when and how manufacturing labour productivity in the United States moved way ahead of Great Britain and of continental Europe. The question why American industry achieved superior efficiency is well-covered by the Rothbarth-Habakkuk thesis and supplementary refinements by others: Already by the nineteenth century the scarcity of labour and capital relative to land had stimulated manufacturing firms in America to economize on shopfloor labour and capital, resulting in high levels of productivity.<sup>3</sup> Additionally, American producers faced a large domestic market for standardized products.<sup>4</sup> Together with abundance of nonreproducible resources the American economy was able to apply high-throughput production methods, and to maximize levels of capacity utilization by making use of new technically and managerially advanced corporate institutions.<sup>5</sup> By the start of twentieth century the United States had established a position of leadership in mass production and mass distribution industries. The persistence of U.S. leadership into the twentieth century has been explained by path dependency in investment patterns and by a fast rise of high technology industries with important complementarities in physical and human capital accumulation.<sup>6</sup> Thus the interwar period showed a considerable productivity growth in American manufacturing with a crucial role for the automobile industry, electrification and science based industries. Richard Nelson and Gavin Wright have mentioned the rise of electrical and chemical engineering in particular. The shift from coal to petroleum as the basic feedstock for chemical plants is seen as a ‘...remarkable blend of mass production, advanced science, and American resources.’<sup>7</sup> But the question of the ‘when and how’ of the productivity gap vis-à-vis Europe’s first industrializer Great Britain lies foremost in the realm of statistics, to which we will turn in the following.

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<sup>2</sup> Hannah, ‘Logistics’, p. 74.

<sup>3</sup> Temin, ‘Labor’; Field, ‘Land’.

<sup>4</sup> Rothbarth, ‘Causes’, pp. 385-86; Habakkuk, *American*, see for example pp. 53-54, 75-77, 121-124; Engerman and Sokoloff, ‘Technology’. The argument of an alleged favorable American market scale has recently been attacked by Hannah, ‘Logistics’, pp. 58, 66, 68.

<sup>5</sup> Chandler, *Scale*; Nelson and Wright, ‘Rise’, pp. 1938-1940. However, there are important exceptions in cotton textiles, see e.g. Leunig, ‘British’, and in tobacco, see Hannah, ‘Whig Fable’.

<sup>6</sup> David, *Technical Choice*; Broadberry, *Productivity Race*; Nelson and Wright, ‘Rise’.

<sup>7</sup> *Ibid.*, p. 1946. See also Mowery and Rosenberg, ‘Twentieth-Century’.

## I. WHAT THE DATA SHOW

The issue of the precise timing of the U.S. taking over in manufacturing in the nineteenth century seems to have been settled by now. A recent study by Stephen Broadberry and Douglas Irwin has come forward with a new benchmark for 1850. This was a response to the claims made by Leandro Prados de la Escosura and Marianne Ward and John Devereux that the U.S. has overtaken the U.K. much earlier than backward projections on the basis of 1990 level estimates of Angus Maddison suggest.<sup>8</sup> The new estimate shows that total economy labour productivity in the U.S. surpassed the U.K.-level around 1890. But for manufacturing alone it shows that as early as 1840 U.S. productivity was already twice as high as the British level. The size of this gap remained nearly two-to-one for the rest of the century, confirming earlier findings of Broadberry.<sup>9</sup> Consequently, the overtaking of the U.K. by the U.S. in total economy productivity was mainly the result of a shift from labour out of agriculture and of comparative productivity increases in the service sector.<sup>10</sup>

According to statistical evidence collected by Broadberry the persistence of the manufacturing productivity gap between the U.S. and the U.K. was carried over into the twentieth century. But there seems to be no clear trend in the movement of comparative performance: ‘...Labour productivity in U.S. manufacturing has fluctuated around a level of about twice the British level...’<sup>11</sup> Deviations from this long term equilibrium were being associated with the disruptions brought on by the two world wars. Again the message is that the United States’ surging ahead at the whole economy level took place outside manufacturing. From his own figures Broadberry concluded that Britain and Germany failed to close the gap on the United States in the interwar period; the gap widened during the 1920s, but was followed by a ‘temporary cyclical narrowing’ during the Great Depression.<sup>12</sup>

Recent studies, however, have emphasized the Depression’s contribution to growth of potential output in the American economy. Both Robert Gordon and Alexander Field have shown that American growth in the first part of the twentieth century has been exceptionally high, especially between 1929 and 1941.<sup>13</sup> Field conjectures that the United States’ fastest productivity growth took place in the middle of the depression of the 1930s and not during WWII.<sup>14</sup> During the interwar

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<sup>8</sup> Maddison, *Monitoring*; Prados de la Escosura, ‘International’; Ward and Devereux, ‘Measuring’.

<sup>9</sup> Broadberry and Irwin, ‘Labor productivity’, p. 265.

<sup>10</sup> Hannah, ‘American’, p. 203.

<sup>11</sup> Broadberry, *Productivity Race*, p. 3. For the period after WWII Broadberry reported comparative U.S./U.K. levels of 2.5/1 until 1960, followed by a decline.

<sup>12</sup> Broadberry, *Productivity Race*, p. 291. See also Temin, ‘Golden Age’, who explains the fast post-1945 growth by pointing at an arrested development of structural change in many European countries between 1914 and 1945.

<sup>13</sup> Gordon, ‘U.S. Economic Growth’, pp. 123-28.

<sup>14</sup> Field, ‘Most’, p. 1399: ‘...the years 1929-1941 were, in the aggregate, the most technologically progressive of any comparable period in U.S. economic history ....’

years the foundations were laid for much of the U.S. productivity growth of the 1950s: ‘...the golden age (1948-1973) no longer has to be understood sui generis, but can be seen as a period reflecting the extension and persistence of trends and technological foundations established during the interwar period... It overturns the conventional wisdom attributing achieved 1948 productivity levels principally to the war...’<sup>15</sup> Thus, the Great Depression did not push down the underlying productivity trend of the American economy, suggesting that the gap with Europe has widened further.

How does this new view of U.S. growth compare with developments in Europe and the rest of the world? Field mentions a widening gap of productivity levels between the U.S. and Europe and Japan already before WWII, but he does not come forward with comparative evidence.<sup>16</sup> If we focus here on manufacturing alone we find on the basis of existing estimates a U.S./U.K. comparative productivity level of 250 in 1929 and of 192 in 1938 on a per worker basis, revealing a relative decrease of U.S. comparative productivity.<sup>17</sup> This estimate sits uncomfortably with Field’s revisionist account of U.S. manufacturing productivity during the Depression. Doubts are strengthened by the fact that many existing studies provide a rather bleak picture of British manufacturing performance during the 1930s. In the literature we find a critical account of the functioning of British capital markets, competition in product markets and effects of industrial relations, which were not very favorable for long-run productivity performance.<sup>18</sup> There was a shortfall on a broad front nurtured by a ‘cosy collusive environment’, that presumably differed a lot from the U.S. competitive environment characterized by modern anti trust legislation.<sup>19</sup>

Given these contrasting views on the United States’ economy opening up the full possibilities of the Second Industrial Revolution and the political and economic disarray of Europe between 1914 and 1945 the alleged persistence of a nineteenth and twentieth century U.S./U.K. manufacturing productivity gap of roughly 2:1 is therefore in need of attention.

The most important quantitative assessment of the comparative performance of the British and American economies in the 1930s is the widely used study of Laszlo Rostas.<sup>20</sup> Many studies of relative U.S./U.K. performance, including the

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<sup>15</sup> Field, ‘Origins’, p. 65; Field, ‘Technological’, pp. 205, 216, and 228: Between 1929 and 1941 TFP growth in the nonfarm economy grew at a rate of 2.31 percent per year, being ‘the highest peak to peacetime peak rate of the century’. Almost 50 percent of TFP growth originated from the manufacturing sector. Between 1919 and 1929 total TFP growth was 2.02 percent per year, with manufacturing’s contribution estimated at more than 80 percent.

<sup>16</sup> Field, ‘Equipment’, p. 49.

<sup>17</sup> Broadberry, *Productivity Race*, p. 2; see also Broadberry and Crafts, ‘Britain’s’, pp. 532-33: TFP growth in the British economy has been estimated at 1.9 percent between 1924 and 1937.

<sup>18</sup> Crafts, ‘Long-run growth’, p. 22.

<sup>19</sup> Eichengreen, *British Economy*, p. 340. See Booth, ‘Manufacturing’, for a revisionist interpretation of U.K. manufacturing performance in the trans-WWII period.

<sup>20</sup> Rostas, *Comparative*.

quantitative assessments of Broadberry and Broadberry and Crafts rely on Rostas's detailed study of physical output per worker from the manufacturing censuses of the U.K. (1935) and the U.S. (1937/39). Being very sophisticated at the moment it was published, we believe that this comparison needs to be revised and completed according to modern standards. The study of Rostas is based on 31 industries only, covering less than half of total manufacturing output. It uses physical output per worker as a measure of productivity performance instead of real value added per working hour, and it applies different census-reporting years between the U.K. and the U.S. Therefore it is hard to make the results of his comparisons consistent with the methods of historical national accounting that are being applied today.

In the present study we introduce new methods of U.S./U.K. comparison and focus on one common census year for both countries, being 1935, to guarantee complete and consistent coverage of all industries that were reported in the census. We use real value added as the measure of output and productivity of industries instead of 'traditional' indicators like physical output per worker. First, we present comparative estimates of gross output, value added and labour productivity for the complete set of industries and industrial branches in manufacturing. Next, we calculate specific prices for product items directly from the British and the American census reports. Input price levels will be compared as well, to perform a double deflation analysis. These prices will be combined into new purchasing power parities (PPP) that will be used to deflate value added for each industry and branch. Finally, adjustments will be made for the number of actual hours worked. We show that aside from the construction of new comparative value added estimates, the adjustment for the variation in the interwar workweek between the U.S. and the U.K. is an important factor in reconciling the different positions in the Anglo-American productivity debate.

One of the central findings in this study is that the Anglo-American productivity gap during the 1930s was not persistent and has become much wider than existing estimates show, when we adjust for hours worked. The new estimates display larger cross-industry variations in productivity levels than those resulting from Rostas's study and present a clear picture of the key-industries that were responsible for widening the gap between American and British manufacturing performance.

## II. THE CENSUS DATA OF 1935

The data for our benchmark comparison come from the official production censuses. For the United Kingdom we used the *Fifth Census of Production* of 1935, published

by the Business Statistics Office (BSO) of the Board of Trade.<sup>21</sup> For the United States we took the *Biennial Census of Manufactures* of 1935, published by the Bureau of the Census of the U.S. Department of Commerce.<sup>22</sup> Both surveys contain detailed information on quantities and values of produced items, average prices, gross output, intermediate input, and employment. As the information for outputs and inputs is based on one and the same questionnaire - for which the information is supplied on the level of firms - internal consistency is guaranteed. Appendix A discusses the comparability of both censuses.

Business cycle and capacity utilization effects can have a significant influence on the measurement of output and productivity levels for one particular year. Rostas addressed this issue in his study of prewar British and American manufacturing and decided that 1937 was the best year for comparison, because the degree of capacity utilization was roughly similar in both economies.<sup>23</sup> But statistical material related to all manufacturing in the U.K. was not fully available for this year. The *Import Duties Act Inquiry* of 1937 does cover some of the manufacturing branches, but the majority of the manufacturing industries were not yet tabulated or published by the time Rostas started his study.<sup>24</sup> To overcome this problem he chose to compare the year 1935 for Britain with the year 1939 for the United States working back towards 1937. The primary reason why Rostas relied so heavily on the American 1939 *Biennial Census of Manufactures* and not the 1935 or 1937 censuses is that it met the sizable data requirements of the quantitative study he employed.<sup>25</sup>

We believe that for the purpose of the present paper, the 1935-censuses for the U.K. and the U.S. are a good match. They allow us to provide a systematic and detailed assessment of all manufacturing industries in both economies. The British census distinguishes 108 manufacturing industries or trades, whereas the American census covers 327 industries and sub-industries. We have reclassified the industries of both countries into 12 branches and 93 common industries based on the classification of the U.K. Census (see Appendix B for further details).<sup>26</sup>

[Figure 1 about here]

Potential effects of the business cycle can be detected by making use of existing productivity time series to calculate the average movement in productivity levels in

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<sup>21</sup> Board of Trade, *Final Report*.

<sup>22</sup> U.S. Department of Commerce, *Biennial Census*, 1935.

<sup>23</sup> Rostas, *Comparative*, p. 24.

<sup>24</sup> Board of Trade, *Preliminary Reports*.

<sup>25</sup> This particular census is part of the 1940 decennial census and contains detailed figures on the size of plants, horse power of machinery installed, and so on. See: U.S. Department of Commerce, *Sixteenth Decennial Census*.

<sup>26</sup> The production censuses cover not only the entire manufacturing sector, but contain also data on mining, construction works, public utilities and government industries. For the purpose of this study we will exclude the latter industries and focus primarily on the manufacturing sector.

the manufacturing sector for both countries between 1935 and 1937. The projection of the comparative productivity figures for the U.K. and the U.S. shows however that the comparative levels of productivity in 1935 do not differ from 1937.<sup>27</sup> Unemployment levels for both countries are presented in Figure 1 illustrating that the British and American business cycles moved correspondingly. This diminishes the scope for cyclical effects on productivity levels resulting from differences in capacity utilization and differential consequences of labour hoarding or selective retention between both countries.

### III. CALCULATING REAL VALUE ADDED

This study presents comparative levels of output and productivity by systematically measuring the production of industries, which is also known as the industry-of-origin approach. Using this approach one can apply either the quantity or the value method. The first method was used by Rostas who made direct comparisons of physical quantities of output (in tons, gallons, or units). The second procedure measures the value of gross output and net output by industry (in national currency) which is then translated into a common currency with a sector-specific purchasing power parity (PPP) adjusted price ratio. As Deborah Paige and Gottfried Bombach have demonstrated, suitable conversion factors can be obtained by constructing so-called industry-of-origin PPPs from either output price data alone (single deflation) or from price data for outputs as well as intermediate inputs (double deflation).<sup>28</sup> We used their method and calculated average factory gate prices from the values and quantities of the items reported in the official production censuses of both countries for the year 1935.

The first step in the calculation of the PPPs is the matching of products between the two countries. The level of detail of the census data with respect to output allowed us to match 361 products (see Appendix C for further details). On the intermediate input side we could match 67 input items (only in textiles and iron and steel, see Appendix D for further details). An average value of a product or an intermediate input, the *unit value* (UV), reflects the domestic producer price of an item. Next, *unit value ratios* (UVR) of identical products in both countries have been calculated and aggregated into a specific industry or branch purchasing power parity. With this PPP output and intermediate inputs of the two countries were translated into a common currency.<sup>29</sup>

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<sup>27</sup> Broadberry, *Productivity Race*, p. 44.

<sup>28</sup> The pioneering study using currency conversions factors for international comparisons is Paige and Bombach, *Comparison*.

<sup>29</sup> The methodology and formulae's that we applied are broadly similar to the procedures that were used in the study on British and German manufacturing by Rainer Fremdling, Herman de Jong and Marcel Timmer. We therefore refer to this study for the description of the methodology applied in the present paper. Fremdling et al., 'British and German,' The methodology is also described in Fremdling et al., 'Censuses Compared', [www.ggdc.net](http://www.ggdc.net)



[Table 1 about here]

Table 1 features the Laspeyres, Paasche and Fisher Gross Output PPPs per branch and for total manufacturing. These PPPs are based solely on output UVRs, aggregated to the branch and sector level using a stratified sampling approach.<sup>30</sup> For this bilateral comparisons the weights of either the base country (U.K.) or the other country (U.S.) can be used, which provide a Laspeyres and a Paasche type PPP respectively. We used the geometric average of the Laspeyres and Paasche indices, the Fisher index, as the currency conversion factor for our productivity comparisons, which is considered common practice in this type of research. The overall Fisher Gross Output PPP is 4.84 U.S. dollar per pound sterling, which is very close to the official exchange rate of 4.94 dollar. But the large cross-industry variation of the output PPPs shows that the exchange rate would function poorly as a PPP on a sector level.

Direct quantity and price information for inputs is not widely available in the American census. By definition inputs for one industry are made up of the output of another industry; the intermediate input PPP for an industry can thus be derived as a weighted set of output UVRs from the industries furnishing its inputs. Therefore, we calculated intermediate input PPPs in the following way. We took the detailed Anglo-American output UVRs for all manufacturing output items as described above. Next we applied weights that were constructed with information on the flow of goods between industries from existing input-output tables. We used the 1935-table for the U.K. by Tibor Barna and for the U.S. we applied the 1939-table by Wassily Leontief.<sup>31</sup> These input-output tables reveal that the large majority of the intermediate inputs for manufacturing industries originate from within the manufacturing sector itself. E.g. in the large clothing and engineering trades nearly 90 percent of the inputs came from other manufacturing industries. We have worked solely with ex-factory output prices. We did not take differences in the cost of transport or trade margins into account, because the differences in these costs for both countries are unlikely to be so large as to have a substantial effect on the resulting input PPPs. We therefore

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<sup>30</sup> A detailed description of the stratified sampling approach is provided in Timmer, *Asian Manufacturing*. In the present study the minimum number of matches for a sample to be accepted was 2 with a coefficient of variation of 10 percent at maximum. The coefficient of variation is given by the expression below; where  $I_j$  is the number of matches for industry 'j';  $w_{ij}$  the relative weight of product 'i' in the total value of production of industry 'j';  $UVR_{ij}$  the unit value ratio of product 'i'; and  $UVR_j$  the unit value ratio, or purchasing power parity, of industry 'j'.

$$\text{var}[UVR_j] = \sqrt{\frac{1}{I_j - 1} \sum_{i=1}^{I_j} w_{ij} \cdot \ln(UVR_{ij} / \overline{UVR}_j)^2 \cdot \left(1 - \sum_{i=1}^{I_j} w_{ij}\right)}$$

<sup>31</sup> Barna, 'Interdependence'; Leontief, *The Structure*.

implicitly assumed the trade and transport margins (relative to total costs) to be similar for both countries.

To construct the intermediate input PPPs we first estimated the American 1935 input-output table based on the available 1939 table. We adjusted the row and column totals for the 1939 input-output table to the 1935 gross output and intermediate inputs taken from the 1935 *Census of Manufacturing*. The changes in the structure of the manufacturing sector could then be translated to the cells of the matrix itself to create a fit as close as possible to the original input-output table. Secondly, based on the structure of the British manufacturing sector, the Laspeyres output PPPs for products that are used further on in the production process (thus excluding the PPPs for final product) were then weighted by the flow of goods in the British input-output table to estimate industry and branch specific intermediate input PPPs. The same was done for the U.S.; in this case the resulting PPPs were based on the American structure and Paasche PPPs. Only for the building materials and timber trades we were not able to construct PPPs for intermediate inputs.

In addition to the gross output PPPs Table 1 also presents the intermediate input PPPs and the resulting double deflated value added PPPs. Fortunately, for the textile and iron and steel industries the American census does provide specific value and quantity data on intermediate inputs. Therefore, we could also derive direct input PPPs for these two large branches, which made it possible to cross-check the reliability of the results we got from the input-output approach. The Fisher intermediate input PPPs between brackets are based on input unit values derived directly from the manufacturing censuses, whereas all other intermediate input PPPs are derived from the input-output procedure. For the textile and iron and steel trades the intermediate input PPPs constructed by the alternative procedures differ within a margin of less than four percent, which we believe is reassuringly close and justifies our procedure of using the input-output tables to calculate input prices. Table 1 also shows that in some large branches PPPs for inputs are very different from those for output, notably in clothing, chemicals and engineering.

#### IV. A NEW COMPARISON OF U.S./U.K. PRODUCTIVITY FOR 1935

Table 2 gives the new estimates of double deflated labour productivity (real value added per worker). The second column shows value added per worker deflated by the official exchange rate. As can be expected, the use of the official exchange rate smoothes out the differences in labour productivity across branches. Effects are large in engineering, food and beverages, and paper.

[Table 2 about here]

In addition to the exchange rate comparison, we also listed the outcome of the industry-of-origin study by Rostas based on physical indicators.<sup>32</sup> Whereas we were able to draw on nearly complete sets for all manufacturing industries in the censuses, Rostas's choice was dictated by the availability of 31 pairs of industries for which quantity and employment data was available in the statistics for both countries. Being well aware of the possible deficiencies he stated that '...our comparison covers not more than half of the output and only about 31 industries, while both *Censuses* distinguish well over 100 individual industries. Such important industries as ship-building, non-ferrous metals, timber, heavy chemicals, petroleum refining (in the U.S.), tailoring, printing, leather, were not included in the sample.'<sup>33</sup>

To compare our results with those of Rostas we took, as far as possible, the same years (mostly 1935) and used an implicit weighting method to aggregate Rostas's comparative (physical) productivity estimates.<sup>34</sup> Whereas we arrived at an aggregate U.S./U.K. level of 224 percent, the estimate of Rostas amounted to 212. On the branch level however, the differences between both estimates are substantial. There is a difference of 22 percent with Rostas's estimates for the food, drink and tobacco industries (the U.S. advantage is 22 percent lower). We estimated a higher advantage for the U.S. in clothing (42 percent higher), chemicals (24 percent), and in engineering (25 percent) compared with the estimates of Rostas. These differences can be tracked down to the industry level, where the estimates by Rostas deviate even further from our own. In general the discrepancies come from the practical deficiencies of the quantity approach as well as the various additional shortcomings of the research strategy he employed. In particular his use of different census years for the benchmark estimate posed a problem in practice. We supply some illustrations of this in the remainder of the section.

Our present estimate reveals a clear American productivity lead in the large tailoring, dressmaking and millinery trade, which raises the overall comparative productivity in the clothing branch significantly compared to the original estimate. The only industry covered by Rostas in the clothing trades was the boots and shoe trade, about 25 percent of the total size of the branch. Rostas's relatively low estimate for this industry can most likely be explained by the non-homogeneity of the end-products for this category. He had to rely on a rather rudimentary conversion factor and in addition had to integrate the sizable American 'boot and shoe, cut stock and findings' trades into the industry.

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<sup>32</sup> Rostas, *Comparative*.

<sup>33</sup> *Ibid.*, p. 29.

<sup>34</sup> This procedure is based on the assumption that the representativity of PPPs of the covered industries for uncovered industries is better than that of productivity in these industries. Implicitly weighted comparative productivity figures can be attained by transforming the comparative productivity figures based on the quantitative approach into *implicit PPPs* using the available census data. These implicit industry PPPs can then be weighted by gross output to obtain implicit Gross Output PPPs, which in turn can be used to calculate comparative productivity estimates on the branch and sector level.

The differences in the estimates for the chemical and allied trades reflect another crucial weakness in the quantity approach adopted by Rostas. Because of its complex structure he was not able to deal with the section of chemicals, dyestuffs, and drugs. As this industry encompasses well over 200 appreciably different products, it was simply not possible for Rostas to find a common conversion factor, or to assign labour to the various products. Consequently Rostas had to omit this industry, even though it is by far the largest industry of the branch. Our new estimate of the chemical and allied trades - which includes the chemicals, dyestuffs and drugs trades and is based on 83 important products in this category (see Table 3 and Appendix C for further details) - thus presents a major improvement over the original estimation.

This study confirms the large productivity lead of the U.S. in the engineering, shipbuilding and vehicles trades. The extent of the American lead in engineering, however, is understated substantially by the method of Rostas, because it does not take the cross-country differences in the comparative price ratios between inputs and outputs into account, which as we noted before can have a large effect on the comparative productivity estimate. Furthermore, as Rostas used quantity indicators of output for his comparison, his estimates reflect gross output per head instead of value added per head, thus ignoring the role of intermediate inputs. Rostas noted the latter point as a major limitation of his quantity approach but was unable to address it at the time.<sup>35</sup> Table 3 presents some details on the comparative productivity of industries. It shows that it is feasible to calculate double deflated estimates of real value added on the level of specific industries.

[Table 3 about here]

Overall, the discrepancies between our new estimates and the quantity method fundamentally challenge studies relying on Rostas's disaggregated figures. The study by Rostas is less representative for the total manufacturing sector and the methodology applied is unable to account for the effects of differing prices and volumes of intermediate inputs used in the British and American production process. Studies using Rostas's estimates in analyzing comparative productivity figures for British and American manufacturing industries are undoubtedly biased. Regardless of the shortcomings of his approach though, the comparative productivity estimate by Rostas for the manufacturing sector as a whole is remarkably close to the present estimate. This may be seen as good news for those studies that continue to use quantity comparisons on the practical grounds that there are insufficiently reliable prices available. However we firmly believe that this result for the total manufacturing sector is more likely to mirror the hard work and impeccable judgment

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<sup>35</sup> Rostas, *Comparative*, p. 3.

of Lazlo Rostas than the validity of using physical quantities as the only measure in productivity comparisons.

## V. ADJUSTING FOR ACTUAL HOURS WORKED

Most historical cross-country productivity comparisons apply the concept of *output per worker* or *real value added per worker*. However, we think that in the present context *real value added per man-hour* is the preferred indicator of labour productivity, as it is best suited to the concepts of economic efficiency and technological capabilities mentioned in the introductory section. It is also more relevant here, since Field has based his story of fast U.S. productivity growth during the Great Depression on John Kendrick's estimates of manufacturing output per hour (and not output per worker).<sup>36</sup> For the present study this distinction is of particular importance since the decline in weekly actual hours worked in the U.S. during the 1930s was more pronounced than in Britain. The practice of work-sharing was widespread in the American Depression-economy. If we do not adjust for this we would underestimate U.S. comparative productivity. Colin Clark estimated the average working week in Great Britain in 1935 at 47.8 hours, compared to only 37.2 hours in the United States.<sup>37</sup> Likewise, Rostas assumed the average length of the U.K. and U.S. working week to be 47.8 and 36.6 hours respectively. However, he did not analyze the effects of this gap in working hours on the actual level of Anglo-American comparative productivity.<sup>38</sup> The lower levels of American working hours are confirmed in the study of actual hours of work per week by Ethel Jones.<sup>39</sup> For the U.K. systematic evidence is more difficult to find.<sup>40</sup> Some occasionally published government statistics give the percentage of short-time workers and the level of short-time work.<sup>41</sup> However, we made estimates of actual hours worked on the basis of information given by Robert Hart, and Michael Huberman and Chris Minns.<sup>42</sup> The actual hours of work per week for the U.K. and the U.S. from 1929 up to 1938 are given in Figure 2. We also included Germany for this specific case. It shows that actual working hours in the American economy declined during the larger part of the 1930s, resulting in an American working week in the manufacturing sector which was

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<sup>36</sup> Kendrick, *Productivity*, pp. 466-75.

<sup>37</sup> Colin Clark, *Conditions*, p. 68.

<sup>38</sup> Rostas, *Comparative*, pp. 25, 27, 29, 43-44, 48-49. He did not adjust for hours worked for two reasons. First, he was more interested towards measuring man-power requirements than to measure the effect of comparative productivity on production costs. Second, he (mistakenly) held the belief that the relatively short hours in the U.S. were part and parcel of the mass-production methods and for that reason per worker comparisons would be more realistic.

<sup>39</sup> Jones, 'New Estimates'; see also ILO, *Year-book*, 1939 and Sutch and Carter, *Historical Statistics of the United States*.

<sup>40</sup> Whiteside and Gillespie, 'Deconstructing', pp. 674, 677.

<sup>41</sup> Thomas, 'Labour market', p. 136.

<sup>42</sup> Hart, 'Hours'; Huberman and Minns, 'Times'.

much shorter than the British and German one. From 1929 onwards the British working week became only slightly shorter due to the introduction of short-time, but by 1934 the average working week had basically returned to the pre-Depression level. However, the American average actual working week dropped by nearly 30 percent in the period 1929 to 1934 and it did not attain its pre-Depression level again. Only during a short period in the 1940s the number of weekly hours in American manufacturing rose to 44.

[Figure 2 about here]

We can also adjust for differences in the number of holidays and vacations and for variations in working hours per branch. The *Yearbook of Labor Statistics* of 1939 contains detailed statistics on average hours of work per worker per week for several industries and industry-groups for both the U.K. and the U.S. We weighed these outcomes by employment to obtain the familiar branch classification that adheres to the British Census of Production.<sup>43</sup> Data by Huberman and Minns on the number of vacations and holidays for the U.K. and U.S. in 1938 allowed us to construct the total number of annual hours worked. The data on weekly and annual average hours worked in 1935 are presented in Table 4.

[Table 4 about here]

Both Figure 2 and Table 4 illustrate that during the 1930s the declines in weekly hours in the United States were ‘deep, prolonged, and widespread.’<sup>44</sup> The explanation for the persistence of high unemployment lies beyond the scope of this paper. But we will shortly touch upon the causes of the widespread practice of American short-time working. Ben Bernanke explained the drop of the American workweek and the introduction of work-sharing as an efficient way of firms to react to falling demand: firms cut production by running certain operations only part time; at the same time the work force was left intact by spread-work schedules. Firms recognized that a proportional cut in wages would bring workers below their subsistence level, hence real hourly earnings rose, which explains a countercyclical pattern in real wage rates.<sup>45</sup> Robert Margo has argued that the legislation connected to the National Industry Recovery Act (1933-1935) promoted worksharing provisions leading to reductions in the length of the workweek. The New Deal legislation as such had created a climate that made wage cutting difficult.<sup>46</sup>

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<sup>43</sup> ILO, *Year-book*, 1939.

<sup>44</sup> Margo, ‘Employment’, p. 48.

<sup>45</sup> Bernanke, ‘Employment’, p. 89.

<sup>46</sup> Margo, ‘Microeconomics’, p. 339.

In Britain short-time working had been a traditional response to trade recessions, and it developed in the 1920s systematically into the so-called OXO-system, an arrangement for days of work (O) and leisure (X).<sup>47</sup> The cuts in working time in British firms during the interwar period have been explained by the high benefit-wage ratio and by hourly wage rate inertia through centralized wage bargaining. But it was not as widespread and extensive as in the U.S.<sup>48</sup>

[Table 5 about here]

Table 5 presents labour productivity statistics on a man-hour basis. The branch specific employment data has been multiplied by the data on annual hours worked from Table 5. This results in an average level of American labour productivity per hour for total manufacturing of 279 percent of the British level, which is 55 percent points (or 25 percent) higher than the productivity per worker estimate. On the level of branches the rise in labour productivity ranges from 16 percent (food, drink and tobacco trades) up to 34 percent (clothing trades). In 1935 hourly productivity in U.S. manufacturing was nearly three times as high as in the U.K. Hourly levels were high in the engineering branch, whereas the differences in textiles and food remained relatively modest.

These new results seem difficult to reconcile with the earlier mentioned outcomes of Rostas's benchmark estimate and Broadberry's reworking of it. The latter has based his backward and forward time series projections of Anglo-American productivity on the per worker comparisons of Rostas. By making these extrapolations Broadberry implicitly assumed that working hours have moved correspondingly in the U.K. and the U.S. We have shown that this was not the case in the interwar period. The uninterrupted line in Figure 3 gives the comparative labour productivity for the American and British manufacturing sector over the period 1889-1989 on a per worker basis, which is similar to the overview of comparative manufacturing productivity in the work of Broadberry.<sup>49</sup> With our new information on differential working hours we projected a time series backward and forward from the 1935-benchmark level of 279, but now on an hourly basis. We applied the same time series on output and employment as Broadberry, and adjusted it for the

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<sup>47</sup> Thomas, 'Labour Market', 135-136; Bowden et al, 'Underemployment', pp. 97-98. In the British cotton-spinning industry short-time working and price maintenance schemes were two sides of the same coin, and ensured the survival of many marginal firms constraining the exit process. See Bowden and Higgins, 'Short-time working', p. 329: 'Under the system of unemployment provision, public unemployment benefit for short-time working subsidized the retention of labour. Unemployment provision and short-time working subsidized operating costs'.

<sup>48</sup> Estimates based on information from Dale, 'Interpretation', pp. 89-90 reveal that in 1934 for manufacturing as a whole the effect of short-time schemes on the standard working week was not larger than 3.5 percent. See also Hart, 'Hours', p. 500; Bowden and Higgins, 'Short-time working', p. 333.

<sup>49</sup> Broadberry, *Productivity Race*, p 2.

movements of average weekly hours per worker in both countries. This new graph reveals that the level of comparative value added per man-hour was slightly below the level of value added per worker in 1889. At the end of the nineteenth century the U.S. had a labour productivity lead of about twice the level of the U.K. From the final decades of the nineteenth century the comparative American level increased, per worker as well as per hour. The two series move in unison up to the year 1929. After 1929 however, the value added per man-hour series does not show the downward movement in comparative labour productivity that is so typical of the comparative value added per worker series. There is no sign anymore of a 'temporary cyclical narrowing' of the gap before WWII, but an upward trend from the end of the nineteenth century to well after WWII instead. After the war there is still a gap between the two series which persists well into the 1960s.

[Figure 3 about here]

We conclude from this new series that there is a clear trend in the widening of the Anglo-American productivity gap when we measure productivity in terms of actual hours worked. This long term process appears not to have been affected greatly by the exogenous shocks of the world wars. During this period U.S. manufacturing increased its productivity lead (measured in hours) over the U.K. from less than 200 percent in 1889 to over 300 percent in the 1950s. This implies, that the stylized fact of a 2:1 productivity ratio between the U.S. and the U.K. can only be substantiated using the concept of labour productivity per worker. But especially in transatlantic comparisons it is important to employ the proper measure of productivity based on actual hours worked. Productivity measured in hours thus provides a fundamentally different picture of the long-term comparative industrial performance of the U.S.

## VI. LONG-TERM MOVEMENTS OF COMPARATIVE PRODUCTIVITY BY BRANCH

In order to determine the driving forces behind the strong and prolonged growth in comparative American productivity we will now approach the issue from a lower level of aggregation. For the year 1935 we have already established that the American productivity lead was widespread across all industries, but that the engineering, chemical, and clothing branches in particular contributed to the comparative productivity gap between these two countries. Still this does not explain how the U.S. was able to continuously outperform the U.K. in terms of manufacturing productivity growth over the entire first part of the twentieth century.

Disentangling each industry's individual contribution to overall sectoral productivity growth can be done by shift-share analysis. It measures both the impact



of shifts in the employment structure (the shift component) and relative increases in labour productivity by industry (the share component). In our case we opted for a base-invariant shift-share formula in order to reduce the bias that occurs due to changes in the employment structure and in the relative industry-specific productivity.<sup>50</sup> We realize that the shift-share analysis is unable to account for inter-industry linkages - for which a total economy input-output framework is required - and may thus underestimate the relative contributions of some industries that have strong forward linkages to other manufacturing industries. Still these ties are unlikely to be so strong as to drastically influence the results of the shift-share analysis as presented in Table 6.

We distinguish between 6 major branches and a shift component which together cover the entire manufacturing sector. These individual series were calculated from the existing estimates for U.S. and U.K. manufacturing by John Kendrick and Charles Feinstein respectively, and underlie the series for total manufacturing already shown in Figure 3.<sup>51</sup> In addition to the figures by Kendrick we used Census data for the U.S. - compiled by Jeremy Atack and Fred Bateman - for aggregation and detailed statistics on employment and hours worked.<sup>52</sup> We supplemented the figures by Feinstein with disaggregated figures on hours worked from the sources listed in Figure 3.

We cover the period 1900-1957 and distinguish between 5 different periods; 1900-1913 (pre-WW I), 1913-1924 (trans-WW I), 1924-1937 (interwar), 1937-1950 (trans-WW II), 1950-1957 (post-WW II). These periods were chosen to represent more or less similar phases of economic development for both economies. We took particular care to start and end these sub periods in similar phases of the business cycle ('peak' or 'standard' years) for both economies in order to obtain a representative estimate of the growth in labour productivity in the manufacturing sector. Because of the turbulent years of the first half of the twentieth century it is very difficult to pinpoint the exact periods of economic expansion, in particular for the years following WW I. The selection of representative years was hampered also by discontinuities in the available statistics. This is particularly true for the U.K. in the years directly following WW I, which prompted John Dowie to express his doubts

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<sup>50</sup> Timmer, *Dynamics*, p. 110 The base-invariant shift-share decomposition uses weights from both the start of the period, superscript 0, and the end of the period, superscript T. LP denotes the labour productivity level and  $S_i$  the branch share in hours worked:

$$LP^T - LP^0 = \sum_{i=1}^n (LP_i^T - LP_i^0) \frac{1}{2} (S_i^0 + S_i^T) + \sum_{i=1}^n (S_i^T - S_i^0) \frac{1}{2} (LP_i^0 + LP_i^T)$$

<sup>51</sup> Kendrick, *Productivity*, pp. 465-475; Feinstein, *Statistical*, pp. T111-T113, T130.

<sup>52</sup> Atack and Bateman, "Manufacturing", *Historical Statistics*, pp. 579-619. For earlier years the disaggregated figures listed by Atack and Bateman were incomplete, we adjusted for this using census data taken directly from the Quinquennial and Biannual Censuses of Manufactures. U.S. Department of Commerce, *Census*, various issues.

regarding the employment figures for this period.<sup>53</sup> We defined the wartime phases as 1913-1924 and 1937-1950 - broadly in line with Robert Matthews, Charles Feinstein and John Odling-Smee - to circumvent this issue and to include the periods of postwar recovery.<sup>54</sup>

[Table 6 about here]

Table 6 presents the results of the shift-share analysis in terms of contributions to average annual logarithmic growth of labour productivity per man-hour for the U.S. and the U.K. In addition, the table shows the relative growth of the U.S. compared to the U.K. which can be conveniently expressed as the difference between the U.S. and U.K. estimates.

Productivity in the American manufacturing sector has grown on average by 2.6 percent each year over the entire period. Growth rates were between 2 and 3 percent annually across the 5 time phases with a peak of 3.5 percent annual growth in the interwar years. Growth in productivity was primarily driven by the engineering and the paper, printing and miscellaneous branches. However, for the post-1913 period we should also include chemicals and food as major contributors to the American manufacturing productivity surge. In general, the contribution of the reallocation of labour inputs, the shift effect, is negligible or in some cases even negative. Labour shifted primarily from the food and textile branches to chemicals and engineering. In the case of chemicals, this caused a positive shift effect since the latter had a substantially higher relative productivity level. However, this effect was largely canceled out by shifts of labour towards the engineering branch, which had a below average productivity level, thus resulting in a negative shift effect.

The following picture emerges for the U.K.: Total manufacturing growth was on average 1.9 percent per year, with a clear peak in average productivity growth rates during the trans-WW I period and the interwar years as well. Long term growth was driven by the engineering and the paper, printing and miscellaneous branches. Textiles showed a remarkable contribution to overall productivity growth in the interwar period. British manufacturing productivity did benefit more from changes in the structure of employment than American industry. Labour was reallocated from the large and relatively low-productive textile industry to chemicals and engineering.

In comparative terms the U.S. was able to outperform the British manufacturing sector by 3 quarters of a percentage point per year on average. The effect of this was a steadily widening of the productivity gap between the two countries as shown in Figure 3; the cumulative effect being well over 50 percent of comparative growth over the entire period. Comparative U.S./U.K. productivity

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<sup>53</sup> Dowie, '1919-20'.

<sup>54</sup> Matthews, Feinstein and Odling-Smee, *British Economic*, p. 22.

growth was positive in all periods. Regardless of its small share in the employment structure, the chemical branch was by far the greatest contributor to the *comparative* U.S. productivity performance in manufacturing. Fast productivity growth in the U.S. food, drink and tobacco branch exerted upward pressure in the interwar period. This may partly be the result of a statistical artifact, because with the lifting of the Prohibition in 1933 the production of liquor became legal and therefore entered the statistical records again. Engineering contributed in particular to the widening gap during the trans-WW II period. The U.K. was able – especially between 1913 and 1924 - to counter the increasing lead of the U.S. by the reallocation of labour, as can be seen from the predominantly negative comparative shift effect. After 1937 the statistical effect of comparative shifts became unimportant. If we take the shift component out of account and solely look at comparative productivity growth within the branches (see column INTRA) we find a fairly constant rise in U.S. labour productivity compared to the U.K. of nearly 0.9 percent annually. Comparative hourly productivity growth within the branches does not reveal an extraordinary American productivity bonus related to the world wars. Both periods conform to the long-term pattern of persistently higher comparative U.S. productivity improvements.

We can also use the time-series estimates of branches to make a forward projection from our 1935 benchmark and make a level comparison with the 1950-U.S./U.K. labour productivity benchmark by Paige and Bombach.<sup>55</sup> Labour input for the 1950 benchmark was adjusted for hours worked to allow for a comparison with our forward projection from the new 1935 benchmark. The results from Paige and Bombach and our projections are similar in the sense that the textile, food, and metal manufacturing branches form the lower part in the spread of comparative productivity levels in the post-WWII period. For some of these groups of industries we find only small differences between our projections and the Paige and Bombach benchmark estimates. They estimated comparative U.S./U.K. labour productivity in textiles at about 224, food at 209, and metals at 289. Our projections from the 1935 benchmark are 229, 164, and 323 respectively for the same groups in 1950. The differences between our projections and the direct benchmark in textiles and metals fall within a margin of ten to eleven percent. In the case of food, drink and tobacco the time-series projection from the 1935 benchmark results in a twenty percent lower level than the outcome of Paige and Bombach.

Bigger differences show up in the engineering and chemical industries, together accounting for 25 percent of manufacturing employment and 29 percent of value added in both the American and British census of 1935. For the year 1950 Paige and Bombach estimated the American productivity level in engineering at 358 percent of the British level. The level in chemicals (including petroleum and fertilisers) was

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<sup>55</sup> Paige and Bombach, *Comparison*.

estimated at 367 percent. However, the projections from our 1935-benchmark show substantially higher levels for 1950: 530 and 500 for engineering and chemicals respectively. Thus we find that the two American sectors outpaced their British counterparts in productivity levels as well as in growth rates. Should we accept our new benchmark estimate for 1935 as well as the 1950-benchmark estimate of Paige and Bombach, then we would run into problems of consistency. For example in the case of engineering, we would have to conclude that there was a moderate U.S./U.K. comparative productivity decline between 1935 (410) and 1950 (358). This is not consistent with the information we can extract from the existing time-series estimates in Table 6, which suggest very fast American productivity growth in engineering and only a moderate performance in the U.K. between 1937 and 1950. Traditional index number problems may play a role here but our opinion is that Paige and Bombach's estimate is too low. It is certainly true that they set out the methodology of double deflation, but in practice they did not fully implement it in manufacturing. This was also the case with engineering and chemicals. In fact, for chemicals they encountered the same kind of measurement problems as in Rostas's comparison. Being not able to address the issue of comparing the many non-homogeneous items in this branch, they had to rely on a small number of price and quantity comparisons: '...The results cannot, therefore, be given the same degree of reliability as those for more homogeneous industries.'<sup>56</sup> For the moment the discrepancy remains. To solve this productivity puzzle it will be necessary to re-examine the existing 1950-benchmark and apply the methodology that we set out in this paper.

## VII. EXPLAINING THE INTERWAR PRODUCTIVITY GAP

Stephen Broadberry and Nick Crafts have tried to quantify the fundamental long-run explanatory forces underlying the U.S./U.K. manufacturing productivity gap. Their regression estimates included effects from higher concentration ratios and lower quality of human capital in British industries.<sup>57</sup> Restrictive practices in interwar Britain may also have hampered competition and the necessary economic adjustment to new technologies. There was less rapid technical change compared with the U.S., maintaining a low effort equilibrium that was carried over into the postwar period.<sup>58</sup> Leslie Hannah has stressed the detrimental influence of protectionism and of the wars on European performance: '...it is surely not necessary to look much further for the sources of the American miracle than the geopolitical maladies that afflicted her major potential competitors.'<sup>59</sup>

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<sup>56</sup> Paige and Bombach, *Comparison*, p. 37.

<sup>57</sup> Broadberry, *Productivity Race*; Broadberry and Crafts, 'Britain's'.

<sup>58</sup> Broadberry and Crafts, 'Britain's', p. 554; Magee, 'Manufacturing', p. 95. See also note 51.

<sup>59</sup> Hannah, 'American', p. 210.

However, British performance in manufacturing was relatively high during the trans-WWI and interwar periods and this suggests that focussing on ‘European failure’ is only part of the story. We believe that it is also necessary to explain the sources of American success as well. American comparative performance resulted from strong domestic modernization in the key sectors of the Second Industrial Revolution. American manufacturing managed to expand much faster those sectors in which it already had comparative and competitive leadership. Some sectors could even take another leap during the Depression. Part of this acceleration of the American productivity level during the interwar period may well have been of a cyclical nature. Claudia Goldin has pointed to mechanisms of selective retention in the 1930s: Workers who were laid off were less productive.<sup>60</sup> This explains the phenomenon of rising real wages and the persistence of high unemployment in the U.S. However, measured within a period of a full cycle between 1929 and 1941 there has been found a positive relationship between a rise in the unemployment rate and a decline in total factor productivity (TFP), which suggests a pro-cyclicality of productivity.<sup>61</sup> We conclude that this issue has not been settled yet.

The role of physical capital deepening as a decisive factor in the interwar productivity growth in the United States is also under discussion. Field has shown with estimations based on Kendrick’s study that rates of TFP growth and rates of output per hour were very similar between 1919 and 1941.<sup>62</sup> This leads to the conclusion that disembodied technical change in particular has been responsible for an outward shift of the American production possibility frontier. Anecdotal evidence of many important process and product breakthroughs as drivers of productivity advance are mentioned in the literature, such as floor space savings, automatic process control, larger units of installations, increased thermal efficiency, improved materials, and fundamental new processes like the switch from coal based to petroleum based chemical technologies.

There was also a change in the composition of firms within and between industries. Within industries we find examples of productivity improvements as an indirect effect of the Depression. Due to the fall in demand weak firms went out of business. The American motor vehicles industry provides an archetypical example of growth of efficiency within an industry. Timothy Bresnahan and Daniel Raff used an establishment-level panel dataset and showed that the removal of the low productivity tail in the spread of plants was responsible for a one-off change in the composition of

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<sup>60</sup> Cited in Field, ‘Most’, p. 1409; Bernanke, ‘Employment’, p. 91: mentions the role of a changing skill mix over the cycle; Margo, ‘Microeconomics’, pp. 333-41: mentions the higher age and the lower levels of schooling of the unemployed; see also Margo, ‘Employment’, p. 46.

<sup>61</sup> Bernanke and Parkinson, ‘Procyclical’, p. 457, find procyclical patterns due to labour hoarding in steel, rubber, and stone, clay and glass. See also Field, ‘Impact’, p. 687.

<sup>62</sup> Field, ‘Impact’, p.5. In contrast, the post-1941 period reveals much larger growth rates of output per working hour compared with TFP. For the basic time-series see Kendrick, *Productivity*.

the total industry, leading to an increase of the average productivity level.<sup>63</sup> Only the large motor-vehicle production plants survived in the Depression years and new entrants had a higher productivity. Evolutionary processes like these were the effect of changed technological practice in the industry as a whole. If we calculate from our present figures the comparative level of hourly productivity for motor vehicles between the U.S. and the U.K. we arrive at a real productivity level of 590 (double deflated). Likewise we find for 1935 very high levels of *hourly* labour productivity in a wide range of industries, such as hosiery (339), blast furnaces (405), electrical engineering (389), chocolate and sugar confectioning (340), and rubber (300).<sup>64</sup> Fast comparative productivity advances were manifest in many branches in American manufacturing, particularly in engineering, chemicals, and food production. Figure 3 confirms that the post-Depression period was an era in which the productivity lead of the U.S. was strengthened further. And table 6 shows that the long term forces of this process were already in place in the 1920s, setting the stage for the expansion of those industries that already had high comparative productivity levels. Our comparative data show that it is not the Second World War that was the decisive factor in widening the transatlantic productivity gap.<sup>65</sup> The 1930s witnessed the implementation and exploitation of new technologies and practices which were to form the basis of much of the labour and multifactor productivity of the post-war period. The advance reflected also the movement along scientific and technological trajectories relatively unaffected by the macroeconomic downturn. Field stressed e.g. the role of a maturing privately funded R&D system, and the expansion of R&D-labs, -employment, and -expenditure during the Depression years. This factor was particularly relevant in some of the rapidly advancing manufacturing sectors, such as chemicals.

## VIII. CONCLUSIONS

This paper presents an industry-of-origin study dealing with the American and British manufacturing sector in the interwar period. We have used the census reports of 1935 to calculate Anglo-American comparative labour productivity levels for all manufacturing industries. The input-output structure of both economies has been used to calculate prices of intermediate inputs, which made it possible to estimate double deflate value added. We find a comparative American/British manufacturing

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<sup>63</sup> Bresnahan and Raff, 'Intra-Industry'.

<sup>64</sup> However, comparative data from the 1935-censuses of both countries reveals additional information that explains the high productivity level. American car manufacturers acquired a much larger percentage of gross output from intermediate inputs and components obtained from industries lower in the chain (70%) against Britain (40%) which points at a more developed pattern of specialization in the U.S. Lewchuk, 'Motor', pp. 138-42. See also our Table 4 for the statistics of the *total* motor and cycle branch on a *per worker* basis. The other productivity measures in Table 3 are also on a *per worker* basis.

<sup>65</sup> Field, 'Technological', pp. 206, 214-215. Field, 'Impact'.

productivity level of 224 on a per worker basis. On the level of branches and individual industries the differences in results from the varying research strategies are substantial and highlight the superior performance of U.S. manufacturing.

Adjusting for actual hours worked is essential in the U.S./U.K. comparison because average annual hours worked on both sides of the Atlantic diverged a lot in the interwar period. Expressed in hours worked the American comparative productivity level increases to a level of 279 in 1935. Hours-adjustment also changes the trend in long term comparative productivity in manufacturing between the two countries. Comparative U.S./U.K. hourly productivity steadily moved from a level of 200 around 1900 to a level of 300 in the trans-WWII period. The American miracle of the twentieth century is therefore not only a matter of shifts from labour out of agriculture and of comparative productivity increases in the service sector, but foremost a process of productivity growth within manufacturing itself. Evidence from time-series data suggests that the drivers of the productivity differential between the U.S. and the U.K. were the chemical and engineering industries. These branches made up 25 percent of employment in manufacturing. This finding is well in line with recent interpretations of post-Depression developments in technological capabilities and productivity growth in American manufacturing.

[Appendix A here]

[Appendix B.1 here]

[Appendix B.2 here]

[Appendix C here]

[Appendix D here]

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## TABLES

**Table 1. Purchasing Power Parities in Manufacturing, U.K. and U.S., 1935**

	Gross output PPP (\$ / £)			Intermediate input PPP (\$ / £) ‡			Value added PPP (\$ / £) ζ		
	Laspey- res	Paasche	Fisher	Laspey- res	Paasche	Fisher	Laspey- res	Paasche	Fisher
Textiles	6.4	5.5	5.9	6.2	5.2	5.7 (5.5)	6.7	5.9	6.3
Leather	5.6	5.9	5.8	5.5	5.8	5.7	5.7	6.1	5.9
Clothing	5.3	5.0	5.1	6.1	5.4	5.7	4.3	4.5	4.4
Iron and steel	5.6	5.4	5.5	5.8	5.2	5.5 (5.4)	5.3	5.6	5.4
Engineering, shipbuilding, vehicles	4.3	3.9	4.1	5.4	4.9	5.1	3.2	3.1	3.2
Non-ferrous metals	5.4	5.2	5.3	5.4	5.2	5.3	5.3	5.1	5.2
Food, drink and tobacco	5.9	5.2	5.5	5.7	5.7	5.7	6.2	4.2	5.1
Chemical and allied products	5.1	3.2	4.1	5.3	3.8	4.5	4.9	2.6	3.5
Clay and building materials	5.4	5.5	5.5						
Timber	2.2	2.2	2.2						
Paper	4.0	3.7	3.9	4.1	3.6	3.8	3.9	3.9	3.9
Miscellaneous	6.2	4.5	5.3	5.3	5.7	5.5	7.1	3.8	5.2
<b>Total manufacturing</b>	<b>5.4</b>	<b>4.3</b>	<b>4.8</b>	<b>5.5</b>	<b>4.9</b>	<b>5.2</b>	<b>5.3</b>	<b>3.7</b>	<b>4.4</b>

Sources: Barna, 'Interdependence'; Leontief, *Structure*; additional sources see Appendix B.

‡) The intermediate input PPPs are based on output UVRs of intermediate products weighted by data on the flow of these goods from input-output tables. The intermediate input PPPs between brackets are based on input UVRs taken directly from the British and American census (see Appendix D for further details).

ζ) The value added PPPs are based on the input-output weighted intermediate input PPPs and the single deflated gross output PPPs. The Laspeyres and Paasche value added PPPs are derived using the formulae below. See Fremdling, de Jong, and Timmer, 'British and German' for further details.

$$VAPPP_j^{AB(A)} = \frac{GO_j^A \cdot GOPPP_j^{BA(A)} - II_j^A \cdot IIPPP_j^{BA(A)}}{GO_j^A - II_j^A} \quad VAPPP_j^{AB(B)} = \frac{GO_j^B - II_j^B}{GO_j^B \cdot GOPPP_j^{BA(B)} - II_j^B \cdot IIPPP_j^{BA(B)}}$$

**Table 2. Comparative Productivity in Manufacturing, U.K. and U.S., 1935**

Branch / Sector	Real Value Added per Worker (% U.S. / U.K.)		
	This study <sup>‡</sup>	Exchange rate <sup>§</sup>	Rostas
Textiles	144 (136)	150	152
Leather	157	148	
Clothing	237	223	167
Iron and steel	186 (177)	191	209
Engineering, shipbuilding, vehicles	327	235	261
Non-ferrous metals	182	156	
Food, drink and tobacco	152	222	195
Chemicals and allied products	263	235	212
Clay and building materials	201	222	204
Timber	293	129	
Paper	278	223	243
Miscellaneous	231	226	242
<b>Total manufacturing</b>	<b>224</b>	<b>211</b>	<b>212<sup>ξ</sup></b>

Sources: Rostas, L. (1948), *Comparative*; see Appendix B for further details.

‡) The value added per worker estimates for this study were deflated by the 'input-output' (Fisher) double deflated value added PPPs listed in Table 1, with the exception of the 'clay and building materials' and 'timber' branches which were deflated by (Fisher) single deflated gross output PPPs. The figures in brackets were deflated by 'standard' (Fisher) double deflated value added PPPs based on input UVRs taken directly from the British and American census.

§) The value added per worker estimates deflated by the overall official exchange rate, which was approximately 4.94 U.S. dollars per pound sterling.

ξ) The figure for the manufacturing sector as a whole as listed in Rostas, *Comparative*. Due to the reduced coverage of the Rostas study it is not possible to assign weights to his branch estimates to arrive at the same value for manufacturing as a whole.

**Table 3. Real Value Added per Worker in Five Major Industries, U.K. and U.S., 1935**

Industry	Share of intermediate input in gross output (%)		Fisher purchasing power parity (\$ / £)			Real Value Added per Worker (% U.S. / U.K.)
	U.K.	U.S.	Gross output	Inter-mediate input	Value added	
Cotton	71	61	5.7	5.4	6.2	142
Electrical engineering	46	43	4.1	5.4	3.4	318
Motor and cycle	57	71	3.9	4.9	2.5	462
Chemicals, dyestuffs, drugs	46	42	4.0	4.5	3.6	269
Rubber	49	54	4.6	5.1	4.1	222

Sources: see Appendix B for details.

**Table 4. Weekly and Annual Average Hours Worked, U.K. and U.S., 1935**

Branch / Sector	U.K.		U.S.	
	Weekly hours worked <sup>†</sup>	Annual hours worked <sup>‡</sup>	Weekly hours worked	Annual hours worked
Textiles	47.7	2,250	35.8	1,774
Leather	48.8	2,302	38.6	1,915
Clothing	45.4	2,142	32.2	1,597
Iron and steel	48.2	2,274	36.6	1,813
Engineering, shipbuilding, vehicles	48.2	2,274	36.5	1,809
Non-ferrous metals	48.2	2,274	37.1 <sup>‡</sup>	1,838 <sup>‡</sup>
Food, drink and tobacco	48.5	2,288	39.5	1,962
Chemicals and allied products	48.0	2,264	38.1	1,892
Clay and building materials	48.0	2,264	36.5	1,812
Timber	48.3	2,278	39.5	1,958
Paper	48.6	2,292	38.2	1,896
Miscellaneous	48.2	2,274	33.9	1,682
<b>Total manufacturing</b>	<b>47.8</b>	<b>2,255</b>	<b>36.6</b>	<b>1,817</b>

Sources: ILO, *Year-book*, 1939; HMSO Department of Employment and Productivity, *British Labour Statistics*, 1971; Huberman and Minns, 'Times.'

‡) The sectoral averages - provided by the *1939 Yearbook of Labour Statistics* - were used when detailed industry level data for hours worked was unavailable.

**Table 5. Real Value Added per Worker and per Hour, U.K. and U.S., 1935**

Branch / Sector	Value Added per Worker <sup>‡</sup>	Value Added per Hour <sup>‡</sup>
	(% U.S. / U.K.)	(% U.S. / U.K.)
Textiles	144	182
Leather	157	190
Clothing	237	318
Iron and steel	186	235
Engineering, shipbuilding, vehicles	327	410
Non-ferrous metals	182	226
Food, drink and tobacco	152	177
Chemicals and allied products	263	316
Clay and building materials	201	253
Timber	293	345
Paper	278	338
Miscellaneous	231	313
<b>Total manufacturing</b>	<b>224</b>	<b>279</b>

Sources: see table 3 and table 4 for further details.

‡) The value added per worker/man-hour estimates were deflated by the (Fisher) double deflated value added PPPs listed in table 1, with the exception of the 'clay and building materials' and 'timber' branches which were deflated by (Fisher) single deflated gross output PPPs.



**Table 6. Sectoral Contributions to Annual Manufacturing Productivity Growth, U.K. and U.S., 1900-1957 (%)**

<i>United States (U.S.)</i>									
	Manu- facturin g (TOT)	Food, drink and tobacco (1)	Textiles, leather and clothing (2)	Chemicals and petroleum products (3)	Metals, ferrous and nonferro us (4)	Engi- neering (5)	Paper, printing and miscel- laneous (6)	Shift Effect (SHIFT)	Intra- branch Effect
1900-1913‡	2.20	0.07	0.36	0.09	0.60	0.37	0.76	-0.04	
1913-1923	2.77	0.32	0.65	0.41	0.13	0.77	0.48	0.03	
1923-1937	3.45	0.62	0.57	0.51	0.26	0.63	0.80	0.06	
1937-1950	2.23	0.24	0.17	0.52	0.36	0.52	0.35	0.06	
1950-1957	2.62	0.40	0.31	0.56	0.14	0.55	0.59	0.08	
<b>1900-1957</b>	<b>2.64</b>	<b>0.35</b>	<b>0.37</b>	<b>0.40</b>	<b>0.27</b>	<b>0.60</b>	<b>0.58</b>	<b>0.07</b>	
<i>United Kingdom (U.K.)</i>									
	(TOT)	(1)	(2)	(3)	(4)	(5)	(6)	(SHIFT)	
1900-1913	1.07	0.17	0.31	0.16	0.04	0.23	0.32	-0.17	
1913-1923	2.55	0.13	0.33	0.09	0.22	0.74	0.58	0.46	
1923-1937	2.58	0.31	0.51	0.14	0.19	0.55	0.60	0.28	
1937-1950	1.40	0.31	0.12	0.06	0.10	0.19	0.48	0.13	
1950-1957	1.89	0.14	0.05	0.35	0.20	0.47	0.51	0.18	
<b>1900-1957</b>	<b>1.88</b>	<b>0.22</b>	<b>0.23</b>	<b>0.16</b>	<b>0.15</b>	<b>0.45</b>	<b>0.49</b>	<b>0.18</b>	
<i>Difference (U.S. - U.K.)</i>									
	(TOT)	(1)	(2)	(3)	(4)	(5)	(6)	(SHIFT)	(INTRA)
1900-1913‡	1.13	-0.10	0.05	-0.07	0.56	0.14	0.43	0.13	1.00
1913-1923	0.21	0.19	0.31	0.32	-0.10	0.03	-0.11	-0.43	0.64
1923-1937	0.86	0.32	0.05	0.37	0.07	0.08	0.19	-0.22	1.08
1937-1950	0.82	-0.07	0.05	0.45	0.26	0.33	-0.13	-0.06	0.89
1950-1957	0.73	0.27	0.26	0.21	-0.07	0.09	0.08	-0.10	0.83
<b>1900-1957</b>	<b>0.77</b>	<b>0.13</b>	<b>0.13</b>	<b>0.25</b>	<b>0.12</b>	<b>0.15</b>	<b>0.09</b>	<b>-0.11</b>	<b>0.88</b>

*Sources:*

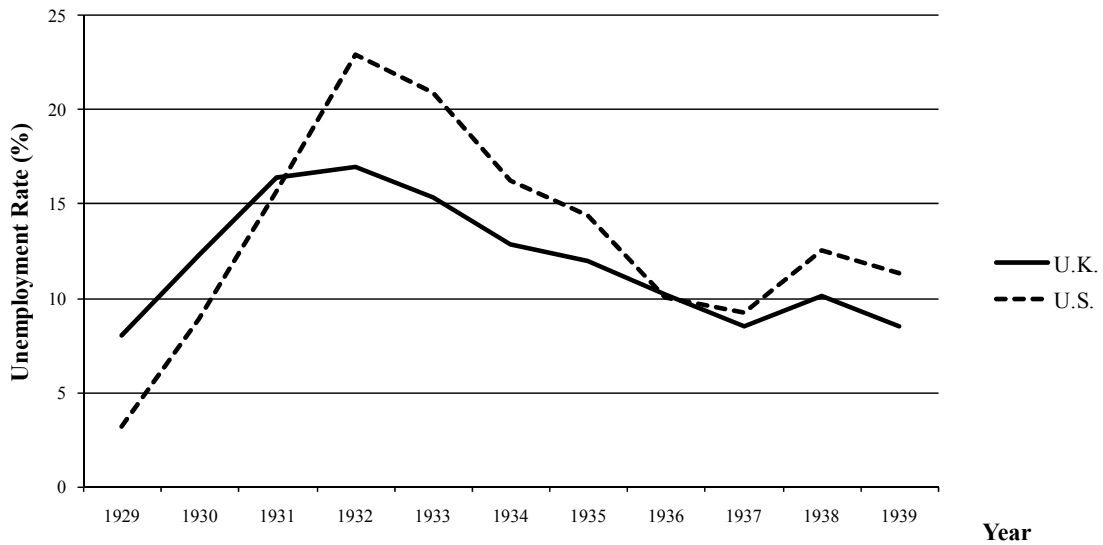
- U.S. from Kendrick, *Productivity*, pp. 465-475; Atack and Bateman, "Manufacturing", *Historical Statistics*, pp. 579-619; U.S. Department of Commerce, Census of Manufactures, various issues; Hours of Work: see table 4 and figure 3.

- U.K. from Feinstein, *Statistical*, pp. T111-T113, T130; Broadberry, *Productivity Race*, pp. 43-46; Hours of Work: see table 4 and figure 3.

‡) Data for the American manufacturing branches was only available for the year 1899; therefore the first U.S. period runs from 1899-1913. Time series for total manufacturing do suggest however that this has extremely little effect on the final estimate of average annual productivity growth during this period.

## FIGURES

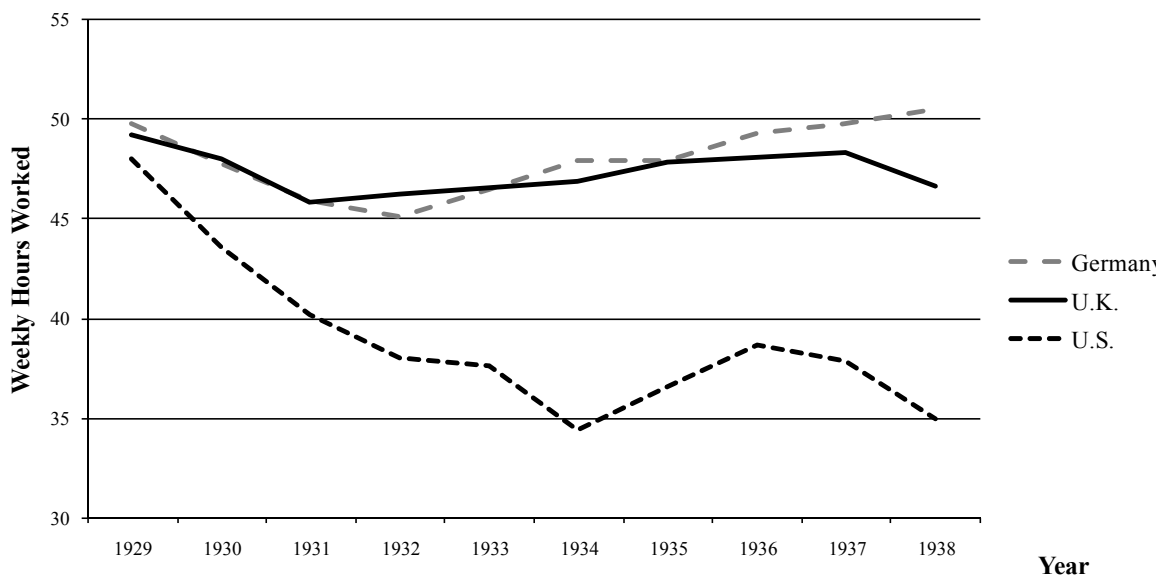
**Figure 1. Unemployment Rate, U.K. and U.S., 1929-1939**



*Sources:*

- U.K. from Boyer and Hatton, 'New Estimates.'
- U.S. from Darby, 'Three-and-a-Half.'

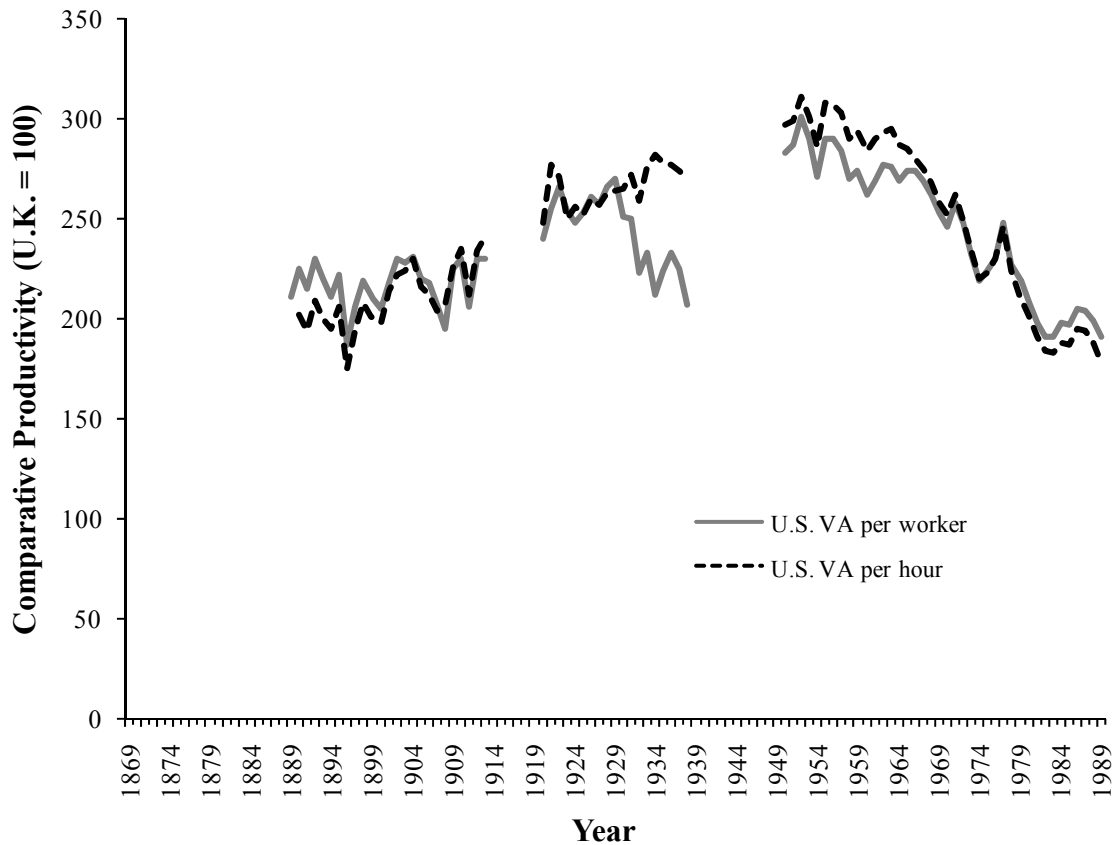
**Figure 2. Weekly Hours in Manufacturing, U.K., U.S., and Germany, 1929-1938**



*Sources:*

- Germany from Länderrat des Amerikanische Besatzungsgebiet, *Statistisches Handbuch*, 1949 and Huberman and Minns, 'Times', p. 546.
- U.K. from Hart, 'Hours' and Colin Clark, *Conditions*; Metcalf et al., 'Still', p. 397.
- U.S. from Jones, 'New Estimates'.

**Figure 3. Comparative Labour Productivity in Manufacturing, U.S. and U.K. 1889-1989 (U.K. = 100)**



*Sources:*

- Benchmark (1935) from own calculations.
- Time Series Output and Employment from Broadberry, *Productivity Race*.
- U.K. Hours of Work from Huberman and Minns, 'Times'; Hart, 'Hours'; Colin Clark, *Conditions*; ILO, *Year-book*, 1931, 1939 and 1962; ; The Conference Board and Groningen Growth and Development Centre, Total Economy Database, January 2007, [www.ggdc.net](http://www.ggdc.net)
- U.S. Hours of Work from Jones, 'New Estimates' and Huberman and Minns, 'Times'; The Conference Board and Groningen Growth and Development Centre, Total Economy Database, January 2007, [www.ggdc.net](http://www.ggdc.net)

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