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CHANGING ECONOMIC LEADERSHIP

A New Benchmark of Sector Productivity in the United States and Western Europe, ca. 1910

Abstract

The debate concerning the exact timing and causes of changes in economic leadership constitutes one of the central themes in economic history. This study aims to improve the measurement of economic performance in the United States and Western Europe (Britain, France and the Netherlands) during the long nineteenth century by constructing a new benchmark of sector productivity and new estimates of comparative GDP per capita and per worker. Our main finding is that the Anglo-Dutch and Anglo-American take-overs should be located earlier in time than suggested by the conventional Maddison database. We offer an explanation for this result by looking at differences in sectoral productivity performance as well as the different structures (sectoral employment shares) of the economy.

Introduction

Long term series of internationally comparable GDP constitute one of the cornerstones of the economic history discipline. The late Angus Maddison (1926-2010), one of the pre-eminent economic historians of the twentieth century, devoted much of his academic career to the construction and improvement of a global dataset of historical national accounts.[1] His efforts

1. See for some of his key publications, A. Maddison, *Phases of capitalist development* (Oxford 1982); idem, *The world economy: a millennial perspective* (Paris 2001); idem, *Contours of the world economy, 1-2030 AD: essays in macro-economic history* (Oxford 2007).

are being continued by a large group of scholars who have committed to pursue his legacy in the so-called *Maddison Project*.[2] Although few scholars, if any, consider GDP series to be a perfect measure of economic welfare at present or in the past, they remain the single-best alternative to study long-term developments in the world economy by displaying phases of growth and stagnation, and by offering a fairly comprehensive tool for comparing the economic performance of national economies at given points in time.

Users, as opposed to constructors, of historical national accounts, often do not fully recognize that the construction of GDP estimates requires substantial amounts of disaggregated data on output, income, expenditure and international trade. This implies that the process of constructing internationally comparable GDP series is, by itself, at least as worthwhile as obtaining the final results at the aggregate level. The construction-process informs researchers about the underlying structure and the disaggregated performance characteristics (comparative productivity levels) of the economy. This study exploits this advantage by building up a new, early twentieth century comparison of GDP in the United States and Western Europe from a disaggregated level. Our benchmark not only provides a check upon existing historical national accounts, but offers new insights into the relative strengths and weaknesses of the main economic sectors (e.g. agriculture, mining, manufacturing and services) for these leading industrial nations as well.

Although the research on historical national income accounts dates back to the early post-war era, with seminal studies of John Kendrick for the US, Charles Feinstein for the UK and early comparative studies by Simon Kuznets, there still remains a lot of work to be done.[3] For sub-Saharan Africa, for instance, there have recently been just the first attempts to push existing post-1950 series back into the colonial era. The preliminary results of these efforts point to a considerable revision of traditional perspectives on long-term African welfare development.[4] For Britain and the Netherlands, existing series for the nineteenth and twentieth centuries have only recently

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2. See J. Bolt and J.L. van Zanden, 'The first update of the Maddison project; re-estimating growth before 1820', *Maddison Project Working Paper* 4 (2013).
3. J. Kendrick, *Productivity trends in the United States* (Princeton 1961); C.H. Feinstein, *National income, expenditure and output of the United Kingdom, 1855-1965* (Cambridge 1972); S. Kuznets, *Modern economic growth. Rate, structure and spread* (New haven 1966).
4. L. Prados de la Escosura, 'Output per head in pre-independence Africa: quantitative conjectures', *Economic History of Developing Regions* 27:2 (2012) 1-36. See for an alternative approach of GDP series the real wage study by E. Frankema and M. van Waijenburg, 'Structural Impediments to African Growth? New Evidence from Real Wages in British Africa, 1880-1965', *Journal of Economic History* 72:4 (2012) 895-926.

been pushed back into medieval times.[5] Nonetheless, the continuous work on historical national accounts does not only involve covering bare territory, it also involves improving of what is already available. Indeed, the adoption of refined methods of calculation and the use of new data sources can lead to marked changes in our views on comparative economic performance, even for those western economies that have been most thoroughly researched by economic historians. These revisions, in turn, spark off new debates on long-term economic development.

In the spirit of Angus Maddison, the key motivation for this study is to further our insights in the dynamics of long-term economic performance among some of the world's leading economies of the past centuries. More specifically, we are interested in a more refined measurement and understanding of the British-Dutch and US-British take-over during the long nineteenth century (1780-1914). We do so by presenting a new benchmark of comparative sector productivity for the Netherlands, the United Kingdom, the United States and France around the years 1907-10. The first three countries have been subsequent technological leaders from the seventeenth century until present. In addition, France provides an interesting case, as one of the largest Western European economies, which followed a rather specific path of economic and industrial development.[6]

In brief, our analysis suggests that the relative position of the Dutch economy vis-à-vis the UK and US was considerably weaker than the conventional Maddison estimates indicate. This finding has important implications for the timing of the historical Anglo-Dutch take-over, which has hitherto been located in the mid-nineteenth century (see figure 1). In fact, our calculations suggest that this take-over should be situated in the late eighteenth century, instead of the mid-nineteenth century as suggested by the Maddison data. The main reason for this revision is that we find the Dutch manufacturing sector to be even more underdeveloped (in comparative terms) at the eve of World War One than previously assumed. Our second finding is that the relative strength of the American economy has been underestimated by Maddison and various other scholars. Our study suggests that the US had challenged British economic leadership in terms of relative labour productivity as well as relative income levels long before 1900, and not thereafter (see again figure 1). This finding ties into an on-going debate on the timing of the Anglo-American take-over, which we will briefly allude to below. Finally,

5.   J.L. van Zanden and B. van Leeuwen, 'Persistent but not consistent: The growth of national income in Holland 1347–1807,' *Explorations in Economic History* 49:2 (2012) 119-130; Broadberry et al., 'British economic growth, 1270-1870', CAGE *Working Paper* 35 (2010).
6.   Ideally we would have included Germany in this study as well, but we have excluded this country for data constraints. These constraints can be dealt with, but warrant a separate study.

Figure 1 *Maddison's GDP per capita series NL, UK, US, and FR (UK=100, 1800-1913)*
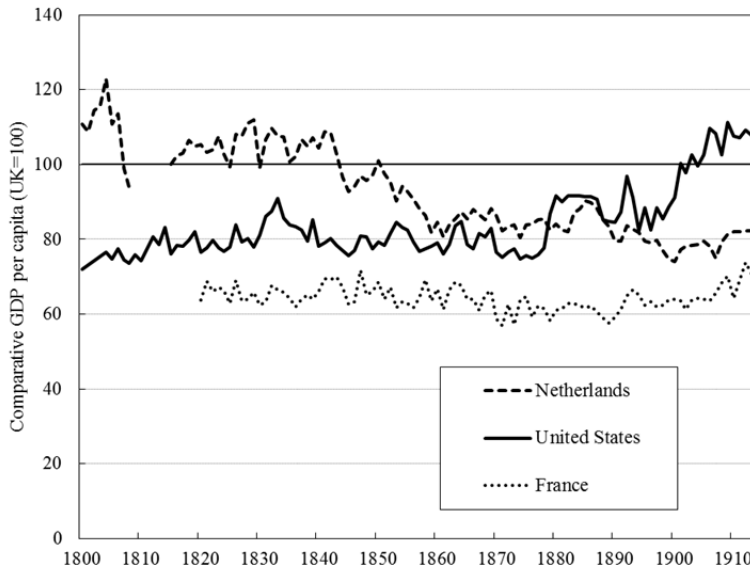
we find that our results for France are closely in line with the Maddison data and that the sector decomposition of our productivity estimates confirm the weak competitiveness of French agriculture. Given the relative importance of agriculture in nineteenth-century France, this offers additional explanatory power to the French resort to economic protectionism during the agricultural depression of the late nineteenth century (1879-1896).

As noted above, in the economic history literature the Anglo-American take-over has been subject to heated academic debate. Although this debate is partly driven by disparate methods of comparing national income and productivity levels as well as the use of different data sources, the controversy ultimately comes down to opposing views on the structural characteristics of both economies in the nineteenth century. All researchers involved agree on one central aspect, namely the huge US productivity advance in manufacturing relative to Western Europe (including the UK). The Anglo-American gap is generally considered to have been of a magnitude of 2-2.5 to 1 around the turn of the century. However, scholars such as Steve Broadberry maintain that British income levels were largely compensated for this productivity gap, prior to 1900, because of two structural features of the British economy. First, the employment shift out of agriculture had advanced much further in the UK than anywhere else. Whereas, in 1907, roughly 12 percent of the UK labour force was active in the low-productive agricultural sector, this share was still as high as 33 percent in the US. The initial British aggregate labour-productivity lead was thus the result of compositional effects rather than superior

productivity at the sector level. Second, labour force participation had been substantially higher in the UK compared to the US, so that part of the productivity gap was compensated for by a higher share of income-earners in the British economy.[7]

Other scholars such as Marianne Ward and John Devereux do not refute the existence of these structural differences, but argue that they were insufficient to compensate for the Anglo-American productivity gap in the nineteenth century and that, consequently, the American take over of economic leadership occurred much earlier in time, somewhere around mid-century. Contrary to Broadberry, Ward and Devereux find a strong US productivity lead in agriculture, mining and construction in addition to the generally acknowledged productivity advance of American manufacturing.[8] The strong American performance in agriculture makes intuitive sense as it appears unlikely that the American agricultural sector was left entirely unaffected by the rapid developments in industry during the late nineteenth and early twentieth century. Given the strong increase in demand for agricultural goods (in particularly from the textile and food and beverage industries), rising wages accompanying the labor productivity gains in industry, as well as access to cheap fertilizers, energy, farm machinery, and the abundance of land, one would expect the American agricultural sector to develop in line with the industrial sector. As noted by Habakkuk, 'scarcity of labour ensured that, within the limits set by geology and climate, American agriculture developed along land-intensive, labour saving lines, that is, assumed high labour-productivity forms'.[9] In addition, a substantial agrarian productivity gap would account for the deep impact of the agricultural depression in Western Europe, when markets in France, the UK and the Netherlands were flooded with cheap American and Russian grain.

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7.   S.N. Broadberry, 'Forging ahead, falling behind and catching-up: A sectoral analysis of Anglo-American productivity differences, 1870-1990', *Research in Economic History* 17 (1997) 1-37; idem, 'How did the United States and Germany overtake Britain? A sectoral analysis of comparative productivity levels, 1870-1990', *Journal of Economic History* 58:2 (1998): 375-407; idem, 'Relative per capita income levels in the United Kingdom and the United States since 1870: reconciling time-series projections and direct benchmark estimates' *Journal of Economic History* 63:3 (2003) 852-63; S.N. Broadberry and D.A. Irwin, 'Labour productivity in the United States and the United Kingdom during the nineteenth century', *Explorations in Economic History* 43:2 (2006) 257-279.
8.   M. Ward and J. Devereux, 'Measuring British decline: direct versus long-span income measures' *Journal of Economic History* 63:3 (2003) 826-851; idem, 'Relative U.K./U.S. output reconsidered: a reply to Professor Broadberry' *Journal of Economic History* 64:3 (2004) 879-891. See for a similar position L. Prados de la Escosura, 'International comparisons of real product, 1820-1990', *Explorations in Economic History* 37 (2000) 1-41.
9.   H.J. Habakkuk, *American and British Technology in the Nineteenth Century. The Search for Labour-saving Inventions* (Cambridge 1962) 34-37.

In a recent study of eighteenth- and nineteenth-century social tables, Peter Lindert and Jeffrey Williamson go even further by claiming that American real income levels had already surpassed British levels before the American war of independence (1775-1783). Their conclusion is based on a benchmark comparison of real incomes of various social classes in 1774, including slave households. According to the authors, the relative income position of the US fell back in the late eighteenth century as a result of the dislocations caused by the war of independence and the gradual decline of the Southern US economy during much of the nineteenth century.[10]

Our study adds evidence to the revisionist view, as we confirm the high Anglo-American productivity differential for agriculture found by Ward and Devereux using newly obtained farm-gate prices. In addition, we argue that the income gap between the US and the UK was compounded by a huge productivity differential in mining, which was a non-negligible sector in both the American and British economy. Finally, we argue, in line with Lindert and Williamson, that it is difficult to pinpoint the American take-over to one particular period in time, as we show a remarkable similarity in economic standing during the two closing decades of the nineteenth century.

The remainder of this article is structured as follows. In the next section we discuss some of the details of the methods and sources we have used to obtain our new benchmark estimate. We then proceed to present our main results. Subsequently, we discuss the main implications of our results for the existing views on changing economic leadership in the nineteenth century and finish with a brief conclusion.

Methodology

The main aim of this section is to introduce the reader into the basic methods, sources and motivations for creating historical benchmarks of output (GDP) and productivity. In addition, we explain – avoiding the use of too many technical details – why we have chosen to work on the basis of the so-called 'industry-of-origin' approach and have selected 1910 as a benchmark year.

An international comparison of productivity levels essentially examines the ratios of output to inputs (e.g. employment, machinery, etc.) between two (or more) national economies.[11] For the production of well-defined, interna-

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10. Yet, to which extent the results produced by income comparisons on the basis of social tables match up with comparisons of historical national still remains to be seen. See P.H. Lindert and J.G. Williamson, 'American incomes 1774-1860', *NBER Working Paper* 18396 (2012).

11. B. van Ark and M.P. Timmer, 'The ICOP manufacturing database: international comparisons of productivity levels', *International Productivity Monitor* 3 (2001), 44-51, 44.

tionally comparable products a straightforward way to obtain these output ratios is to directly compare physical output, or *quantity relatives* (e.g. volume or weight).[12] Productivity in the coke industry, for instance, can be simply gauged from the volume of output per worker; when an employee in country A is able to produce 100 tons of coke over the course of a year while the average employee in country B produces 200 tons, the 'physical labour productivity' in country A is half that of country B. However, as noted by Inklaar and Timmer, the direct comparison of physical units of output for the measurement of productivity is only possible for a specified product or a closely related group of products.[13] Consequently, this greatly limits the quantity approach's ability to estimate productivity for firms or industries producing a wide array of heterogeneous goods or services, which is always the case when comparing productivity at the industry or total economy level. At this level, one is also more likely to have access to figures on the total values rather than quantities of output and inputs.

To compare the value of production requires a conversion factor that expresses the output values of countries A and B into a common currency. The most direct way is to use the official exchange rate.[14] However, the use of exchange rates can substantially underestimate levels of national income and product in less-developed countries.[15] Exchange rates only reflect the comparative price levels of tradable goods and service in an economy, ignoring the price movements of non-tradable commodities and services. In addition, exchange rates tend to be affected by capital movements and speculation on the currency markets, which may lead to exchange rates volatility. Finally, exchange rates may suffer from prolonged over- or undervaluation as a result of deliberate trade policies and, therefore, offer a biased indication of purchasing power.

A widely used alternative is a conversion measure based on the relative prices of products and services produced or consumed *within* the countries under comparison. Such a measure is often referred to as a Purchasing Power Parity (PPP). A PPP systematically weighs the prices of a selection of products and services in any pair of economies and, by doing so, offers a conversion measure that allows one to express levels of output or income in the currency of a single (base) country. Most of the benchmark studies – most notably the

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12. R. Inklaar and M.P. Timmer, 'GGDC productivity level database: international comparison of output, inputs and productivity at the industry level', *GGDC Research Memorandum* 104 (2008) 6-8.
13. Inklaar and Timmer, 'GGDC Productivity level database', 6.
14. A. Maddison and B. van Ark, 'International comparison of purchasing power, real output and labour productivity: a case study of Brazilian, Mexican and U.S. manufacturing, 1975', *Review of Income and Wealth* 35 (1989) 31-55, 31-32.
15. I.B. Kravis, A. Heston and R. Summers, *World product and income: international comparisons of real gross product* (Baltimore 1982).

work done under the auspices of the International Comparison Project (ICP) by the United Nations – develop PPPs using the *expenditure* approach.[16] Here, for a certain benchmark year, the relative price level is derived by gathering lists of (average) consumer prices for a sample of final demand products across countries. For example, the relative price level of a haircut in France is compared to the price of a haircut in the United States. The PPP is then defined as the ratio of these prices. If, for example, a haircut cost 30 francs in France and 10 dollars in the US the PPP (expressed in dollars) is equal to 3 (30/10=3). Typically, in expenditure studies, the PPPs for various final consumer products are aggregated to the Gross Domestic Product (GDP) level and used to compare total output.

The expenditure approach establishes a direct link between comparative income levels and consumption possibilities, making these estimates particularly well suited for international comparisons of income and living standards. However, for the international comparison of productivity and economic performance in general, a direct comparison of output at the industry level is preferable.[17] Previous studies have shown that large cross-industry differences exist in the relative prices levels, obviating the need for industry-specific PPPs. One of the drawbacks of using expenditure PPPs for this purpose is that they are based solely on final consumer products, thus ignoring the relative price levels of intermediate goods which can make up as much as half of total output for some industries. In addition, the expenditure PPPs are influenced by imports, trade margins, domestic taxes and the cost of transportation, which may create a substantial bias in the retail price levels as opposed to the recorded farm or factory-gate values of products.

Alternatively, the *industry-of-origin* approach can be applied. In line with the expenditure approach, the industry-of-origin approach computes PPPs on the basis of (average) prices. The main difference is that the industry-of-origin approach derives the relative price levels from output data at the producer level.

We opt for the industry-of-origin approach because this method is better suited to draw inferences about economic performance and changes in economic leadership, as opposed to comparing living standards. In addition, by opting for the industry-of-origin approach we are able to break down GDP and estimate the comparative performance at both the industry as well as the total economy level, using industry-specific PPPs that convert sector or branch-level output into a common currency. As we will show below, these disaggregate productivity levels prove to be instrumental in explaining the forces behind first the British and then the American cycle of catch-up, taking-over and forging ahead.

16. Kravis, Heston and Summers, *World product and income.*
17. B. van Ark, *International comparisons of output and productivity: manufacturing productivity performance of ten countries from 1950 to 1990* (Groningen 1993).

Long-run time-series

Maddison's dataset is based on an international price comparisons for the benchmark year 1990. He relies on the expenditure approach described above and expresses his GDP series in so-called international dollars using these 1990 PPPs. Time-series of GDP are then obtained by backward and forward extrapolation of the individual series, adjusting for annual GDP growth (or decline) and changes in domestic price levels (inflation or deflation).

While relying on just one benchmark year for the conversion of long-run GDP series to a common currency – as opposed to constructing direct benchmarks for each year individually – saves an enormous amount of additional research, the major drawback of this approach is that the potential margin of error widens the further one gets into the past. There are at least three reasons for this. Firstly, the deflators used by national statistical offices to adjust time-series of national income do not contain the same products and services as captured by the 1990 PPPs. Secondly, the type of commodities and services that are being consumed or produced shifts over time. For instance, a 1990 PPP may contain consumer prices of a mid-sized family car, a personal computer and a vacuum cleaner, commodities that did either not exist (or were of a complete different quality) in 1900, let alone 1800 or 1500! Thirdly, time-series always contain major breaks for periods where price, income or production data is scarce or non-existent. For the twentieth-century GDP series, for instance, there are gaps during the two World Wars. In addition, for the accurate measurement of inflation occasional bouts of hyperinflation or a change in currency (e.g. introduction of the euro) may lead to further biases.

To accommodate these concerns we created a new PPP benchmark for the year 1909/10, providing us with a new point of reference just before World War One, and at the end of a long period of relative price stability in the Western economies. Without doubt, the products that we were able to include in our PPP estimates offer a much more accurate reflection of production patterns in the nineteenth century than the 1990 expenditure PPPs that are currently in use. This new early 20th century benchmark allows us to check the validity of existing long term series from the Maddison database and to adjust the existing series with the new conversion factor at hand.

Sources

We have calculated average farm and factory gate prices from the values and quantities of the products reported in official agricultural, mining and manufacturing production censuses. These surveys contain detailed information on quantities and values of produced items, average prices, gross output, intermediate input and employment, enabling us to construct labour productivity comparisons bottom-up. For the United States we based our analysis

on the *Thirteenth Census of the United States taken in the year 1910*, published by the Bureau of the Census of the U.S. Department of Commerce and the *Mineral Resources of the Unites States* published by the Department of the Interior as part of the United States Geological Survey. For the United Kingdom we relied primarily on the *First Census of Production of 1907* published under the census of production act of 1906. The data for the Netherlands was taken from the *Verslag over den Landbouw in Nederland 1910* and the *Statistiek van de voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* published by the Department of Agriculture (Departement van Landbouw) and the National Statistical Office (Centraal Bureau voor de Statistiek). For France we based our analysis on the *Evaluation de la Production* published by the Chambers of Commerce (1910) and the *Statistiques Administratives* (1912). In addition we relied on the *Annuaire Statistique de la France* for 1908 and the summary tables of 1966. A complete overview of sources used can be found in the appendix.

Business cycle and capacity utilization effects can have a significant influence on the measurement of output and productivity levels for a particular year. However, as the countries included were all in a comparable state of economic growth at that time, we believe that for our purposes the years 1909/1910 are suitable for a fair comparison.[18] In addition, the detailed source data required for this type of analysis is largely available for these years, or some years sufficiently close (see the appendix). As already mentioned above, the censuses do not refer to exactly the same year and they are not completely comparable in coverage. The British census of 1907, the American census of 1910 and the Dutch census of 1913 provide an almost complete coverage of agriculture, mining and manufacturing. The two French censuses for 1910/12 and 1912/13 consist of several investigations for single industries and do not provide the same coverage as for the other countries. Nonetheless, additional sources for France, such as the studies of Markovitch, Toutain and Dormois enabled us to apply our PPP estimates to value added estimates at a sector and total economy level.[19] Where necessary we used existing price indices to extrapolate price data backwards or forwards to our 1909/10 benchmark.

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18. For an elaborate discussion of the business cycle and capacity utilization effects and a sensitivity analysis for the interbellum see H. de Jong and P. Woltjer, 'Depression dynamics: a new estimate of the Anglo-American manufacturing productivity gap in the interwar period', *Economic History Review* 64 (2011) 472-492.

19. T. Markovitch, 'Le produit physique de l'économie francasie de 1789 à 1964', *Cahiers de l'ISEA* 164:4 (1965); J.C. Toutain, 'Le produit intérieur brut de la France de 1789 à 1982', *Economies et Societés* 15 (1987); J.P. Dormois, 'Tracking the elusive French productivity lag in industry, 1840-1973', *Hi-Stat Discussion Paper* 152 (2006).

Main results[20]

This section discusses our main results. Table 1 presents our PPP estimates for agriculture, mining, manufacturing and the combined PPP for agriculture and industry; the latter also including construction.[21] These relative prices were constructed on the basis of 149 different products in the case of the Anglo-American comparison, 66 in the case of the Netherlands and 59 for the France-US comparison. The sample of products in this study ranges from wheat to pig meat for the agricultural sector, iron ore to petroleum in mining and jute yarn to sulphuric acid in manufacturing.[22]

TABLE 1   *Purchasing Power Parities, US, UK, NL and FR (ca. 1910)*

	purchasing power parities (US=1)			products matched (#)		
	UK (£/$)	NL (Dfl/$)	FR (Ffr/$)	UK	NL	FR
Exchange rate	*0.21*	*2.5*	*5.2*	...	...	...
Agriculture	0.23	2.2	7.9	29	15	13
Mining	0.34	4.9	7.6	9	1	10
Manufacturing	0.19	2.5	5.2	111	50	18
Metals & machinery	0.22	3.9	5.8	30	7	2
Textiles, leather & clothing	0.16	2.1	3.8	24	12	3
Food, drink & tobacco	0.19	1.9	6.2	20	11	7
Chemicals	0.21	3.4	7.7	23	14	4
Miscellaneous	0.20	1.9	5.4	14	6	2
Total: agriculture & industry	0.20	2.3	6.2	149	66	59

Sources: see appendix A.

The number of product-matches for each individual sector are shown in the last three columns of table 1. Overall, for the Anglo-American comparison, the products included in our benchmark comparison covered nearly 90 percent of total gross output in the UK and approximately 70 percent in the US for both the agriculture and mining sectors. This so-called coverage ratio was substantially lower for the manufacturing sector, however, which is explained by the

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20. All the underlying data that we used to produce the results shown in this section can be obtained via the authors. Please send an email with a data-request to pieter.woltjer@wur.nl.
21. Note that the PPPs are based on 1909 prices in the case of manufacturing and 1910 prices in the case of agriculture and mining. The first row of table 1 lists the 1910 exchange rate (which was identical to 1909).
22. A complete list of products included in the calculation of the PPPs can be found in the appendix to E. Frankema, J.P. Smits and P. Woltjer 'Comparing Productivity in the Netherlands, France, UK and US, ca. 1910: A new PPP benchmark and its implications for changing economic leadership', *GGDC Research Memorandum* 113 (2010).

greater heterogeneity of products in this sector, as well as the unique national character and qualitative differences of some of the commodities produced. Nonetheless, we were able to cover well over 30 percent of the American and 40 percent of British manufacturing output. For the comparison between the Netherlands and the US we covered approximately 50 percent of output in agriculture and mining and close to 20 percent in manufacturing. The French coverage ratios for the agricultural, mining and manufacturing sectors were 30, 80 and 15 percent respectively. Generally, this is comparable to coverage ratios found in previous pre-war productivity studies.[23]

Table 1 demonstrates that substantial relative price differences existed between industries during this period and shows how these related to the official exchange rate (presented in the upper row). In the three Western European countries the mining products, which primarily consisted of coal, were rather expensive as compared to the US. In France and the UK agricultural products were also quite expensive, especially when compared to the relative price level of manufactured goods. In contrast, the differences between the producer prices of agricultural and manufactured commodities in the Netherlands were relatively small.

How do our PPP estimates compare to other existing estimates? O'Brien and Keyder constructed a total economy PPP for their Anglo-French comparison of nineteenth century economic development. Their PPP is based on a selection of only six representative commodities; i.e. beef, wheat, coal, flour, pig iron and cotton yarn. For the period 1905-1913 their France-UK PPP was estimated at 29.0 (using French output weights) and 29.8 (on the basis of UK weights), which is in line with our implied PPP estimate of 30.5 French francs per British Pound (matched via the US benchmark).[24] In an unpublished working paper Burger presented industry PPPs for the US, Netherlands and France using the UK as base country. Transforming his PPPs to US dollar based estimates we find comparable results for the Anglo-American comparison; Burger, for instance, reported a PPP of 0.19 £/$ for industry while we find a relative price level of around 0.20 £/$. For the Netherlands and France the differences are somewhat larger. We find an industry PPP of around 2.04 Dfl/$ for the Netherlands against 2.44 Dfl/$ according to Burger. For France the difference between our own estimate and Burger's is around 10 percent (4.67 against 5.18 Ffr/$ for total industry).[25]

23. R. Fremdling, H. de Jong and M.P. Timmer, 'British and German Manufacturing Productivity Compared: a New Benchmark for 1935/6 based on Double Deflated Value Added', *The Journal of Economic History* 67 (2007) 350-378; de Jong and Woltjer, 'Depression Dynamics'.

24. O'Brien and Keyder, *Economic growth*, 40-47.

25. A. Burger, 'A five-country comparison of industrial labour productivity 1850-1990', *N.W. Posthumus Institute Working Paper* (1994) 5.

A further decomposition of the manufacturing sector offers additional insights in the price structure of the four economies. Table 1 shows that the relative price differences across the manufacturing branches were quite substantial as well, especially in the Netherlands and France. Such price differences testify to a specific pattern of industrial specialisation which will become even more evident when we discuss the labour productivity comparisons further below. The Dutch case offers the best example. Considering the official exchange rate of 2.49 Dfl/$ (see table 1) it appears that the Dutch food and textile trades managed to produce at competitive price levels, while the chemical and metal trades were way too expensive to be internationally competitive.[26] The observed price differences within the manufacturing sector show that the use of a uniform currency converter, such as the official exchange rate, will not generate accurate productivity comparisons at branch or sector level since it rules out the possibility of inter-industry price differences.[27]

Comparative labour productivity

What new light do these PPP estimates shed on international labour productivity comparisons? Table 2 presents the comparative labour productivity estimates with the US as base country. Unsurprisingly, our results confirm the existence of a large transatlantic productivity gap in industry. This phenomenon has been extensively documented in the economic historical literature.[28] US industrial productivity levels were about 220 percent of the UK, 240 percent of France and 350 percent of the Netherlands. The intra-European productivity gaps were substantial as well, with the UK having a productivity lead of roughly 50 percent over the Netherlands and France in agriculture and industry combined. However, the industrial productivity gap between France

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26. J. de Jonge, *De industrialisatie in Nederland tussen 1850 en 1914* (Amsterdam 1968); R. Griffiths, *Industrial retardation in the Netherlands: 1830-1850* (Den Haag 1979), J.P. Smits, E. Horlings and J.L. van Zanden, *Dutch GNP and its components, 1800-1913* (Groningen 2000).
27. D. Paige, and G. Bombach, *A comparison of national output and productivity of the United Kingdom and the United States* (Paris 1959).
28. See for instance Paige and Bombach, *A comparison*; L. Rostas, *Comparative productivity in British and American industry* (Cambridge 1948); R.J. Gordon, 'Two centuries of economic growth: Europe chasing the American frontier', *CEPR Discussion Paper* 4415 (2004); S.N. Broadberry, *The Productivity Race: British Manufacturing in International Perspective* (Cambridge 1997); Ward and Devereux, 'Measuring British decline'; A. Field, 'The most technologically progressive decade of the century', *The American Economic Review* 93 (2003) 1399-1413; ibid, 'The origins of US total factor productivity growth in the Golden Age', *Cliometrica* 2 (2007) 63-90.

and Britain was far less dramatic.[29] Nonetheless, the British economy was considerably ahead in terms of structural change with a far more specialized agricultural sector. Around 1910 only 12 percent of the British labour force was engaged in agriculture, whereas this share was closer to 30 percent in the Netherlands and as high as 41 percent in France. Having a large portion of its labour force tied down in the low-productive agricultural sector dragged down the average productivity level in both the Netherlands and France.

TABLE 2 *Comparative labour productivity, US, UK, NL and FR (ca. 1910)*

	comparative labour productivity (US=100)		
	UK/US	NL/US	FR/US
Agriculture	56	47	37
Industry	45	29	41
Mining	38	10	39
Construction	75	32	53
Manufacturing	42	29	40
Metals & machinery	38	18	45
Textiles, leather & clothing	48	29	46
Food, drink & tobacco	47	40	38
Chemicals	49	10	32
Miscellaneous	43	40	49
Total: agriculture & industry	56	35	38

Sources: see appendix A.

So far our findings are in line with a large body of literature discussing the comparative advantages of the Western European economies during the late nineteenth and early twentieth century. For instance, it clarifies the French policy choice for agricultural protectionism in an era of globalisation.[30] It squares with the evolution of a specialised agro-commercial economy in the Netherlands in an era of rapid industrialisation in its neighbour countries.[31]

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29. P. O'Brien and C. Keyder, *Economic growth in Britain and France 1780-1914* (London 1978) 146.
30. L.C.A. Knowles, 'Economic development in the nineteenth century. France, Germany, Russia and the United States' *Studies in Economics and Political Science* 109 (1932) 239-253; J.P. Dormois 'The impact of late-nineteenth-century tariffs on the productivity of European industries (1870-1930)', in: J.P. Dormois & P. Lains (eds.) *Classical Trade Protectionism 1815-1914* (London 2006) 160-192.
31. Griffiths, *Achterlijk, achter of anders? Aspecten van de economische ontwikkeling van Nederland in de 19e eeuw* (Amsterdam 1980); J.L. van Zanden and A. van Riel, *The strictures of inheritance: the Dutch economy in the nineteenth century* (Princeton 2004).

A Mississippi river landing in Memphis, Tennessee, 1906. Steam ships greatly reduced transportation costs in domestic and international trade since the mid-nineteenth century. Source: Library of Congress, Call no. LC-D4-19395.

And our results also underscore the Dutch economy as a coal-poor economy.[32] Considering the Anglo-French productivity comparison it is remarkable to see how close our estimates are to the 1978 results of O'Brien and Keyder, who estimated French industrial labour productivity in the years 1905-1913 to be somewhere between 94 to 98 percent of the British level.[33]

The difference with the results reported by Dormois is larger though. Dormois finds French industrial productivity levels at 32 of the US level in 1909, against 41 percent in our estimation.[34] As we rely on Dormois' value added and employment estimates, this gap must be fully attributed to the different currency conversion methods applied.[35] Dormois uses the official exchange rate to convert French industrial labour productivity into US dollars for 1909.

32. B. Gales, *Ondergronds bovengronds. Techniek en markt van de Limburgse steenkolenmijnbouw gedurende de achttiende en negentiende eeuw* (Capelle aan de IJssel 2002).
33. Our 1910 estimate for industry shows a comparative French productivity level of approximately 91 percent of the UK, see table 2.
34. Dormois, 'Tracking the elusive French productivity lag', 7-8.
35. A small part of the difference is due to the inclusion of mining in Dormois' comparison, which we treat separately in this paper.

However, as we have argued above, considering the large inter-industry price differences we find this approach difficult to defend.

Compared to the work on the Anglo-American productivity comparison the picture is mixed. Our UK-US manufacturing productivity level of 42 is lower than the estimate of 49 reported by Broadberry and Irwin, but both these estimates confirm the existence of a large transatlantic productivity gap for manufacturing in the early twentieth century, as previously discussed.[36] Britain's falling behind the US during the nineteenth century has traditionally been explained by differences in factor and resource endowments as well as demand patterns.[37] The abundance of land and natural resources in the US gave rise to more capital- and resource-intensive production, a process which was further facilitated by a relatively homogenous demand for goods.[38] In contrast, in Britain natural resources were scarce while skilled labour was in ample supply, providing an incentive to economize on fixed capital in the form of machinery.[39]

However, the role played by resources in the Anglo-American manufacturing productivity gap is underscored by the relatively high Anglo-American PPP we find for agriculture and particularly mining – the sectors providing the bulk of resources and inputs for production in manufacturing – presented in table 1, and it is here that our results deviate from part of the literature. We find a substantially greater Anglo-American productivity gap in mining than Broadberry and Irwin. We appraise British value added per worker at 38 percent of the American level, while Broadberry and Irwin cite an estimate of 62 percent. The main source for the discrepancy between both benchmark estimates is the method of productivity comparison. Broadberry and Irwin rely on 'quantity relatives' and estimate comparative productivity in mining solely on the basis of the physical production of coal and iron ore. Even though coal and iron ore comprise the bulk of output and employment in this sector, by focusing solely on these two items Broadberry and Irwin ignore the contribution of other upcoming mining products, most notably gas and fuel oils (e.g. petroleum).[40]

The superior performance of the American mining sector can, in part, be explained by the sheer quantity and quality of natural resources in this country. For the coal-mining sector, McCloskey shows that the 'American seams were generally thicker, closer to the surface, freer from faults, flatter and drier

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36. Broadberry and Irwin, 'Labour productivity', 261; S.N. Broadberry, 'Comparative productivity in British and American manufacturing during the nineteenth century', *Explorations in Economic History* 31 (1994) 521-548, 524.
37. Habakkuk, *American and British technology*, 122; Broadberry, *The productivity race*, 3.
38. Broadberry, 'Technology leadership', 291.
39. P. Temin, 'Labour scarcity in America', *Journal of Interdisciplinary History* 1 (1971) 162.
40. International Labour Office, *The world coal-mining industry* (Geneva 1938) 33-36.

than British seams.'[41] The favourable geological conditions allowed American miners to introduce new mechanized methods of production and work considerably more efficiently than their British counterparts. Taylor's analysis underscores the British mine-owners conservative attitude toward the adoption of new innovations and technologies through, for instance, the late adoption of electricity as well as the hesitant introduction of the mechanized coal-cutter in the British mines.[42] As was the case for manufacturing, American miners took full advantage of the major improvements in labour-saving technologies during the late nineteenth and early twentieth century, whereas British improvements focused primarily on overcoming the diminishing returns to land as the coal and ore deposits were slowly being exhausted.[43] These developments drove a wedge between the labour productivity levels of both countries, resulting in a productivity ratio in the mining sector around 0.38 to 1 in favour of the US.

Contrary to the consensus view, our results also highlight the comparatively strong performance of the American agricultural sector. We find a vast American lead in agricultural productivity of almost 2:1, while Broadberry and Irwin arrive at a figure close to parity.[44] The main source for the discrepancy in the agricultural labour productivity estimates is not the method of productivity comparison but is the underlying figure of US value added per worker for this sector. In an earlier study, on which Broadberry and Irwin base their estimate, Broadberry lists a US net output per employee value of 347$.[45] We base our considerably higher estimate of 488$ per worker on the value added figures listed in the *Historical Statistics* and the agricultural employment reported by Lebergott.[46] Although the estimation of employment and particularly value added in agriculture is considerably more difficult than it is for other sectors, none of the primary sources point in the direction of a figure as low as suggested by Broadberry. In addition, net output per worker in the British agricultural sector appears to be overstated by Broadberry; 78£ versus

41. D. McCloskey, 'International differences in productivity? Coal and steel in America and Britain before World War 1', in: D. McCloskey (ed.), *Essays on a mature economy* (Princeton 1971) 285-304, 293.

42. A. Taylor, 'Labour productivity and technological innovation in the British coal industry, 1850-1914', *Economic History Review* 14 (1961) 48-70, 58; see also, R. Walters, 'Labour productivity in South Wales steam-coal industry, 1870-1914', *Economic History Review* 28 (1975) 280-303, 296.

43. McCloskey, 'International differences in productivity?', 289-90.

44. Broadberry and Irwin estimate British productivity in agricultural to have been 92 percent of the American level; see, Broadberry and Irwin, 'Labor productivity', 261.

45. Broadberry, 'Forging ahead', 27.

46. S. Carter et al., *Historical statistics of the United States, vol. 4: economic sectors* (Cambridge 2006) 193; S. Lebergott, *Manpower in economic growth: the American record since 1800* (New York 1964) 510.

our estimate of 64£.[47] The higher estimate by Broadberry is the result of his choice to exclude the agricultural production in Ireland from his productivity estimate. This, however, is inconsistent with the definition used by Feinstein as well as the industrial benchmark.[48] We reincorporated Irish production and employment in the productivity figures and made a (minor) revision to the relative Anglo-American price levels listed by Broadberry.[49]

These adjustments to the productivity estimates listed above are not only in line with those suggested in a recent paper by Ward and Devereux, they also substantiate Habakkuk's claim of relatively high levels of productivity in American agriculture.[50] In his monograph, Habakkuk argues that during the nineteenth century 'America[n] improvements in agriculture took the form primarily of increasing output per head and the increase initially was probably more rapid than in industry; in England on the other hand, agricultural improvement was devoted primarily to increasing yields per acre.'[51] Reflecting his well-known thesis for industry, Habakkuk contends that the abundance of resources and scarcity of (skilled) labour in the US forced American farmers to pursue capital-intensive methods of production. Machinery and particularly land were substituted for labour, resulting in high levels of labour productivity. The importance of labour-saving innovations also features prominently in subsequent accounts of the American agricultural development, stressing the relative productivity of this sector in international perspective.[52] Furthermore, Olmstead and Rhode demonstrate the importance of biological innovations in the form of improved crops and livestock.[53] These biological innovations allowed the farm frontier to be pushed to the drier and harsher West and North, continuously expanding the available land for cultivation. This depressed the price of farmland in relation to labour even further. These developments allowed American agriculture to become regionally specialized, reaping all the benefits of returns-to-scale and raising productivity levels in the process.

The labour productivity comparisons for the five manufacturing branches (table 2) shows that in the Netherlands the comparative productivity gap between the heavy industries such as the metal and chemical trades and the

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47. Broadberry, 'Forging ahead' 27; Feinstein, *National income*, 208; C.H. Feinstein, *Statistical tables of national income, expenditure and output of the UK* (Cambridge 1976) T60, T131.

48. Feinstein, *National income*, 8-10.

49. Broadberry, 'Forging ahead', 27.

50. Ward and Devereux, 'Relative British and American income levels', 267-268.

51. Habakkuk, *American and British technology,* 11-14.

52. W. Hayami and V. Ruttan, *Agricultural development: an international perspective* (Baltimore 1985) 16.

53. A. Olmstead and P. Rhode, *Creating abundance: biological innovation and American agricultural development* (New York 2008) 387.

lighter industries such as textiles and foodstuffs loomed large. Labour productivity in the food producing industries was, on average and relative to the us, more than twice as high as in the metal industries and even three times as high as in the chemical industries. It reveals the defects of the Dutch industrial sector during the nineteenth century: a complete absence of competitive heavy industries. Dutch manufacturing was based on the linkages it could establish with the specialised agricultural sector (food industries) and the colonial relationships with the Dutch Indies (textiles).[54] Only during the interwar years did the Dutch manufacturing sector experience a strong phase of catch-up growth and diversification enhanced by the rapid adoption of electricity.[55] The Anglo-American figures confirm that American producers excelled in the production of durable goods (e.g. metal, engineering and wood products), while the British manufactures were relatively productive in the non-durable industries (e.g. food, textile and chemicals). As noted by Broadberry, these industry-specific productivity results are broadly in line with the figures on revealed comparative advantage in British and American manufacturing trade by Crafts and Thomas.[56] In contrast, in France the chemical industry was comparatively weak, about 32 percent of the us level, while the textile industries did comparatively well, roughly 46 percent of the us level.

Structural differences

A more detailed analysis of the productivity gap between the us and the three Western European countries in manufacturing also sheds new light on the impact of 'structural' and 'compositional' differences. Standard economic theory predicts that in an open economy setting countries tend to specialise in activities in which they have a comparative advantage. In the hypothetical case that the employment structure of the uk, Netherlands and France would have been exactly identical to the us, 'compositional' differences are zero and would not affect the aggregate manufacturing productivity gap. Yet, in reality, The French and British textile industry employed respectively 46 and 37 percent of the manufacturing labour force against 26 percent in the us. And while the us food industry employed only 11 percent, in the Netherlands this share was 35 percent of the manufacturing workforce.

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54. Smits et al., *Dutch GNP*, 40-45; Van Zanden and Van Riel, *Strictures of inheritance*, 295-304.
55. The most comprehensive account available of this process is offered by the H. de Jong, *Catching up twice: the nature of Dutch industrial growth during the twentieth century in a comparative perspective* (Berlin 2003) 160.
56. Broadberry, *The productivity race*, 523; N. Crafts and M. Thomas, 'Comparative advantage in uk manufacturing trade', *The Economic Journal* 96 (1986) 629-645, 639.

To find out how large the effects of industrial specialisation on the productivity comparison are, table 3 repeats the manufacturing productivity comparison of table 2 in the last column, based on the geometric average of the employment distribution in the base economy and the comparison economy (Fisher). The columns above report the comparative productivity levels using the employment distribution of the US (Laspeyres) and the comparison country (Paasche).

TABLE 3 *The effects of the employment structure on comparative labour productivity in manufacturing: US, UK, NL and FR (ca. 1910)*

| | *comparative labour productivity (US=100)* | | |
	UK/US	*NL/US*	*FR/US*
Laspeyres (US weights)	40	25	40
Paasche (own country weights)	44	35	40
Fisher (geometric average)	42	29	40

Sources: see appendix A.

Table 3 shows that all three countries reveal higher productivity levels vis-à-vis the US when we use their own employment distribution. It can thus be argued that, again in relation to the US, the Western European economies indeed specialised in a 'rational' way, that is, according to their comparative advantages. Given the small differences observed for the UK and France we should not make too much of this conclusion though. More interesting, however, is the compositional effect on labour productivity in the notably smaller and more open economy of the Netherlands: using a Laspeyres or Paasche PPP makes a difference of nearly 10 percentage points in estimated manufacturing productivity! This again supports the view that the industrialisation process in the Netherlands before World War One was based on developing some niches, rather than an encompassing industrial sector. We will see in the next section that missing the boat during the first and second industrial revolutions put the Dutch economy in a more backward position than existing comparative estimates of GDP per capita suggest, despite the strong performance of the Dutch in services.

Total economy and long-run implications

Until now this study focused on agriculture, mining and industry- the goods producing sectors of the economy. However, in our attempts to chart the relative strength of the various economies at the eve of World War one, the service sector needs to be taken into account as well. Table 4 summarizes the main findings from the previous section and includes estimates for services made

by Burger and Smits.[57] These data are aggregated in order to get an idea of international differences in economy-wide labour productivity as well as variations in GDP per capita.

TABLE 4 *Comparative productivity and income, US, UK, NL and FR (ca. 1910)*

	comparative productivity and income (US=100)		
	UK/US	*NL/US*	*FR/US*
Agriculture	56	47	37
Industry	45	29	41
Services	84	85	68
GDP per worker	71	53	47
GDP per capita	77	52	60

Sources: see appendix A.

Burger and Smits constructed their service sector productivity estimates based on an industry-of-origin approach for transport (railways), communication, trade, government and other (personal) services. Their estimates were derived from the relative prices of transportation (freight rates as well as tariffs for passengers), the prices of postal items, telegrams and telephone calls as well as average trade margins for the trade sector. Burger and Smits used two different sets of estimates for government and other (personal) services. In one set the differences in real wages were used as an indication of comparative levels of labour productivity for these types of services, assuming perfect market conditions. In the second set of estimates these two branches within the service sector were set at 100, assuming no international productivity differences. It seems that the overall comparative productivity levels for the service sector at large are hardly affected by these different methods of estimation.

The main conclusion that can be drawn from table 4 is that international disparities in productivity in the service sector were much lower than they were in the goods-producing sectors. Including services in the total economy comparison thus results in a much higher degree of convergence around 1910 than suggested by the combined estimates for agriculture and industry. The addition of services raises the French economy-wide productivity levels with 9, the British with 15 and the Dutch with 18 percentage points versus the US.

Table 5 compares our new results with previous attempts to measure the differences in GDP per capita between the four countries. Our industry-of-

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57. A. Burger and J.P. Smits, 'A benchmark comparison of service productivity between Europe and the United States for 1910', *Economic and social history in the Netherlands* 7 (1996), 133-158.

origin estimates are compared with expenditure-based productivity calcula-tions by Ward and Devereux. Besides, for the UK, also the Broadberry and Irwin estimates (both industry-of-origin and expenditure based calculations) are included. Moreover, the estimates are compared with the various versions of the Maddison dataset expressed in 1970, 1985 and 1990 dollars.

TABLE 5 *Different approaches to estimate comparative levels of GDP per capita, US, UK, NL and FR (ca. 1910)*

			Comp. GDP per capita (US=100)		
Author	*Approach*	*Year*	UK	NL	FR
This study	industry-of-origin	1910	77	52	60
Ward & Devereux	expenditure	1905	82/92	63	67
Broadberry & Irwin	quantity relatives	1909/11	89		
Broadberry & Irwin	expenditure	1909/11	95		
Maddison	1990 GK$	1910	93	76	60
Maddison	1985 GK$	1910	80	65	55
Maddison	1970 GK$	1910	79	68	64

Sources: Ward and Devereux, "New perspectives" (92, 63 and 67) and "Measuring British decline" (82); Broadberry and Irwin, "Labour productivity"; Maddison, Phases of capitalist development (1970$); Maddison, Dynamic Forces (1980$) and Maddison, The world economy (1990$)

For all three Western European countries our GDP per capita estimates are lower than hitherto suggested in the literature. For France the differences are between 0 and 11 percent. For the UK our estimate amounts to 77 percent, which is 14 to 21 percent below the Broadberry and Irwin estimate. However, our Anglo-American figure is perfectly in line with Ward and Devereux's fig-ures once we take the difference in benchmark year (1905 versus 1910) into account (see figure 2 below).[58] Yet, the largest difference we find is for the Netherlands. The most recent Maddison data point at an income level of 76 percent of that of the United States. The expenditure based estimate of Ward and Devereux stands much lower at 63 percent and our new industry-of-ori-gin figure measures a relative income level of only 52 percent. Interestingly, the Maddison estimates expressed in 1985 and 1970 dollars are in all cases closer to our new benchmark estimate, suggesting that they reflect the rela-tive prices of 1910 better than the 1990 PPPs.

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58. This estimate '92' is taken from a yet unpublished working paper presented at the International Economic History Congress 2006, in Helsinki. We would like to thank the authors for permission to cite their paper. See Ward and Devereux, 'New perspectives on international standards of living in the late nineteenth century', *paper presented at XIV Economic History Congress* (Helsinki 2006).

Implications for the debate on changing economic leadership

This final section focuses on the implications of our results for the debate concerning the timing of the Anglo-Dutch and American-Anglo take over during the long nineteenth century.

The Anglo-American take over

The discussion on the timing of the economic overtaking of the US during the nineteenth and early twentieth century has been quite intense. In his 1997 and 1998 articles Broadberry argued that the United States overtook the United Kingdom in the 1900s.[59] In 2003 this view has been contested by Ward and Devereux who, on the basis of brand-new expenditure PPP estimates, maintained that already in the 1870s the relative level of GDP per capita of the US was higher than that of the UK.[60] Prados de la Escosura even argued that the US was already ahead of the UK in the first half of the nineteenth century.[61] However, in subsequent publications Broadberry and Broadberry and Irwin maintained their view that the economic overtaking of the United States cannot be dated as early as Ward and Devereux suggest.[62]

A backward projection of our benchmark estimates on existing time-series presented in figure 2 adds evidence to the revisionist view, although it also suggests that the takeover may be more difficult to pin-point to a single decade than hitherto has been assumed. For the time series we rely on figures by Maddison, allowing us to compare the extrapolated GDP per capita figures against the Anglo-American comparative per capita income figures by Broadberry and Irwin.[63]

The estimates by Broadberry and Irwin show a substantial British lead in per capita income terms between 1870 and 1890. According to their estimates, the US overtook the UK in GDP per capita between 1900 and 1910.[64] Our benchmark extrapolation dates the overtaking considerably earlier. We find that around 1870 the UK enjoyed a small lead in per capita income terms.

59. Broadberry, 'Forging ahead'; S.N. Broadberry, 'How did the United States and Germany overtake Britain? A sectoral analysis of comparative productivity levels', *Journal of Economic History* 58 (1998) 375-407.
60. Ward and Devereux, 'Measuring British decline', 840.
61. Prados de la Escosura, 'International comparisons of real product', 24-31.
62. Broadberry, 'Relative per capita income differentials', 860-861; Broadberry and Irwin, 'Labour productivity in the United States and the United Kingdom', 272.
63. Broadberry and Irwin, 'Labour productivity in the United States and the United Kingdom', 261; Maddison, *The world economy*; Bolt and van Zanden, 'The first update of the Maddison project'.
64. Broadberry and Irwin, 'Labour productivity in the United States and the United Kingdom', 269.

FIGURE 2 *Comparative GDP per capita, US and UK (UK=100, 1870-1930)*
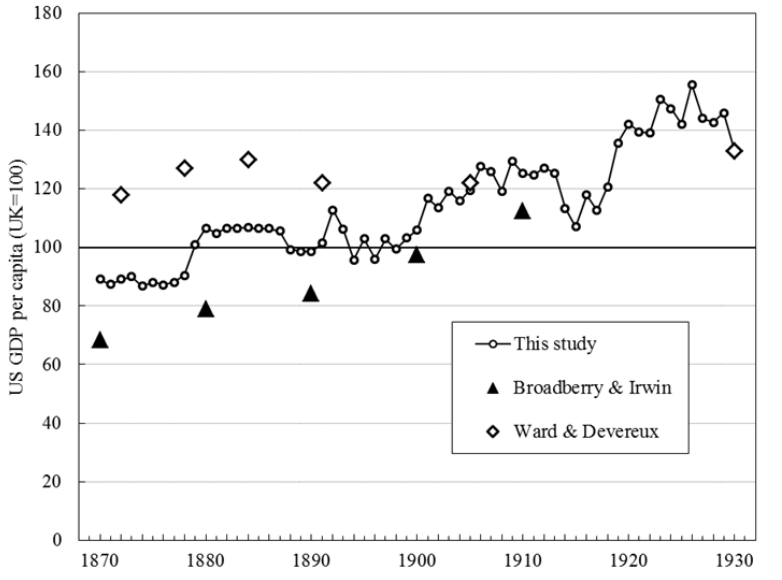
By 1880 this lead had dissipated and between 1880 to 1900 the US level of GDP per capita remained roughly on par with the UK. During the first three decades of the twentieth century, however, the US charged ahead and the income gap widened to nearly 60 percent in the 1920s.

Particularly the substantial US lead in agriculture and industry, which we observe in our 1910 benchmark, provides firm evidence for a strong overall lead in total economy productivity. Our study adds evidence to the revisionist view by Ward and Devereux, as we confirm the high Anglo-American productivity differential for agriculture as explained in more detail above. In addition, the Anglo-American income gap was widened further by the substantial productivity differential in mining, which was a non-negligible sector in both the American and British economy. However, as argued by Broadberry, differences in the employment structure between both economies did play a role in the relative income and productivity differentials. The low share of British employees in the agricultural sector provided Britain with a structural advantage that substantially reduced the gap in the overall level of productivity between the US and the UK.

Even though our new estimate of relative GDP per capita is very similar to the early twentieth century benchmark by Ward and Devereux, the long-run trend illustrated in figure 2 does not correspond well to their nineteenth century expenditure benchmarks either. Ward and Devereux show the US leading in terms of income per capita as early as 1872. In addition, they estimate a considerable gap in relative income levels between the US and the UK

throughout the 1872-1905 period. On the basis of our new benchmark and time-series evidence, we come to the conclusion that this appears to overstate the actual relative American income level in comparison to the UK. This difference should be attributed to our different choice of method, as Ward and Devereux rely on final consumer prices using the expenditure approach, whereas our estimates are based on the industry-of-origin approach.

Nevertheless, our 1910 benchmark confirms the existence of a large gap in comparative productivity between the US and the UK in agriculture and industry and provides strong evidence for a sizable American advantage in terms of GDP per worker and GDP per capita at the start of the twentieth century.

The Anglo-Dutch take over

Our results also shed a new light on the comparative productivity performance of the UK versus the the Netherlands. According to the Maddison data it was only after mid-century that the UK overtook the Netherlands in terms of income per head of population. The backwards extrapolation of our new benchmark provides a long-run view in comparative economic strength which we believe is more plausible. Table 6 presents the differences.

TABLE 6 *Long-run changes in relative levels of GDP per capita in the Dutch Republic/the Netherlands (UK=100, 1700-1913)*

	Maddison	This study
1700	162	134
1820	105	87
1850	101	83
1870	86	71
1890	79	65
1910	82	68

Sources: Table 4; Bolt, J. and J. L. van Zanden (2013). The First Update of the Maddison Project; Re-Estimating Growth Before 1820. Maddison Project Working Paper 4.

In the early eighteenth century the Dutch Republic still enjoyed higher levels of income per head of population than the UK. However, we find that the income lead of the Dutch was much smaller (34 against 62 percent) than suggested by Maddison. Besides, a backwards extrapolation of our time-series, based on Maddison's time series, indicates that already before the 1820s the British economy had forged ahead in terms of relative income levels. Our estimates are more in line with the Dutch historiography claiming that output levels plummeted in the Dutch Republic during the last quarter of the eighteenth century. Van Zanden and Van Riel label the Dutch economy and its underlying technological and institutional basis as 'obsolete' in this peri-

od.[65] For similar reasons de Vries and Van der Woude locate the take-over of England (note: not the UK!) around 1790.[66]

Data on comparative labour productivity at an industry level may shed more light on the timing of the change in economic leadership. First of all, the figures for Dutch manufacturing in table 7 point out the huge 'productivity problem' in this sector of the economy. The levels of comparative productivity in manufacturing were rather low around 1850 and they hardly showed any increase in the period up to 1910. The poor productivity performance can be explained from the slow and limited adoption of steam power in Dutch manufacturing.[67] Traditional sources of energy, like wind, water and horsepower prevailed. These technologies had remained unchanged from the seventeenth century until about the 1850s.[68]

TABLE 7 *Comparative levels of labour productivity in the Netherlands versus the UK, (UK=100, 1850-1910)*

	Agriculture	Manufact.	Total Industry	Transport	Trade	Total Services
1849/51	n.a.	58	54	65	130	101
1859/61	106	51	46	77	110	94
1869/71	108	49	43	73	123	100
1879/81	96	63	46	66	109	98
1889/91	78	70	61	76	126	104
1899/01	89	65	57	92	113	102
1909/11	83	70	64	102	118	102

Sources: tables 2 and 4; Smits et al., Dutch GNP

The reason for the limited use of steam power was two-fold. First, levels of aggregate domestic demand were so low that traditional types of production (i.e. based on the use of wind- and water power) retained their cost advantage over the introduction of steam engines characterised by high initial fixed costs.[69] But even more important, in the industries in which the Dutch economy had strongly specialised, such as the food-processing industries, the use

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65. Van Zanden and Van Riel, *Strictures of inheritance,* 20-32.

66. J. de Vries and A. van der Woude, *Nederland 1500-1815. De eerste ronde van moderne economische groei* (Amsterdam 1995) 814.

67. Smits, 'The determinants', 239-240.

68. Jansen, *De industriële ontwikkeling.*

69. J.P. Smits, 'The determinants of productivity growth in Dutch manufacturing, 1815-1913', *European Review of Economic History* 4 (2000) 235-238; Horlings and Smits point at the importance of demand constraints in the Dutch economy and its impact on the timing of modern economic growth, see: E. Horlings and J.P. Smits, 'Private consumer expenditure in the Netherlands, 1800-1913', *Economic and Social History in the Netherlands* 7 (1996) 15-40.

Potato starch factory 'Hollandia' at Nieuw-Buinen (Groningen province), established in 1898. Early Dutch manufacturing industry specialised mostly in the lighter industries, such as food, beverages and textiles, and were often embedded in the rural areas of the country. Source: http://www.terapelercourant.nl/tag/hollandia/; this picture from 1960.

of steam power proved difficult for technological reasons because of of a lack of feasible scale economies.[70]

Other branches of the economy performed better. Midway the nineteenth century the Dutch level of labour productivity in agriculture as well as that of services was on par with the British level. The latter was especially due to the strong performance of the Dutch trade sector, which had a level of labour productivity which was substantially higher than in the UK. Indeed, agriculture and services had been the two main pillars on which the economy of the Dutch Republic had been built in its Golden Age.

Both of these branches witnessed a steady decline in comparative productivity rates vis-à-vis the US as well as the UK throughout the second half of the nineteenth century however. For agriculture the declining levels of comparative labour productivity can at least partly be explained from the already high levels of productivity which were attained in the early nineteenth century:

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70. H.W. Lintsen et al, *Geschiedenis van de techniek in Nederland. De wording van een moderne samenleving, 1800-1890* (Zutphen 1992) 269-271.

Dutch agriculture had already reached its efficiency frontier. [71] The agricultural sector became strongly commercialised and export-oriented from the late Middle Ages onwards. De Vries explains the high levels of productivity in farming in the early modern period in terms of a deliberate process of specialisation.[72] The scope for further increases in labour productivity was limited, as the slow increases in agricultural output per worker indeed show.[73]

For services the explanation of a poor comparative productivity performance in the second half of the nineteenth century is less straightforward. Also in this case the levels of comparative productivity were initially quite high. But these high levels of labour productivity cannot be ascribed to the 'modern' or efficient features of the Dutch service sector, on the contrary. They were rather a symptom of the pre-modern (and sometimes even archaic) way in which the domestic trade and transport industries were organised, built on intimate relationships between regional, national and international staple markets. The main aim of these staple markets was to keep stocks up so as to be able to supply goods to the hinterland whenever necessary. Within this intricate trade system with its many middlemen who all enjoyed monopolies on their specific types of trade, huge trade margins could be realised. The same applied to the domestic transport system which until the first half of the nineteenth century was bound by strict rules and under the control of city councils which guaranteed entrepreneurs in the shipping high freight rates.[74] All in all, the specific institutions built around the trade and transport sector ensured people working in services with high incomes.

From the 1870s onwards the comparative Dutch labour productivity in trade and transport showed a significant relative decline as can be seen from table 7. Especially in the last quarter of the nineteenth century, when due to infrastructural improvements and better communication technologies there was less need for intermediate trade, more direct trade relations between producers and consumers were established. This resulted in declining trade margins, reflected in lower levels of labour productivity for the trade sector. It was only from the 1890s onwards, when the 'old institutions' of the Dutch

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71. Van Zanden, 'The First Green Revolution: The Growth of Production and Productivity in European Agriculture, 1870-1914', *Economic History Review* 44 (1991) 219.

72. J. de Vries, *The Dutch rural economy in the golden age, 1500-1700* (New Haven 1974).

73. Smits, 'Technological change, institutional development and economic growth in Dutch agriculture, 1870-1939', in: P. Lains V. Pinilla *Agriculture and economic development in Europe since 1870* (London 2009). However, huge gains were made in terms of land productivity, as land became the scarcest factor of production. Output per hectare showed a strong increase throughout the second half of the nineteenth century. Even though levels of labour productivity did not increase that much, around 1910 the Dutch farmers were among the most productive in terms of land productivity.

74. J.P. Smits, *Economic growth and structural change in the Dutch service sector, 1850-1913. The role of trade and transport in the process of 'modern economic growth'* (Amsterdam 1995).

Republic had been broken down, that a new phase of productivity growth started in trade and transport. But in this case, productivity growth was not boosted by protection and monopolistic pricing, but by organisational change and technological innovation (especially in the transport sector), a process of innovation that had set in much earlier in the leading economies of the UK and the US.

Conclusion

In terms of its empirical contribution this study is the first we know of to have systematically applied an industry-of-origin approach to an international comparison of labour productivity between Western Europe and the United States for a pre-World War One benchmark year, including all sectors of the economy. It complements the extensive work that has been undertaken on the UK-US comparison and it has cleared some uncovered terrain for the Netherlands and France. This article has made a deliberate distinction between a presentation of the main results, focusing on the productivity estimates for agriculture and industry between the four countries, and the total economy and long run implications which always tend to be of a more tentative nature.

The main results demonstrate that the Atlantic productivity gap around 1910 extended to nearly all goods producing sectors of the economy. Also in the UK, agricultural productivity did not keep pace with the US, implying that the differences in the sector structure of the British economy played an important role in the intra-European productivity gap. For France we have documented a considerable difference in the international competitiveness of its manufacturing sector versus a large (in terms of employment shares) but much more vulnerable agricultural sector. The uneven development of Dutch manufacturing, with its strong bias towards lighter industries, underlines the importance of so-called compositional effects.

Even though the international disparity in levels of labour productivity in services was not as large as in agriculture and manufacturing, our estimates nevertheless point at less convergence in total national income and productivity levels on the eve of World War One than the Maddison estimates suggest. Applying the new benchmark estimates for 1910 to long term projections of GDP per capita and GDP per worker back into the nineteenth century reveals an interesting new perspective on the dynamics of comparative long-term economic development. It rejects the view of Broadberry and Irwin that the UK maintained an income lead until the closing decades of the nineteenth century and lends support to Ward and Devereux's revisionist view. Our results also indicate that the Dutch lost their economic leadership already before 1820 and not after 1850, as suggested by the Maddison data.

Rather than offering any definitive answers to the questions of long run economic growth and dynamics, our new 1910 benchmark estimate serves as a starting point for further investigations based on an industry-of-origin approach. A lot of work remains to be done on improving the quality of time-series of gross output, value added and employment for the nineteenth century, and in many cases the early twentieth century as well. In addition, expanding and improving estimates of service sector productivity is crucial to arrive at a more complete picture of convergence and divergence of income and productivity levels since the industrial revolution.

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Appendix　Primary and secondary sources used to calculate PPPs and estimate comparative labour productivity

UNITED STATES

Purchasing Power Parities (PPP)

Agriculture: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume V, Agriculture 1909 and 1910, General Report and Analysis* (Washington 1913).

Mining: Department of the Interior, *United States Geological Survey, Mineral Resources of the United States 1910* (Washington 1911).

Construction: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington 1913).

Utilities: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington 1913); ibid, *Census of Electrical Industries 1917, central electric light and power stations* (Washington 1920).

Manufacturing: Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington 1913).

Services: A. Burger and J.P. Smits, 'A benchmark comparison of service productivity between Europe and the United States for 1910', *Economic and social history in the Netherlands* 7 (1996); S.N. Broadberry and D.A. Irwin, 'Labour productivity in the United States and the United Kingdom during the nineteenth century', *Explorations in Economic History* 43:2 (2006).

Value Added (VA)

GDP at market prices: J. Kendrick, *Productivity trends in the United States* (Princeton 1961) table A-IIb, 296-29.

Agriculture: S. Carter et al., *Historical statistics of the United States: millennial edition* (Cambridge 2006) volume 4: economic sectors.

Mining: Department of the Interior, *United States geological survey, mineral resources of the United States 1910* (Washington 1911).

Construction: W. King, *The national income and its purchasing power* (New York 1930).

Manufacturing: S. Carter et al., *Historical statistics of the United States: millennial edition* (Cambridge 2006) volume 4: economic sectors; Bureau of the Census, *Thirteenth Census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington 1913).

Services: Obtained by deducting agriculture and industry from total economy.

Labour Force

Total employment: J. Kendrick (1961), *Productivity trends in the United States* (Princeton 1961) table A-VII, 308.

Agriculture: Lebergott (1964), *Manpower in economic growth: the American record since 1800* (New York 1964) 510.

Industry and services: J. Kendrick (1961), *Productivity trends in the United States* (Princeton 1961) table A-VII, 308.

Manufacturing shares: Bureau of the Census, *Thirteenth census of the United States taken in the year 1910, Volume X, Manufactures 1909, Reports for Principal Industries* (Washington 1913).

Total Population: A. Maddison, *Statistics on world population, GDP and per capita GDP, 1-2008 AD* (Groningen 2009).

UNITED KINGDOM

Purchasing Power Parities (PPP)

Agriculture: Board of Agriculture and Fisheries, *Agricultural statistics, 1908* (London 1910).

Mining: Board of Trade, *Final report on the first census of production of the United Kingdom, 1907* (London 1912).

Construction: A. Burger, 'A five-country comparison of industrial labour productivity 1850-1990', *N.W. Posthumus Institute Working Paper* (1994).

Utilities: A. Burger, 'A five-country comparison of industrial labour productivity 1850-1990', *N.W. Posthumus Institute Working Paper* (1994).

Manufacturing: Board of Trade, *Final report on the first census of production of the United Kingdom, 1907* (London 1912).

Services: A. Burger and J.P. Smits, 'A benchmark comparison of service productivity between Europe and the United States for 1910', *Economic and social history in the Netherlands* 7 (1996); S.N. Broadberry and D.A. Irwin, 'Labour productivity in the United States and the United Kingdom during the nineteenth century', *Explorations in Economic History* 43:2 (2006).

Note: All UVRs based on 1907 prices have been adjusted with the final output deflator from C.H. Feinstein, *Statistical tables of national income, expenditure and output of the UK* (Cambridge 1976) T132.

Value Added (VA)

GDP at market prices: C.H. Feinstein, *Statistical tables of national income, expenditure and output of the UK* (Cambridge 1976) T10.

Sectoral shares: C.H. Feinstein, *National income, expenditure and output of the United Kingdom, 1855-1965* (Cambridge 1972) table 10.2, 208.

Manufacturing shares: Board of Trade, *Final report on the first census of production of the United Kingdom, 1907* (London 1912).

Labour Force

Total employment: C.H. Feinstein, *Statistical tables of national income, expenditure and output of the UK* (Cambridge 1976) T131.

Sectoral shares: C.H. Feinstein, *Statistical tables of national income, expenditure and output of the UK* (Cambridge 1976) T131.

Manufacturing shares: Board of Trade, *Final report on the first census of production of the United Kingdom, 1907* (London 1912).

Total Population: A. Maddison, *Statistics on world population, GDP and per capita GDP, 1-2008 AD* (Groningen 2009).

THE NETHERLANDS

Purchasing Power Parities (PPP)
Agriculture: Departement van Landbouw, Nijverheid en handel, *Verslag over den Landbouw in Nederland 1910* ('s-Gravenhage 1911).
Mining: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* ('s-Gravenhage 1920).
Construction: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* ('s-Gravenhage 1920).
Utilities: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* ('s-Gravenhage 1920).
Manufacturing: Centraal Bureau voor de Statistiek, *Statistiek van de Voortbrenging en het Verbruik der Nederlandsche Nijverheid in 1913 en 1916* ('s-Gravenhage 1920).
Services: A. Burger and J.P. Smits, 'A benchmark comparison of service productivity between Europe and the United States for 1910', *Economic and social history in the Netherlands* 7 (1996).
Note: All manufacturing UVRs based on 1913 prices have been adjusted with sector specific wholesale price indices from J.P. Smits, E. Horlings and J.L. van Zanden, *Dutch GNP and its components, 1800-1913* (Groningen 2000) 124-53.

Value Added (VA)
GDP at market prices (1909): J.P. Smits, E. Horlings and J.L. van Zanden, *Dutch GNP and its components, 1800-1913* (Groningen 2000) 221.
Sectoral shares (1909): J.P. Smits, E. Horlings and J.L. van Zanden, *Dutch GNP and its components, 1800-1913* (Groningen 2000) tables D.1-D.3, 121-55.

Labour Force
Total employment (1909): J.P. Smits, E. Horlings and J.L. van Zanden, *Dutch GNP and its components, 1800-1913* (Groningen 2000) table B.3, 114.
Sectoral shares (1909): J.P. Smits, E. Horlings and J.L. van Zanden, *Dutch GNP and its components, 1800-1913* (Groningen 2000) table B.3, 114.
Total Population: A. Maddison, *Statistics on world population, GDP and per capita GDP, 1-2008 AD* (Groningen 2009).

FRANCE

Purchasing Power Parities (PPP)
Agriculture and industry: Ministere du Commerce, *de l'Industrie, des Postes et des Telegraphes, Evaluation de la Production, fournis par les chambres de commerce (1910) et les statistiques administratives (1912)* (Paris 1917); Ministère du Travail et de la Prévoyance Social, *Annuaire Statistique de la France 1908* (Paris 1909); Ministère de l'Economie et des Finances, *Annuaire Statistique de la France 1966, Résumé Rétrospectif, Soixante-Douzieme Volume* (Paris 1967).
Services: A. Burger and J.P. Smits, 'A benchmark comparison of service productivity between Europe and the United States for 1910', *Economic and social history in the Netherlands* 7 (1996).

Note: all UVRs based on 1908 price data have been adjusted with the price index of J.C. Toutain, 'Le produit intérieur brut de la France de 1789 à 1982', *Economies et Societés* 15 (1987) Chapitre 2. Les donneés annuelles (1815-1938).

Value Added (VA)

GDP *at market prices (1910):* J.C. Toutain, 'Le produit intérieur brut de la France de 1789 à 1982', *Economies et Societés* 15 (1987) Chapitre 2. Les donneés annuelles (1815-1938).

Agriculture: B.R. Mitchell, *International historical statistics. Europe 1750-2005* (Basingstoke 2007) table J2, p. 1037.

Industry: J.P. Dormois, 'Tracking the elusive French productivity lag in industry, 1840-1973', *Hi-Stat Discussion Paper* 152 (2006) table A7.

Services: Obtained by deducting agriculture and industry from total economy.

Labour Force

Total employment: B.R. Mitchell, *International historical statistics. Europe 1750-2005* (Basingstoke 2007) table B1, 153.

Agriculture: Mitchell (2007) table B1, 153.

Industry: J.P. Dormois, 'Tracking the elusive French productivity lag in industry, 1840-1973', *Hi-Stat Discussion Paper* 152 (2006) table A7.

Services: Obtained by deducting agriculture and industry from total labour force.

Total Population: A. Maddison, *Statistics on world population,* GDP *and per capita* GDP*, 1-2008* AD (Groningen 2009).