

The Yankees of Europe?

Detailed Source Description

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This appendix describes the sources which we use to develop productivity estimates for the United States, United Kingdom and Germany between 1899 and 1939. These new estimates allow us to measure technological change and develop a novel decomposition framework based on Data Envelopment Analysis (DEA) to analyze the diffusion of U.S. technologies in interwar Germany.

1. Note on American data

The basic source of output, employment and capital data for U.S. industries is the *Census of Manufactures*. Data on total employment, value added and total horsepower employed is available in the quinquennial censuses between 1899 and 1919 and the biennial censuses of 1923 to 1929 and 1939 (United States Department of Commerce 1913, 1923, 1933, 1942). In this appendix we will clarify the industry classification, define the basic variables and discuss the comparability of the figures between different census years.

STANDARD INDUSTRIAL CLASSIFICATION

In our analysis we rely on the industrial classification laid out in the 1947 Census of Manufactures (Bureau of the Census, 1949, 862-914). The census classification was derived from the 1945 *Standard Industrial Classification* (SIC), which was the first attempt to standardize the collection and reporting of data across different agencies while maintaining consistency over a longer time-frame.¹ The industrial classifica-

tion groups establishments primarily engaged in the same line or similar lines of economic activity which, in the case of manufacturing, is generally defined in terms of the products made (demand side) or the processes of manufacture used (supply side); see, Kendrick (1961, 405-6). The SIC scheme places primary emphasis on the latter, whereas the original, prewar, census classifications relies heavily on the former.² The supply-side grouping of businesses i.e. the categorization according to the way in which inputs are transformed into outputs, mainly depending on the technology used fits neatly into our productivity study. Although the SIC has undergone several revisions (the latest in 1987), we explicitly chose to use the 1945 vintage as the introduction of new products and production techniques over time make the more recent classifications less applica-

²Although in many respects the SIC resembles the prewar census classifications, there have been a number of important changes that highlight the shift from a demand-side to a supply-side oriented classification. Notably in metals, the prewar censuses grouped establishments according to whether they produced ferrous or nonferrous products. The 1945 SIC reclassified these industry groups according to whether the production process was mainly associated with primary production (e.g. refining, smelting, rolling, etc.) or the production of finished metal products (e.g. nails, wire, hardware, etc.), regardless of the type of metal from which the end-product consisted.

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¹The differences between the 1947 census and the 1945 SIC are minor; for a detailed discussion see Bureau of the Census (1949, 931-3).

ble to the period preceding the Second World War.

Following the standard industrial classification, the manufacturing division comprises approximately 450 industries in 1939, which are included in 127 industry groups and 20 major groups. These major groups are commonly referred to as two-digit industries and are broken down into three-digit industries (i.e. industry groups), which in turn are separated into four-digit industries (Carter et al., 2006, 4:4). We generally estimate a frontier at the two and three-digit level, implicitly assuming that industries share a production function at this level of aggregation. As previously noted, the SIC groups industries according to a similarity in their inputs, outputs or use of production techniques, giving credence to the assumption of a joint production function. For a number of two-digit industries this assumption was violated, in which case we estimate two or more frontiers for that respective group.³

BASIC SOURCES

Nominal value added is derived directly from the census figures as the net of the ex-factory value of products (the selling value at the factory or plants) minus the cost of materials, purchased fuel and electric energy and contract work. No attempt was made to adjust for inventory revaluations or fully account for maintenance work and repairs, but evidence presented by Fabricant (1940, 340-50) suggests that these adjustments would only marginally affect gross value added for the years in our sample. We calculated deflators at the industry level on the basis of the Fabricant (1940, 123-321; 605-39) indices of physical output and nominal output series. Subsequently, we incorporated the modifications and extensions to the indices of production proposed by Kendrick (1961, 416-21;

³The most notable example is chemicals and allied products (28) for which five separate technology frontiers were estimated. See table 4 for further details.

467-75). Lastly, we reclassified these deflators to fit the 1945 Standard Industry Classification (SIC), which constitutes the basis for both the Kendrick series and our own.⁴ Throughout, nominal value added was converted to constant prices (with a 1929 base) by applying the price deflators at the two-digit SIC level.

We define employment as the sum of wage earners, salaried officers and employees.⁵ We exclude all proprietors and firm members as we wish to limit our analysis to manufacturing personnel whose activity directly contributes to the value added reported in the census. In censuses prior to 1935, manufactures were instructed to report all personnel employed in both production activities and in auxiliary activities such as maintenance, shipping, warehousing, etc. at the same location. Our employment figures thus invariably include a number of employees engaged in these kinds of non-manufacturing activities. This distinction is complicated further by the 1939 schedule that asked employers to report separate figures for their manufacturing and non-manufacturing personnel, based either on- or off-site. Although it is difficult to establish to what extent this change in definition affects the comparability of the employment figures between the censuses, Fabricant (1942, 173) concludes that “the implicit census definition of factory employment has given rise to no serious ambiguities in the data.” For 1939 we included all non-manufacturing personnel in our employment totals while still excluding proprietors and firm members, which is compatible with the definition applied by Kendrick (1961, 434) for this year.

The census employment figures were converted to total hours worked on the basis

⁴For the computation of the aggregate price indices we maintained the Marshall-Edgeworth formula with 1909, 1919 and 1929 as base-years.

⁵The category ‘salaried officers and employees’ includes all superintendents, managers and clerical workers.

of industry-specific average annual hours of work obtained from various sources. For the interwar period we relied on data by Inklaar, de Jong and Gouma (2011, 852-4), who provide detailed estimates of average hours of work for wage earners.⁶ We extended their dataset to include the census years prior to World War I. The censuses of 1909 and 1914 provide industry specific data on prevailing hours of labor per week; no data is available for the years 1899 and 1904, we used the 1909 average hours instead (Bureau of the Census, 1913, 316-9; 1917, 482-9). We normalized the industry-specific weekly hours over the total manufacturing figures provided by Jones (1963, 375), using census wage earners as weights. Lastly, we converted the prewar estimates to annual average hours worked, based on the 1900 estimate of American vacation and holidays by Huberman and Minns (2007, 546).

Capital intensity is defined as the sum of the horsepower capacity of prime movers and the horsepower rating of motors driven by purchased electric energy, divided by our measure of employment. This definition coincides with the census measure of primary power, which also excludes the power of electric motors run by current generated in the same establishment to prevent duplication. The census years 1921 and 1931 to 1937 were entirely excluded from our sample as data on power equipment was either not collected or incomplete for these years. Although it is likely that rates of capacity utilization have changed during our period of study, partly as a result of the shift from the use of prime movers toward electric motors, we were unable to adjust for these.

⁶These figures relate exclusively to wage earners, however this group comprises the bulk of our employment measure, and any deviations in hours worked between wage earners and salaried officers and employees are bound to be small compared to the annual fluctuations observed during this period.

SCOPE AND COMPARABILITY

During the 1899-1939 period the scope of the activities covered by the census has changed somewhat. Prior to 1919, the American industrial census exempted all establishments with an annual production valued at less than \$500; for the years since 1919 this limit was raised to \$5,000. In the 1921 census report this resulted in a 21.6 percent reduction in the number of establishments covered. However, the comparability of the figures since 1919 were not appreciably affected as, according to the Bureau of the Census (1942, 2), "99.4 percent of the total wage earners and 99.7 of the total value of products reported at that census [1919, red.] were contributed by the establishments reporting products to the value of \$5,000 or more." In addition, from 1904 onward, the Census of Manufactures was confined to establishments conducting work under the factory system, thus excluding neighborhood industries and hand trades. For 1899 we relied on reclassified figures provided in the 1909 census. The adjusted figures omit all non-factory establishments for 1899 and are thus fully comparable to the statistics for subsequent census years (Bureau of the Census, 1913, 507-17).

Over the course of our period of study several major industries, engaged in activities no longer considered as manufacturing, were excluded from the census.⁷ We followed this convention and withdrew these industries from our sample. Over the various censuses numerous changes were made to the classification of industries and products, inevitably resulting in discontinuities and breaks in the series. Fabricant (1940, 605-39) and Fabricant (1942, 179-230) discuss the continuity of the census value added and employment data over the period 1899

⁷Important industries that were dropped are motion picture production, manufactured gas, automobile re-pairing, and railroad repair shops; see e.g. Kendrick (1961, 404).

to 1939 at length. Overall, predominantly smaller industries were affected by the changes across the various census years, thus limiting the overall impact on the coherence of the data set. Where necessary, we have combined related industries into aggregate groupings to ensure continuity.⁸

of the Census (1917, 530-43); **1919-29**: see *nominal value added*; **1931-37**: derived by interpolation, based on statistics from the 1929 and 1939 censuses and biannual trends in industry-level gross operating surplus; **1939**: Bureau of the Census (1942, 22-40).

DETAILED LIST OF SOURCES

- *Nominal value added*: **1899-09**: Bureau of the Census (1913, 507-17); **1914**: Bureau of the Census (1917, 516-29); **1919**: Bureau of the Census (1923, 160-70); **1921-25**: Bureau of the Census (1928, 26-30, 213-17, 417-19, 504-06, 590, 616, 632-34, 699-701, 858-59, 930-32, 979, 981-82, 1065, 1084, 1148, 1161-64, 1171-92); **1927**: Bureau of the Census (1930, 1316-29); **1929**: Bureau of the Census (1933, 310-22); **1931**: Bureau of the Census (1935, 22-9); **1933**: Bureau of the Census (1936, 21-32); **1935**: Bureau of the Census (1938, 22-33).
- *Real value added*: Fabricant (1940, 123-321), Kendrick (1961, 416-21, 467-75).
- *Persons engaged*: **1899-09**: Bureau of the Census (1913, 518-41); **1914**: Bureau of the Census (1917, 530-43); **1919**: Bureau of the Census (1923, 278-95); **1921-35**: see *nominal value added*.
- *Weekly hours*: **1899-09**: Bureau of the Census (1913, 316-9); **1914**: Bureau of the Census (1917, 482-9); **1919-35**: Inklaar, de Jong and Gouma (2011, 852-54).
- *Vacations and holidays*: Huberman and Minns (2007, 546).
- *Horsepower*: **1899-09**: Bureau of the Census (1913, 518-41); **1914**: Bureau

⁸E.g. Cigarettes (211) and Cigars (212) were combined into an aggregate industry group as well as Flat Glass (321) and Pressed and Blown Glassware (322).

2. Note on German data

Data for horsepower per hour worked for 1933 and 1938, and real value added per hour worked for 1936 was constructed. The primary German data on value added per hour worked has been taken from the unpublished census of production conducted by the *Statistischen Reichsamts*. The primary German data on horsepower per hour worked has been taken from the censuses of employment conducted by the *Statistik des Deutschen Reichs*. The basic sources for output, employment and horsepower for Germany are given below.

BASIC SOURCES

For interwar Germany we use the comprehensive archival records of the German production census published in *Die deutsche Industrie: Gesamtergebnisse der amtlichen Produktionsstatistik* (henceforth, production census of 1936). This is the first official German national census of manufactures and is available in two forms; a published edition and the original archival records. The former has been set up to hide particular manufacturing activities that were related to the war effort. Consequently, the archival records contain considerably more detailed and accurate information and are therefore used in this study. The archival data underlying the official 1936 census was kindly made available to us by Herman de Jong. A comprehensive discussion of the difference between the official census and the archival records is provided in Fremdling, de Jong and Timmer (2007a, 354). We have classified all industries according to the Standard Industrial Classification (SIC) discussed above.

Nominal value added was calculated as the ex-factory value of products (*Produktionsertrag*) minus the cost of materials (*Rohstoffe and Sonstige Material*), fuel (*Energie*) and contract work (*Bez. Lohnarbeiten*). Nominal value added in 1936 Reichsmark was then converted to 1935 U.S. dollars using purchasing power parities (henceforth,

PPPs) and, lastly, deflated with the U.S. price series to get real value added in 1929 U.S. dollars.⁹ We divided real value added by total hours worked to derive our final measure of labor productivity for Germany in 1936. As in the case of the U.S., total hours worked is calculated as the persons engaged in production multiplied by the industry-specific prevailing weekly hours, compensated for changes in the annual number of vacation and holidays. Industry-specific employment figures are taken from the production census of 1936 (*Zahl der beschftigten Personen*). We obtained average annual hours of work from various sources. Industry-specific weekly hours worked in 1936 are derived from the statistical yearbook (Kaiserlichen Statistischen Amtes, 1939, 384-5) and Hoffmann (1965, 214). The number of weeks of work per year are taken from Huberman and Minns (2007, 532, 548).

Horsepower is calculated as the sum of the horsepower capacity of prime and the horsepower rating of motors driven by purchased electric energy (using information on *Leistung der zum Antrieb von Arbeitsmaschinen bestimmten Wind-, Wasser- und Wrmekraftmaschinen, Leistung der zum Antrieb von Arbeitsmaschinen bestimmten Elektromotoren* and *Leistung der zum Antrieb von elektrischen Stromerzeugern*). Horsepower statistics for Germany can be found in the national employment censuses (*Betriebszählung*) for 1909 and 1933. Also, the *Wirtschaft und Statistik* – the bimonthly publication of the *Statistischen Reichsamts* – reports in 1938 data on horsepower intensity for the largest provinces (*Provinzen*). The latter has a lower geographical coverage and less detail than the 1933 employment census. However, we prefer not to rely fully on the 1933 data alone. In 1933 Germany was still in the grip of the Depression with unemployment rates of 36 percent (Pierenkemper,

⁹See Appendix “Methodology of productivity comparisons” for details on the calculation of PPPs.

1987, 59). While it was relatively easy for firms to lay off labor, the stock of machinery changed little in the short run. Thus, the 1933 figures overestimate machine-intensity levels in German manufacturing. The 1938 data, on the other hand, underestimate machine intensity. By 1938 the German economy operated at almost full capacity, partly due to the build-up to WWII. Unemployment rates had dropped from 36 percent in 1933 to 12 percent in 1936 and just 2 percent in 1938. Since the level of capacity utilization in 1936 - as indicated by unemployment rates - was in between the levels of 1933 and 1938, we solve the problem by taking the average machine-intensity levels of 1933 and 1938.

SCOPE AND COMPARABILITY

Because Germany is included in the DEA only for the year 1936, there are no concerns over the comparability of the sources over time. A potential worry is the comparability of the employment coverage provided by the German sources with that of the U.S. and Great Britain. With few exceptions, the German production census of 1936 includes all establishments with five employees or more. More specifically, in industries which were of military strategic importance all firms had to report, while in most industries of limited military importance the cut-off point was less than 5 people employed (Fremdling, de Jong and Timmer, 2007*b*). The German employment censuses of 1933 and 1939, on the other hand, have no cut-off point and thus cover full employment. The German production census data comprise the German Empire (*Deutsches Reich*) with the border of 1937, thus including Saarland but not Austria and Sudetenland. The totals for the 1938 employment census include Austria and Sudetenland, but we have excluded these regions to make the data comparable to the 1936 census of production. In the 1933 employment census, the Saarland is not included, but it is impossible to correct

for this.

DETAILED LIST OF SOURCES

- *Nominal value added: 1936*: Statistischen Reichsamts (1936, Nr. R3102/2941, 2994, 3019, 3082, 3270, 3273-76, 3277, 3279, 3281-82, 3288, 3534, 3540-42, 3544-46, 3615, 3636, 4151-52, 5866, 5915-16, 5922, 5986-87, 6124, 6193, 6254.).
- *Real value added*: 1936 U.S./German PPP for gross output taken from Veenstra (2014, 189-200); 1929 dollar price deflator, see U.S. *real value added*.
- *Persons engaged: 1936*: see *nominal value added*; **1933**: Statistik des Deutschen Reichs (1933, Band 462.2, Tabel 1); **1938**: Reichsamts für Wehrwirtschaftliche Planung (1939).
- *Weekly hours: 1933*: Hoffmann (1965, 214); **1938**: Kaiserlichen Statistischen Amtes (1939, 384-5).
- *Vacations and holidays*: Huberman and Minns (2007, 542, 548).
- *Horsepower: 1933*: Statistik des Deutschen Reichs (1933, Band 462.1/462.2/462.3, Tabel 1,3,6); **1938**: Statistischen Reichsamts, Wirtschaft und Statistik (1938 März-Heft, Tabel A).

3. *Note on British data*

The primary British data is taken from the First (Board of Trade, 1912) and Fourth (Board of Trade, 1933) *Census of Production*. In this appendix we will provide an in-depth discussion of the basic variables and methods of construction behind this data set. We explore the amendments required for changes in geographical coverage and discuss the exclusion of small firms. In addition, we analyze the comparability of the British and American data and review the steps required to make them analogous.

BASIC SOURCES

British output, labor and capital data is derived from the official production censuses. We selected the years 1907 and 1930, as both these surveys contain detailed information on gross output, intermediate inputs, employment and installed horsepower. Even though the terminology in the British, American and German censuses differ slightly, the concepts of value added, employment and horsepower capacity are equivalent for these countries. Gross output is again defined as the ex-factory value of products, whereas intermediate input represents the cost of materials, fuel and contract work. Value added, or net output, is the net of gross output and intermediate input and constitutes the sum of wages, salaries, rent, royalties, rates and taxes, depreciation of plant and machinery, advertisement and selling expenses and all other similar charges as well as profits.

As a first step in the construction of our dataset, we reclassified the British industrial classification to fit the 1945 US Standard Industrial Classification (see U.S. sources). As was the case for the American data, we restrict the classification to the two- and three-digit level. The level of detail in the British classification necessitated a number of modifications to the level of aggregation in order to maintain comparability and continuity

over time.¹⁰ The resulting dataset for both 1907 and 1930 cover the British factory trades in their entirety.

Subsequently, we converted British output to nominal dollar values on the basis of the price conversion factors in Frankema, Wolter and Smits (2013) and de Jong and Wolter (2011). In both these industry-of-origin studies the industry level conversion factors were calculated on the basis of producer prices, using the procedures first set out by Paige and Bombach (1959) and clearly demonstrated in the work of van Ark (1993). Note that the interwar PPPs rely on price data taken the Fifth Census of Production, which refers to the year 1935. We extrapolated the interwar conversion factors to a 1930 base using price deflators taken from the work of Feinstein (1976, 61-9). The nominal dollar values were then converted to constant prices (with a 1929 base) by applying the American price deflators, discussed above. Both the Anglo-American PPPs and the American price deflators were implemented at the two-digit SIC level.

For Britain we define employment as the sum of operatives (wage earners) and administrative, technical and clerical staff. In line with the definition used for the US, we include only those personnel whose activity directly contributes to the firm's production (thus excluding owners and firm members). We converted the 1907 employment figures to annual hours of work on the basis of Matthews, Feinstein and Odling-Smee (1982, 566) estimate of the average number of weeks worked per year as well as weekly hours of work listed in the British Labour Statistics (Great Britain Department of Employment and Productivity, 1971, 95).¹¹ For the interwar period we again rely on Matthews,

¹⁰Particularly the British engineering trades lacked the detail specified in the US SIC. In this case we opted for the lowest feasible aggregation level based on the detail provided in the census.

¹¹Note that the pre-WWI figures for the average length of the working week are industry specific and refer to the year 1906.

Feinstein and Odling-Smee (1982, 566), but base our estimate of the average length of the working week on a study by the International Labour Office (1939, 82-3).

For the British capital-intensity data we utilize the American formula of adding motors using purchased electricity. The 1930 census directly reports both the power available from prime movers and the horsepower of electric motors driven by purchased electricity. Unfortunately, no data is available for the horsepower capacity of electric motors in 1907 and we rely on figures of electricity purchased to estimate the horsepower of electric motors.¹² The prewar census does provide detailed figures on the total capacity of (non-electric) prime movers, however.

SCOPE AND COMPARABILITY

The 1930 census deal exclusively with industrial production in England, Wales and Scotland, whereas the 1907 Census of Production relates to United Kingdom as a whole. Fortunately, the 1907 census does provide separate figures for England and Wales, Scotland and Ireland.¹³ To make the prewar census directly comparable to the interwar census, we excluded Ireland from the 1907 sample and rely exclusively on the production figures for Great Britain. This adjustment does not materially affect the

¹²Although our estimate of electric motors driven by purchased energy is fairly rough, its possible impact on the British capital intensity figures is limited as electric motors were still fairly uncommon at this time. Comparable figures for the US and Germany reveal that, prior to the First World War, less than 20 percent of the installed horsepower consisted of electric motors, while only a fraction of these were run by purchased electricity.

¹³In some cases the Board of Trade chose to aggregate the production figures to prevent the disclosure of particulars relating to specific firms. The latter measure is taken primarily for small Irish firms that have no, or only a few, direct competitors within the confines of the country. Consequently, although our data for 1907 does, invariably, include some residual production figures for Ireland, the overall impact is limited on account of the small size of the firms in question.

productivity estimates, however, as only a fraction of industrial production in the United Kingdom took place in Ireland at this time.¹⁴

Comparability between both census years is affected by the exemption of small firms from the interwar schedule. At the 1930 census, firms employing ten persons or less were exempted from making detailed returns. Full returns were required from all businesses, irrespective of their size, at the 1907 census. Although the extent of the bias is difficult to determine, evidence presented by Rostas (1948, 25, 2832) suggests that small plants and firms generally have a lower productivity than their larger counterparts. The exclusion of these firms from the 1930 schedule thus results in an overestimate of efficiency and productivity in comparison to the prewar numbers. In all, the proportion of the people working in British manufacturing employed by smaller firms is estimated in the 1930 census at approximately 10 percent (Board of Trade, 1933, V:9-11). On the basis of this proportion, Fremdling, de Jong and Timmer (2007a, 372-3) reckon that an upward bias of approximately 2 percent is introduced in the British interwar productivity statistics. As noted above, prior to the First World War, the US census exempted only those establishments with an annual production valued at \$500 or less. As the average output per person engaged in manufacturing amounted to \$2,560 in 1909, the scope of the American census is thus nearly as wide as the 1907 British census.

DETAILED LIST OF SOURCES

- *Nominal value added: 1907*: Board of Trade (1912, 93-4, 239, 285, 387, 443-4, 543, 595-6, 653, 693, 743, 797); **1930**: Board of Trade (1933, pt. 1-4).

¹⁴The production in Ireland focused mainly on the textiles and food sectors and, overall, accounted for just 3.2 percent of net output and 4.2 percent of employment in the manufacturing sector of the United Kingdom (Board of Trade, 1912, 18-9).

- *Real value added: 1907:* U.S./U.K. PPP for gross output from Frankema, Woltjer and Smits (2013, 90); **1930:** US/UK PPP from de Jong and Woltjer (2011, 478); 1929 dollar price deflator, see U.S. *real value added*.
- *Persons engaged:* see *nominal value added*.
- *Weekly hours: 1907:* Great Britain Department of Employment and Productivity (1971, 95); **1930:** International Labour Office (1939, 82-3).
- *Vacations and holidays:* Matthews, Feinstein and Odling-Smee (1982, 566).
- *Horsepower:* see *nominal value added*.

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