Title: The Manufacturing Comparative Advantages of Late-Victorian Britain

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Abstract

This article constructs indicators of revealed comparative advantage (RCA) for 18 British manufacturing industries for the years 1880, 1890, and 1900. The indicators constitute the earliest systematic estimates of the relative performance of British industries. The indicators are then employed in a four-factor Heckscher-Ohlin model of trade, with the factors being capital, labour, material inputs, and human capital. Contrary to previous literature, the manufacturing comparative advantages of late-Victorian Britain were not in the relatively labour-intensive industries. By 1890, there was a distinctly labour-economizing regime within British manufacturing. Contributing to this pattern of within-sector specialization were emigration from Britain and the full absorption of displaced agricultural labour into the manufacturing sector. This article concludes with the suggestion that, in the late-Victorian era, British and American manufacturing were not so dissimilar, at least relative to Continental manufacturing.

Keywords: manufacturing, comparative advantage, Britain, nineteenth century

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1. Introduction

Economic historians have generally understood that 'the industries of the Industrial Revolution retained their comparative advantage until the First World War' (Harley 2014, p. 6). Indeed, the staple industries of textiles and iron continued to dominate the composition of British exports through the late-Victorian era.[1] However, there remains the question of whether Britain realized comparative advantages in the many other industries that characterized its manufacturing sector and, increasingly, the manufacturing sectors (and exports) of other industrial countries. Accordingly, this article contributes to the existing literature by constructing indicators of revealed comparative advantage (RCA) for 18 British manufacturing industries for the years 1880, 1890, and 1900.

The RCA indicators constructed in this article represent the earliest systematic measurements of the relative performance of individual British manufacturing industries. Broadberry's (1997, pp. 28-32) industry-disaggregated estimates of comparative *labour productivity* begin in 1907, when output data for the manufacturing sector becomes available

[1] The staple industries of textiles and iron accounted for fully 66% of Britain's manufactured exports in 1902-4 (Schlote, 1952, p. 74).

in the *First Census of Production*. For the late nineteenth century, an absence of standardized output data across the range of industries precludes any industry-disaggregated estimation of comparative labour productivity. Consequently, Broadberry's analysis of the relative performance of Britain's manufacturing industries, vis-à-vis those of the United States and Germany, was dependent upon a broad range of secondary sources. Nevertheless, the high-quality trade data available for industrial countries in the late nineteenth century permit the construction of RCA indicators, which can cautiously be approached as a quantitative complement to Broadberry's analysis of Britain's manufacturing industries in the pre-1907 period. Of course, comparative advantage is not the same as comparative labour productivity; as Broadberry (1997, p. 158) observed, 'Clearly, there is no one-to-one mapping between variations in comparative labour productivity and comparative advantage, since labour is not the only factor of production'. Still, there is an historically close correspondence between comparative labour productivity and comparative advantage, and areas of particular strength and weakness in Britain's manufacturing sector should be apparent from both measures.[2]

In this article, the RCA indicators are extended into the debate over the factor pattern of Britain's manufacturing comparative advantages. Crafts and Thomas (1986, p. 637) argued that the manufacturing comparative advantages of late-Victorian Britain rested in the relatively labour-intensive industries. Their argument is difficult to reconcile with the historically lower wages that prevailed in Continental Europe, which supplied 52% of world manufactured exports in 1899 (calculated from Tyszynski, 1951, p. 277). The novel finding of this article is that the manufacturing comparative advantages of late-Victorian Britain were in the relatively labour-economizing industries, not the relatively labour-intensive industries as Crafts and Thomas have argued. Whereas Crafts and Thomas relied upon (non-

[2] For example, in the 1930s, Britain tended to realize comparative advantages and lesser gaps in labour productivity (relative to the United States) in light manufacturing industries (Broadberry and Crafts, 1992, p. 542).

normalized) gross British exports for the year 1880 as a proxy for comparative advantage, this article relies upon purposely constructed RCA indicators following a modified version of the Balassa (1965) method. The labour-economizing factor pattern of late-Victorian Britain's manufacturing comparative advantages, identified in this article, renders British manufacturing closer to American manufacturing than might have been assumed from a canonical literature—the classic contribution is Habakkuk (1962)—stressing Anglo-American differences in nineteenth-century manufacturing.[3]

This article also enables an understanding of the longer-term development of Britain's manufacturing comparative advantages throughout the nineteenth century, which began with Britain's Industrial Revolution and ended with foreign industrialization. To be sure, the closing decades of the nineteenth century were a period when Britain's supremacy in the world market for manufactured goods was eroded to a not inconsiderable extent. It has been estimated that, from 1880-1899, Britain's share of world manufactured exports fell from 41.4% to 32.5% (Saul, 1965, p. 12). Did the beginnings of Britain's relative industrial decline in the late nineteenth century correspond to major changes in Britain's manufacturing comparative advantages? This article compares Britain's *late*-Victorian manufacturing comparative advantages and *early*-Victorian manufacturing comparative advantages, which Temin (1997, pp. 73-9) essentially inferred from the presence of industries among British exports and the absence of those same industries among British imports. This article finds that, like in the early-Victorian era, Britain's late-Victorian manufacturing comparative advantages were not restricted to a narrow range of industries. Those industries in which early-Victorian Britain did, in fact, realize a comparative disadvantage were, in many instances, also those (labour-intensive) industries in which late-Victorian Britain would also realize a comparative disadvantage. One of the broader contributions of this article is to

[3] Although, as later observed in this article, Habakkuk (1962, pp. 194-5) himself conceded that the distinction had diminished by the late nineteenth century.

identify a substantial continuity in Britain's manufacturing comparative advantages into the period of foreign industrialization in the late nineteenth century.

2. Previous literature

According to Temin (1997, p. 76), the manufacturing comparative advantages of early-Victorian Britain spanned a broad range of industries. Temin did not actually construct measurements of comparative advantage, but rather concluded the existence of a comparative advantage in an industry if it was present in Britain's export basket and absent from its import basket. In 1850-2, Britain's export basket included an array of industries that were also absent from Britain's import basket. There were some industries, such as silk manufactures and clocks and watches, in which Britain had a comparative disadvantage. Still, according to Temin (1997, p. 76), 'Britain maintained a clear comparative advantage in a wide variety of manufacturing industries throughout the first half of the nineteenth century'.[4]

Temin's identifying Britain's manufacturing comparative advantages at mid-century was an approach to assessing whether productivity growth during Britain's industrialization was a phenomenon exclusive to key manufacturing industries, chiefly cotton textiles, as Crafts (1989a, p. 425) had argued, or whether productivity growth was pervasive throughout the sector and extended to traditional manufacturing industries. According to a Ricardian model with a continuum of goods arranged according to comparative advantage, if technical change between the late-eighteenth century and the mid-nineteenth century, i.e. the Industrial Revolution era, was limited to just a few key industries, such as cotton textiles and iron, then the range of manufacturing industries in Britain's export (import) basket should have fallen (risen).[5] Temin (1997, pp. 74-6) found that Britain's traditional industries largely persisted

[4] Temin (1997, p. 76) correlated the exports of traditional industries at the endpoints of various intervals spanning the early nineteenth century. He found very high correlation coefficients.

[5] Temin's exposition of the model followed that of Dornbusch *et al.* (1977).

among Britain's exports through the mid-nineteenth century, leading him to conclude that technical change was indeed widespread during the Industrial Revolution.

By the mid-nineteenth century, a great international commodity-market integration, which resulted from declining transport costs, was contributing to Britain's specialization in manufacturing (O'Rourke and Williamson, 1999). As the price of manufactured goods rose relative to the price of agricultural goods in Britain, there followed a sectoral adjustment out of agriculture and into manufacturing (and services). In short, O'Rourke and Williamson depicted an Atlantic economy specializing along Hechscher-Ohlin (H-O) lines—the Old World in the manufacturing sector, the New World in the agricultural sector. They employed the H-O model to explain Britain's specialization in manufacturing, but can the H-O model also explain Britain's specializations *within* manufacturing, or among industries?

Crafts and Thomas (1986) estimated the factor determinants of Britain's manufacturing comparative advantages in selected years from 1910-35, by which time there were regular censuses of production from which factor intensities could be calculated. They employed a three-factor H-O model, with the factors being capital, (unskilled) labour, and human capital. Throughout the period from 1910-35, the manufacturing industries in which Britain realized a comparative advantage were relatively intensive in labour, but not in human capital; comparative advantage was unaffected by the capital intensity of the industry. They then applied the model to late-Victorian Britain, using the cruder data from the *Factory Inspectorate Returns* of 1870, and found similar results, except that capital was a statistically significant and positive determinant of Britain's manufacturing comparative advantages during this earlier period (Crafts and Thomas, 1986, p. 637).

Crafts and Thomas used the term 'comparative advantage' loosely. For the period from 1910-35, they estimated the factor determinants of British gross and net exports. For the late-Victorian era, they estimated the factor determinants of just British gross exports in the year

1880, using factor proportions calculated from 1870 data. The issue here is that the value of gross exports alone does not indicate the presence of a comparative advantage. Consider the industries of silk manufactures and cement. In 1900, the value of British silk exports was more than double the value of cement exports, yet Britain realized a comparative disadvantage in the former industry and a comparative advantage in the latter industry. This article improves upon the work of Crafts and Thomas through the construction of RCA indicators.

Crafts (1989b) did, in fact, construct RCA indicators for Britain's manufacturing industries, along with the manufacturing industries of ten other mostly industrial countries, for the years 1899, 1913, 1929, 1937, and 1950. In doing so, he employed the method advanced by Balassa, which is discussed fully in the next section of this article. For the year 1899, Crafts (1989b, p. 130) observed that Britain's comparative advantages were greatest in the more mature industries of shipbuilding, iron, and textiles, rather than in the industries of the Second Industrial Revolution, which exhibited greater scope for new technology by the closing decades of the nineteenth century. Crafts did not offer any factor-based explanation for the pattern of Britain's manufacturing comparative advantages, however.

One weakness of Crafts' RCA indicators, especially the RCA indicators for Britain (and even more especially for 1899), is the manner in which Crafts divided world manufactured exports among industries. For the 1899 RCA indicators, nearly half of Britain's manufactured exports are concentrated in the single industry of textiles, while the other half of Britain's manufactured exports are dispersed among 15 industries. In contrast, the RCA indicators in this article are constructed for industries that are defined more consistently with a nineteenth-century distribution of manufactured exports. The discrepancies between the industry definitions used by Crafts and those used in this article are addressed more fully in the next section. Here, it should simply be observed that the data-construction component of this article does not seek merely to replicate Crafts' 1899 RCA indicators.

Crafts and Thomas's portrayal of manufacturing in late-Victorian Britain as intensive in labour, but not in human capital, was the opposite of what Harley (1974) argued was true of manufacturing in (slightly later) Edwardian Britain. He argued that Britain was relatively abundant in skilled labour and that the United States, given its influx of migrants from southern and eastern Europe, was relatively abundant in unskilled labour (Harley, 1974, pp. 394-5).[6] Harley's argument is not entirely comparable to that of Crafts and Thomas. Whereas Crafts and Thomas were concerned with the pattern of specialization among industries, Harley was concerned with intra-industry differences in technique between British and American manufacturing, specifically within the industries of shipbuilding, textiles, engineering, and iron and steel. Of course, it is essential not to confuse an Anglo-American comparison with an Anglo-World comparison. Indeed, one of the themes of this article is that Continental Europe, along with the United States, must serve as the reference when explaining late-Victorian manufacturing in international context.

The relationship between human capital and British manufacturing before the First World War was revisited by Broadberry (1997, p. 158), who observed that Britain tended to realize its highest levels of comparative labour productivity in those industries that used intensively Britain's relatively abundant supply of human capital. Such industries were not so amenable to mass production techniques, and instead relied upon a highly-skilled labour force. Insofar as comparative advantage approximates comparative labour productivity, the finding of Broadberry can be regarded as contrasting with that of Crafts and Thomas on the

[6] As Harley noted, the distinction between skilled and unskilled labour offered a potential resolution to the famous Leontief paradox in post-war American trade. He speculated that there might have been a Leontief paradox in Edwardian British trade, whereby labour-scarce Britain exported labour-intensive manufactured commodities. While he did not quite make such an assertion, he did claim that the two-factor (capital and labour) H-O model was inadequate (Harley, 1974, pp. 411-13).

association between human capital and the best performing industries within late-Victorian manufacturing.

3. Constructing the RCA indicators

Balassa (1965) was interested in identifying the comparative advantages of industrial countries, not during the late nineteenth century, but rather during the period of trade liberalization that followed the Second World War. For Balassa to have determined comparative advantages directly would have required an enormous amount of systematically-collected data on production costs for every industry-country pair. Instead, Balassa endeavoured to determine comparative advantages indirectly, based upon the pattern of world trade. Assuming that countries actually traded according to their comparative advantages, Balassa (1965, p. 103) then argued that the pattern of world trade 'revealed' the comparative advantages of countries.

Balassa's method for calculating an indicator of RCA is expressed as follows:

$$RCA_{c,i} = \frac{X_{c,i}}{X_{n,i}} \Big/ \frac{X_c}{X_n} \qquad [1]$$

Here, X refers to the current value of exports, i to the manufactured commodity, c to the industrial country, and n to the collectivity of industrial countries. The RCA indicator is therefore the country-share of world exports of the manufactured commodity, normalized by the country-share of world exports of all manufactured commodities. An indicator greater than 1 implies a comparative advantage, an indicator less than 1 a comparative disadvantage. Theoretically, specialization according to comparative advantage would cause a country's RCA indicators to cluster around X_n/X_c (complete comparative advantage) and 0 (complete comparative disadvantage). However, empirically, indicators fall anywhere between these two values, oftentimes quite close to the threshold value of 1. One reason is that the manufactured commodity, as defined, encompasses enough heterogeneity such that a country may realize a comparative advantage in one variety of the commodity, but a comparative disadvantage in another variety of the commodity. This situation is especially likely when the RCA indicators are calculated at higher levels of aggregation, such as the industry level, as was done by Crafts (1989b), and as is done in this article. Another reason is that the effects of trade costs, such as transport costs and tariffs, are internalized in the RCA indicators.[7]

For every year from 1870-1913, Jacks *et al.* (2010) calculated an all-inclusive measure of trade costs for each of a 16-country sample of Britain's (bidirectional) bilateral trade flows.[8] Additionally, they estimated the intertemporal determinants of Britain's bilateral trade costs using a panel regression with country-pair, i.e. bilateral, fixed effects. They found exchange-rate volatility and maritime freight rates to have been positive intertemporal determinants of Britain's bilateral trade costs, and gold standard adherence to have been a negative intertemporal determinant (Jacks *et al.*, 2010, p. 135).[9] In addition to intertemporal variation, Britain's bilateral trade costs exhibited cross-sectional variation.[10] In 1890, Britain's bilateral trade costs were lowest for Australia and New Zealand, despite their distance from Britain, and highest for Indonesia and Japan. To the extent that differing

[7] On the relationship between tariffs and RCA, Balassa (1965, p. 104) observed that '…as long as all exporters are subject to the same tariff, data on relative export performance are not distorted by differences in the degree of tariff protection'. However, whereas *ad valorem* tariffs predominated at the time of Balassa's writing, specific tariffs predominated in the late nineteenth century. Differences (across exporting countries) in the price of a commodity would result in differing *ad valorem* equivalent tariffs and, consequently, differing trade costs. Thus, even if all exporters are subjected to the same (specific) tariff, the tariff can still distort the data on relative export performance.

[8] Their measure of trade costs is the difference between actual bilateral trade and frictionless bilateral trade. The measure is comparable across country pairs.

[9] However, in the very large Anglo-American trade, Varian (2018) found tariffs to have been the sole intertemporal determinant of trade costs.

[10] Jacks et al. (2010, p. 135) did not estimate the intertemporal *and* cross-sectional determinants of exclusively Britain's bilateral trade costs, but they did estimate the intertemporal and cross-sectional determinants of bilateral trade costs for a larger sample of bilateral pairs that included both British and non-British bilateral pairs, e.g. Franco-German. In this random effects regression that exploited both the intertemporal and cross-sectional variation in the data, they found that distance and tariffs were positive determinants of bilateral trade costs, whilst gold standard adherence, membership in the British Empire, and railway density were negative determinants.

bilateral trade costs distorted the industry composition of Britain's exports, the RCA indicators would inaccurately measure Britain's comparative advantages.[11]

One way to gauge whether trade costs fundamentally distorted the industry composition of Britain's exports is to compare Britain's industry-level bilateral exports. In Britain's trade statistics, the disaggregation of exports by both commodity (or industry) and, *within that*, by destination country is highly incomplete.[12] Thus, the scope for comparing Britain's industry-level bilateral exports is limited. Nevertheless, even a limited comparison can offer some indication of the degree to which trade costs altered the industry composition of Britain's exports. In several respects, machinery and silk are ideal industries for comparing Britain's bilateral exports. Crucially, the bilateral disaggregation of the constituent commodities of these industries is relatively extensive, permitting an industry-level comparison of machine and silk exports to an adequate number of countries.[13] In 1890, the value of world exports of these mid-sized industries was broadly similar at approximately £33.1 million for machinery, including steam engines and locomotives, and £25.3 million for silk manufactures.[14] Yet, Britain exported almost eight times as much machinery (£16.4 million) as it did silk manufactures (£2.2 million). As identified later in this section, Britain had a comparative advantage in machinery and a comparative disadvantage in silk manufactures. If trade costs did not fundamentally distort the industry composition of Britain's exports, then it would be

[11] For example, in the presence of transport costs, a commodity might be imported from a geographically proximate country, rather than from a country with a comparative advantage in the commodity.

[12] In the commodity disaggregation section of the British trade statistics, the further bilateral disaggregation is incomplete due to the category of 'other foreign countries'; the composition of 'other foreign countries' varies according to the commodity. Similarly, in the bilateral disaggregation of the British trade statistics, the further commodity disaggregation is incomplete due to the category of 'all other articles'; the composition of 'all other articles' varies according to the country.

[13] As discussed later in this section, industries are constructed from various commodities. Therefore, in order to compare the exports of machinery and silk manufactures to a particular country, that country must be specifically reported in the bilateral disaggregation of all of the commodities constituting both the machine and silk industries, as those industries are defined in this study.

[14] The method of estimating the value of world exports in these industries is covered later in this section.

expected that the ratio of bilateral machine exports to bilateral silk exports would be consistently high across Britain's trade partners. Of the 28 destination countries for which there are data on Britain's bilateral exports of both machinery and silk manufactures in 1890, the median ratio of machine exports to silk exports was 8.8. The interquartile range was from 5.1 to 23.7. All but three of the destination countries had a ratio above 3.0. Certainly, trade costs exerted some distorting effect upon the industry composition of Britain's exports, but not to a degree sufficient to render the RCA indicators a widely inaccurate measure of comparative advantage.

In recent literature, a couple of alternative measures to Balassa's RCA that correct for country-pair-specific and commodity-specific trade costs have been proposed. However, there is empirical evidence that Balassa's RCA is broadly consistent with these other measures. For the 54 HS-6 commodities in the motor vehicles manufacturing industry (HS-2), French (2017) estimated three measures: French's (2017) 'gravity-based RCA', Costinot *et al.*'s (2012) 'revealed productivity', and Balassa's (1965) RCA. The measures were estimated for the United States relative to Germany. The Spearman rank correlation coefficient was 0.94 between Balassa's RCA and gravity-based RCA, and 0.84 between Balassa's RCA and revealed productivity (French, 2017, p. 94). In view of the alignment between Balassa's RCA and the other measures, as well as the data limitations associated with the nineteenth-century trade statistics, this article settles on Balassa's method for identifying comparative advantages.

RCA indicators are calculated for 18 British manufacturing industries for the years 1880, 1890, and 1900. The industries—Balassa's method involved individual manufactured commodities—are beer; cement; chemicals; clocks and watches; copper manufactures; cotton manufactures; earthenware and chinaware; flax, hemp, and jute manufactures; glass; iron, steel, and manufactures thereof; leather and manufactures thereof; machinery; musical instruments; paper and manufactures thereof; rubber manufactures; silk manufactures; spirits; and woollen and worsted manufactures. These 18 industries differ noticeably from the 16 industries for which Crafts calculated RCA indicators. Crafts' industries were largely predetermined in the sense that he relied solely on the highly aggregated manufactured export data in Tyszynski's (1951) statistical compilation, rather than the more disaggregated manufactured export data available in the underlying government trade statistics. Crafts' industries are suited to the period he considered, which was the early twentieth century. However, several of these industries, such as the electrical industry and the cars and aircraft industry, are obviously unsuited to the late nineteenth century. The textile industry presents a more serious issue. In 1899, textiles comprised 34% of world manufactured exports and 46% of British manufactured exports (calculated from Tyszynski, 1951, p. 277). Earlier in the nineteenth century, the share of textiles in British manufactured exports was even higher, at 61% in 1882-4 (Schlote, 1952, p. 74). Concentrating half of British manufactured exports and a third of world manufactured exports into a single industry obscures the actual comparative advantages held by countries, which differed based upon the particular class of textile. Therefore, for the purpose of calculating RCA indicators for the late nineteenth century, this article divides textiles into four classes: cotton manufactures; flax, hemp, and jute manufactures; silk manufactures; and woollen and worsted manufactures. In general, the 18 industries included in this study mirror the industry classifications in the *Annual Statements of the Trade of the United Kingdom*, which is the source for data on the values of British manufactured exports.

It might be argued that these 18 industries do not sufficiently account for the newer manufactured commodities and, indeed, industries of the Second Industrial Revolution. Of course, such an argument would be more applicable to the year 1900 than the year 1880. Yet, it should be observed that many of the industries associated with the Second Industrial

Revolution were still quite nascent by the close of the nineteenth century. In 1899, electrical goods and automobiles (combined) amounted to slightly more than 1% of the *manufactured* exports of Britain and slightly more than 1% of the *manufactured* exports of Germany, a putative leader in the Second Industrial Revolution (calculated from Tyszynski, 1951, p. 277). Although, by 1913, these shares had increased to 4% for Britain and 7% for Germany (calculated from Tyszynski, 1951, p. 278). On the whole, the 18 industries offer generally adequate coverage of world manufactured exports in 1900, even despite the emergence of some industries that did not exist in earlier decades.

Having obtained data on British manufactured exports per industry from the *Trade of the United Kingdom*, the next step in calculating the RCA indicators is to gather data on world manufactured exports per industry. This latter value is initially approximated by the manufactured exports, per industry, of Britain, Belgium, France, Germany, and the United States combined, as recorded in their respective government trade statistics.[15] Due to the varying classifications of industries in the trade statistics of the different countries, this step in constructing the RCA indicators is an immensely challenging one. Crafts and Thomas (1986) matched industries between the British and American trade statistics, in order to compare the factor determinants of these countries' exports. They referred to this matching process as a 'problematic and protracted exercise' (Crafts and Thomas, 1986, p. 632). When the trade statistics of five countries are involved, the process is considerably more problematic and protracted. For example, the British trade statistics separate saddlery and harnesses from leather and manufactures thereof, whereas the trade statistics of other countries do not. Such inconsistencies are, however, generally reconcilable, since the finest

[15] The sources are *Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions* (Britain); Ministère des Finances, *Tableau Général du Commerce avec les Pays Étrangers* (Belgium); Administration des Douanes, *Tableau Général du Commerce de la France avec ses Colonies et les Puissances Étrangères* (France); Kaiserlichen Statistischen Amt, *Statistisches Jahrbuch für das Deutsche Reich* (Germany); Treasury Department, *Foreign Commerce and Navigation of the United States* (United States). The American data are for the years 1879/80, 1889/90, and 1899/1900, its statistical year having spanned from 1 July to 30 June.

levels of disaggregation in the trade statistics usually permit the reconstructing of industries. Where inconsistencies are ultimately irreconcilable, they are minor and do not materially alter the resulting RCA indicators. In order to add together the values of the manufactured exports, per industry, of the five industrial countries, all values are converted to sterling using the exchange rates reported in Mitchell (1988, p. 702).

The manufactured exports of Britain, Belgium, France, Germany, and the United States accounted for most, though not all, manufactured exports in the late nineteenth century. In 1899, the manufactured exports of these five countries accounted for 87% of the manufactured exports of the 11 industrial countries included in Tyszynski's statistical compilation.[16] A coverage rate of 87% implies a reweighting of the value of manufactured exports, per industry, of the five industrial countries ($X_{n,i}$) by a factor of 1.15.[17] Balassa's original method, represented in equation 1, is therefore modified to include the reweighting:

$$RCA_{UK,i} = \frac{X_{UK,i}}{1.15X_{n,i}} \Big/ \frac{X_{UK}}{X_n} \qquad [2]$$

This modification to Balassa's method does not alter the rank order of the indicators. However, in marginal cases, the reweighting renders an otherwise comparative-advantage industry as a comparative-disadvantage industry, as it does for the British glass industry in 1880, for example.

The next step is to normalize the British share of world manufactured exports per industry ($X_{UK,i}/1.15X_{n,i}$) by, according to Balassa's method, the British share of world manufactured exports across all industries (X_{UK}/X_n). Normalizing by the country-share of only secondary-sector world exports was criticized by Vollrath (1991, p. 269), who argued for the inclusion of the primary sector in determining comparative advantage. Because the British share of secondary-sector world exports exceeded the British share of total world

[16] The 11 countries include the five abovementioned industrial countries, as well as Italy, Sweden, Switzerland, Canada, India, and Japan.

[17] The implicit assumption is that the share of the omitted industrial countries was equal across industries and constant from 1880-1900.

exports, the exclusion of the primary sector from the normalization factor reduces the levels of the RCA indicators for Britain's manufacturing industries.[18] Balassa's procedure for normalization, which was employed by Crafts, risks misidentifying a comparative-advantage industry as a comparative-disadvantage industry. Because the objective of this study is not to identify Britain's *intra-sector* industrial comparative advantages, but rather Britain's industrial comparative advantages in a *multi-sector* economy, the normalization factor includes both the primary and secondary sectors. As with the reweighting of per-industry manufactured exports, the choice of normalization factor only alters the levels of the indicators, not their rank order. Data on the value of total British exports for the years 1880, 1890, and 1900 come from the *Trade of the United Kingdom*. Data on the current value of total world exports in these years are taken from the recent estimates of Federico and Tena-Junguito (2016).

Table 1 presents the resulting RCA indicators for Britain's manufacturing industries, ordered by their rank in 1880. Given the data assembled, calculating RCA indicators for the manufacturing industries of the other four industrial countries is simple. Since these indicators are likely to be of interest to future researchers, corresponding tables for Belgium, France, Germany, and the United States are supplied in Appendix A.

As evident from the RCA indicators in Table 1, Britain's late-Victorian manufacturing comparative advantages were not restricted to a narrow range of industries, similar to Britain's manufacturing comparative advantages in 1850-2, as found by Temin (1997, p. 76). Silk manufactures and clocks and watches, which Temin specifically identified as comparative-disadvantage industries at mid-century, were also among Britain's comparative-disadvantage industries in the late-Victorian era. Another continuity between the early and

[18] In contrast, the American share of secondary-sector world exports was less than the American share of total world exports in 1899/1900. Thus, excluding the primary sector from the normalization factor increases the levels of the RCA indicators for American manufacturing industries. In 1899/1900, the primary sector contributed 68% of American exports (United States, Treasury Department, 1901).

late nineteenth centuries was Britain's comparative advantage in cotton textiles, which held pride of place in all three decadal years. During the late nineteenth century, Britain actually advanced its comparative advantage in woollen and worsted manufactures considerably, even in spite of the heavy protection that this industry received in other industrial countries.[19]

Economic historians have debated the international position of the British engineering (machine) industry in the late 1890s, when the American engineering industry greatly increased its exports, especially its exports to Britain.[20] Nicholas (1980) argued that the rise in American machine exports to Britain resulted from a strong upswing in the British business cycle, which caused domestic demand to exceed short-run domestic supply. Irwin (2003, p. 369), however, attributed the occurrence to the increasing international competitiveness of American machinery, driven by a shift in the Anglo-American relative price of iron and steel—material inputs of the machine industry.[21] Although the RCA indicator for the British machine industry declines somewhat between 1890 and 1900, Britain still maintained a clear comparative advantage in this industry. Nonetheless, it should be recognized that the heightened level of American machine exports to Britain abated after 1899. If the indicator was calculated for a year between 1896 and 1899, it could be substantially lower.

In order to gauge the relative persistence of Britain's comparative advantages, Spearman rank correlation coefficients are calculated for various intervals, following the approach undertaken by Crafts. Table 2 presents coefficients for the intervals covered in this

[19] For a discussion of the protection that British woollen and worsted exports encountered in foreign markets, see Saul (1960, p. 151). If such protection enabled foreign manufactures to become internationally competitive, per the infant industry argument, then Britain's comparative advantage in this industry would have been affected.

[20] Although, Clapham (1938, p. 36) noted, 'Long before the 'nineties, exports of new American machinery, or of American mechanical notions, had affected the course and pace of industrial change in Britain'.

[21] The decline in the American price of iron and steel (relative to the British price) can be attributed to the fall in the American price of iron ore resulting from the opening of the Mesabi Range in the 1890s.

article, as well as for the intervals covered by Crafts. Different industry classifications prohibit the calculation of coefficients for intervals that span the turn of the twentieth century. Persistence during the late-Victorian era was roughly on par with persistence during the early twentieth century. The correlation coefficient is slightly lower for 1880-1900 than for 1899-1913, but this should be expected given the greater length of the former interval. What can be claimed with some certainty is that Britain's comparative advantages underwent a more substantial reordering during the 1890s than during the 1880s, when the comparative advantages were remarkably persistent. By the 1890s, the protectionist backlash in Continental Europe had been underway for a decade, and the reordering of Britain's comparative advantages in the 1890s may have been influenced by some Continental industries having emerged as internationally competitive.

4. Factor determinants of Britain's comparative advantages

In this section, the factor determinants of Britain's manufacturing comparative advantages are estimated using a four-factor H-O model, with the factors being capital, labour, material inputs, and human capital. For all factors apart from human capital, intensities (or proxies therefor) for the 18 British manufacturing industries are calculated from the data included in the *Final Report of the First Census of Production*, which covers manufacturing activity in Britain in the year 1907. Conveniently, the data is disaggregated at the industry and sub-industry levels, thereby permitting the reconstructing of industries so that they are consistent with the industries defined in the previous section of this article. The process is rather straightforward, and the exact components of the reconstructed industries are detailed in Appendix B. One important assumption is that the sub-industry of (textile) bleaching, dyeing, printing, and finishing trades is allocated among the four classes of textiles proportionally, according to gross output.[22]

Factor intensities per industry are reported in Table 3. Capital intensity is proxied by horsepower per £1 million of gross output.[23] Labour intensity is proxied by workers per £1 million of gross output. Both of these proxies resemble the ones employed by Crafts and Thomas (1986) for estimating the factor determinants of British exports in 1880, although their source of data was the more rudimentary *Factory Inspectorate Returns* of 1870, as compiled by Musson (1976, pp. 437-9). Because the *First Census of Production* reports the value of material inputs, material intensity is measured directly as the share of material inputs in gross output. This factor was not among the three factors in Crafts and Thomas's model. The omission of material intensity is not trivial, since the share of material inputs in gross output typically exceeded one-half and varied widely across industries, ranging from 36% for clocks and watches to 83% for copper manufactures.

Imposing Edwardian factor proportions on late-Victorian manufacturing industries is, recognizably, less than ideal.[24] This approach is mostly necessitated by the lack of systematically collected data across a range of industries for the late-Victorian era. Britain was a latecomer among industrial countries in collecting data on manufacturing output, and

[22] In 1907, the gross output of this sub-industry was £17.9 million, or about 6% of the entire textile industry. This sub-industry is allocated as follows: 60.7% to cotton manufactures, including yarn; 26.4% to woollen and worsted manufactures, including yarn; 11.2% to flax, hemp, and jute manufactures, including yarn and cordage; and 1.8% to silk manufactures.

[23] A proxy for capital intensity per industry is necessary, as the *First Census of Production* of 1907 did not collect data on the manufacturing capital stock. The census did, however, collect data on horsepower per industry and sub-industry. Somewhat rudimentary evidence of the suitability of horsepower as a proxy for capital can be obtained from the American *Twelfth Census* of 1900, which collected data on both capital and horsepower per industry. At the 15-industry level of disaggregation of American manufacturing, the correlation coefficient between the capital *stock* (standardized by gross output)—not the capital *cost*—and horsepower (standardized by gross output) is 0.52. This coefficient is statistically significant at the 5% level. Excluding the industry of lumber and its remanufactures, which existed to a far lesser extent in Britain than in the United States, causes the correlation coefficient to rise to 0.57. As should be expected, the 15 industries defined in the *Twelfth Census* do not match the 18 industries defined in this article.

[24] Beach and Hanlon (2018) offers a recent precedent for backdating factor intensities from the 1907 census into the nineteenth century. They applied the cross-industry variation in coal use per worker from the 1907 census to the year 1851.

the 1907 census was the first such exercise.[25] The error of backdating the factor proportions is perhaps not so grave in the context of mature industrial Britain, with its generally slow growth in output and inputs. While acknowledging some change in the factor proportions of individual industries between the late nineteenth century and 1907, the foregoing analysis nonetheless relies on the cross-industry variation in factor intensities calculated from the *First Census of Production*, which represents the best available source for the given purpose.

The proxy for human capital intensity per industry is calculated as the difference between the average industry wage and the wage of unskilled or 'raw' manufacturing labour. Variations of this approach have been used in other studies of the nineteenth-century economy (e.g. Williamson, 1985; Rosés, 1998). In calculating the human capital intensity proxy, the data used are the average industry wages of adult males working full time.[26] The unskilled manufacturing wage is taken to be the average wage (£1.01 per week) of an adult male 'general labourer' working full time in the cotton textile industry. The data for the human capital intensity proxy are obtained from the reports of the *Earnings and Hours Enquiry* of 1906, and are therefore contemporaneous with the data for the other factor-intensity proxies.[27] Once again, industries are reconstructed from the sub-industries in the *Earnings and Hours Enquiry* so that the resulting industries correspond to the RCA indicators. The components of the reconstructed industries are detailed in Appendix B, along with the employment-share weights applied to the sub-industry average wages.

The H-O model takes the form of a semi-log OLS regression. The dependent variable is a symmetric version of the RCA indicator. Following the procedure advanced by Laursen

[25] By comparison, the United States was collecting such data a century before Britain.

[26] Using the average industry wages of all labourers, including females, would likely understate the human capital intensity of those industries that relied disproportionately on female labour. For example, an adult male warper working full time in the woollen industry was paid a time-wage of £1.20 per week, while an adult female warper working full time in the woollen industry was paid a time-wage of £0.70 per week.

[27] The sources are *Earnings and Hours Enquiry: I*; *Earnings and Hours Enquiry: II*; *Earnings and Hours Enquiry: VI*; *Earnings and Hours Enquiry: VIII*.

(2015), an indicator of revealed symmetric comparative advantage (RSCA) is calculated as (RCA-1)/(RCA+1).[28] The baseline specification of the regression equation can be expressed as follows, with *i* referring to the industry and *t* referring to the year (1880, 1890, or 1900):

$$\text{RSCA}_{i,t} = C + \alpha \ln(CAPITAL_i) + \beta \ln(LABOUR_i) + \gamma \ln(MATERIAL_i) + \delta ln(HUMANCAPITAL_i) + \epsilon_{i,t} \qquad [3]$$

Each of the regressions (apart from those in columns 5-7 of Table 4) combines the RSCA observations from all three decadal years. The regressions are estimated using decade (time) fixed effects, which control for any decade-to-decade overall changes in Britain's RSCA indicators, such as may have resulted from foreign industrialization and increasing foreign manufactured exports in the late nineteenth century. Moreover, in a particular decadal year, the RSCA indicators may have been generally lower or higher due to the cyclicality of British exports.[29]

The results of the regressions are presented in Table 4, with robustness checks presented in Appendix C. From column 1, which presents the results from the baseline specification of the regression, it is evident that Britain's comparative advantages were in the relatively capital-intensive manufacturing industries and, inconsistent with Crafts and Thomas, in the relatively labour-economizing manufacturing industries. This finding is discussed shortly.

The statistical insignificance of the coefficient of material intensity does not permit the claim that the manufacturing comparative advantages were material-economizing. Given Britain's limited natural resource endowments, this result may seem surprising. However, one

[28] The RCA indicator is asymmetric, as the range for comparative disadvantage lies between 0 and 1, while the range for comparative advantage lies between 1 and the reciprocal of the country's share of world exports, which would be 6.2 for Britain in 1890. Laursen (2015, pp. 105-7) called for making the RCA indicator symmetric for the purpose of regression analysis, since the use of an asymmetric indicator would more likely result in a violation of the normality assumption for the error terms.

[29] For a discussion of the cyclicality of British exports in the late nineteenth century, see Ford (1963).

potential explanation lies in what lay beneath Britain: coal. Insofar as coal was a material input in the manufacturing sector, Britain's natural resource endowments were exceptionally favourable. It would stand to reason that the RCA indicators would be higher, *ceteris paribus*, for particularly coal-intensive industries, including cement and earthenware.[30] Is the statistical insignificance of the coefficient of material intensity attributable to Britain's abundant supply of coal? Because the *First Census of Production* recorded the quantities of coal and coke use per industry, it is possible to adjust the material-intensity variable to exclude coal and coke.[31] Column 2 presents the results of the regression with non-coal material intensity. Still, the statistical insignificance of the coefficient of material intensity remains unchanged.[32]

A more compelling explanation comes from trade policy. Victorian Britain was unique in espousing a policy of free trade, which extended to raw materials and intermediate inputs. Unlike in other industrial countries, where a protectionist backlash had taken hold, the British manufacturing sector could obtain material inputs at the world price. The relatively material-intensive industry of woollen and worsted manufactures illustrates this point well. By the late nineteenth century, the majority of the raw wool used in the British woollen and worsted industry was imported, and this imported share reached as high as four-fifths by 1895-9

[30] In 1907, the factor proportion of coal (and coke) in the cement and earthenware industries was 22% and 7%, respectively. In each of the other 16 manufacturing industries, the factor proportion was less than 5%.

[31] The material intensity variable is adjusted to exclude coal and coke usage per industry, the domestic prices of steam coal (£0.458 per ton) and coke (£0.839 per ton) calculated from the *First Census of Production*.

[32] Attention should be directed to columns 3 and 4 of Appendix C, which presents several robustness checks. When the RSCA indicators are regressed against only material intensity (column 3), the coefficient of material intensity is positive and statistically significant. When the RSCA indicators are regressed against only non-coal material intensity, then the coefficient is positive, but statistically insignificant. This discrepancy suggests that Britain's manufacturing comparative advantages were coal-intensive. In the main specification of the model (Table 4, column 1), however, the coefficient of material intensity is insignificant, likely because coal usage is captured by the proxy variable for capital intensity, which is horsepower per £1 million gross output. Nevertheless, there is no basis for claiming that the manufacturing comparative advantages of late-Victorian Britain economized upon non-coal material inputs.

(Deane and Cole, 1964, p. 196). The American woollen and worsted industry also relied heavily on imported wool. However, whereas Britain imported wool free of duty, the United States imposed a high duty on this imported material input. Following the passage of the McKinley Tariff of 1890, the *ad valorem* equivalent tariff on wool exceeded 40% (United States, Treasury Department, 1892). The divergent trade policies of Britain and the United States may account, at least in part, for why the RCA indicator for the British woollen and worsted industry steadily increased throughout the late nineteenth century, whilst the American woollen and worsted industry remained at a nearly perfect comparative disadvantage.

In addition to wool, Britain imported a range of material inputs for its manufacturing sector, and many of these material inputs were sourced from the British Empire. The recent gravity literature yields unambiguous evidence for an empire effect on commodity trade. Mitchener and Weidenmier (2008) estimated that membership in the British Empire alone more than doubled intra-Empire bilateral trade flows. Following a different empirical strategy, Jacks *et al.* (2010, p. 135) estimated that membership in the British Empire reduced intra-Empire bilateral trade costs by half. To be sure, access to a resource-rich empire mitigated the effects of Britain's relatively unfavourable (non-coal) natural resource endowments on its manufacturing sector and may partly account for the statistical insignificance of the coefficient of material intensity.

The coefficient of human capital intensity is statistically insignificant. It is therefore not possible to draw any conclusion on whether Britain's manufacturing comparative advantages utilised or economised on human capital in the final decades of the nineteenth century.

As already discussed, the estimation of equation 3 uses late-Victorian data for the dependent variable and Edwardian data for the explanatory variables. Given this temporal mismatch, it is worth checking whether use of earlier data from the *Factory Inspectorate*

Returns of 1870 bears out a similar result. Industries are reconstructed from the sub-industries in Musson's (1976, pp. 437-9) compilation of the *Factory Inspectorate Returns,* so that the resulting industries correspond to the RCA indicators. The components of the reconstructed industries are listed in Appendix B. The *Factory Inspectorate Returns* report the quantities of steam horsepower and labourers in each industry and sub-industry, but not the value of output. Thus, it is necessary to standardize capital and labour relative to each other. Column 4 regresses the RSCA indicators against the log of the proxy for the 1870 capital-labour ratio. The coefficient is positive and statistically significant, as expected. This result is reminiscent of Wright's (1990, p. 659) finding that the capital-labour ratio was a positive and statistically significant determinant of the *net* exports of American manufacturing industries in 1879.

It should be observed that the 1870 and 1907 (proxied) capital-labour ratios are highly correlated.[33] The correlation coefficient is 0.94 and is statistically significant at the 1% level.[34] This high correlation suggests that the discrepancy between the finding of this article and that of Crafts and Thomas on the factor determinants of Britain's manufacturing comparative advantages does not derive from the vintage of the sources used for calculating factor intensities, but rather likely from the use of actual measures of comparative advantage, i.e. (symmetric) RCA indicators, instead of gross exports.

Did the factor determinants of Britain's manufacturing comparative advantages change throughout the 1880s and 1890s? Does pooling the data for all three decadal years obscure an instability in the statistical significance (or possibly signs) of the factor coefficients? These questions are answered by estimating separate regressions for each of the three decadal years. In view of the small number of observations, only the variables for capital intensity and labour intensity are included in the regression. Column 4 presents the results of the two-factor

[33] For clarity, it should be stressed that the 1907 capital-labour ratio is not an explanatory variable in any of the specifications in Table 4.

[34] This correlation coefficient is calculated from the 17 industries, which exclude cement, as it was not reported in the *Factory Inspectorate Returns* of 1870.

H-O model, combining the data from all three years. Columns 5-7 present the results of the decadal regressions.

In the 1880 regression (column 5), the coefficient of labour intensity, though negative, is statistically insignificant at any conventional level. This finding might well be interpreted as a vestige of the repeal of the Corn Laws in 1846 and the increased imports of grain that followed. The grain imports displaced agricultural labourers, who formed a cheap supply of labour that the British manufacturing sector could draw upon. To be sure, this process was not an immediate one, with O'Rourke and Williamson (1999, p. 87) observing that the British agricultural sector did not begin its absolute decline until the 1870s, with the start of the so-called Grain Invasion. However, by the late-Victorian era, as Habakkuk (1962, p. 195) noted, 'The rise of real wages of English agricultural labour in the 1880s and '90's certainly suggests that the surplus of agricultural labour had been absorbed in English industry or by emigration'.

Emigration contributed to the increasing relative scarcity of labour in late-Victorian Britain, most acutely during the 1880s. Net emigration from Britain, almost entirely to the higher-wage Dominions and the United States, averaged 3.2/1,000 population per annum from 1880-9, compared to 2.9 for Germany, 0.2 for France, and -1.1 for Belgium (Hatton and Williamson, 1998, p. 33). In the counterfactual scenario of zero net emigration from 1870-1910, Hatton and Williamson (1998, p. 224) estimated that real wages in 1910 would have been 9% lower in Britain, 3% lower in Germany, unchanged in France, 9% higher in Belgium, and 15% higher in the United States. The comparatively high (among industrial countries) net emigration from Britain was not without consequence for Britain's manufacturing comparative advantages.

By the closing decade of the late-Victorian era, there was a distinctly labour-economizing regime within British manufacturing. This labour-economizing regime should be appreciated in a global context that includes the United States and, even more importantly, Continental Europe. Continental Europe supplied more than half of world manufactured exports in 1899. There, labour was comparatively more abundant than in Britain. Ignoring Continental Europe and embracing the textbook archetype of labour-economizing American manufacturing (and labour-utilizing British manufacturing) would obscure what was a fundamentally labour-economizing regime in British manufacturing.[35] Altogether, it might be suggested that, in the late-Victorian era, the starker contrast was not between the factor determinants of the manufacturing comparative advantages in Britain and in the United States, but rather between the factor determinants of the manufacturing comparative advantages in the Anglosphere and on the Continent.

5. Conclusion

In his classic study of the Anglo-German commercial rivalry, Hoffman (1964, p. 127) identified Norway was an export market in which Britain and Germany closely competed in the 1880s. While the values of British and German bilateral exports to Norway were roughly equal, there were some stark differences in the compositions of bilateral exports. In 1890, Norway imported three times the value of cotton textiles from Britain as from Germany (Norway, Det Statistike Centralbureau, 1891). Yet, Norway's imports of silk textiles from Germany exceeded its imports of silk textiles from Britain by a factor of ten (Norway, Det Statistike Centralbureau, 1891). Indeed, such compositional differences are attributable to the relative scarcity of labour in Britain and the labour-economizing pattern of its manufacturing comparative advantages. In the relatively labour-intensive silk industry, Britain was at a comparative disadvantage. In the cotton industry, with its lower factor proportion of labour,

[35] On this point, it is worth noting that Habakkuk (1962, pp. 194-5) stated, 'And if American labour was, except in the remoter parts of the country, no longer scarce, in England it was no longer as abundant as it had been earlier in the century'.

Britain possessed a definitive comparative advantage that persisted throughout the late-Victorian era. More generally, it can be concluded that the H-O model is useful for explaining Britain's intra-sector manufacturing comparative advantages.

This article has revised the prevailing idea that the manufacturing comparative advantages of late-Victorian Britain were in the relatively labour-intensive industries (Crafts and Thomas, 1986, p. 637). One implication of this revision is to accentuate the distinction between manufacturing in Britain and manufacturing on the Continent. A lengthy literature has already parsed the differences between British and American manufacturing in the nineteenth century, and these differences need not be diminished. However, future scholars might prefer to emphasize some of the similarities between British and American—Anglosphere—manufacturing, compared to Continental manufacturing. Indeed, the labour-economizing regime of manufacturing in late-Victorian Britain suggests a greater similarity between Britain and the United States than had perhaps been thought.

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Table 1. RCA indicators for Britain, 1880-1900

Industry	1880	1890	1900
Cotton manufactures, including yarn	4.6 (1)	4.4 (1)	4.3 (1)
Copper manufactures	4.2 (2)	3.9 (2)	1.5 (10)
Iron, steel, and manufactures thereof, excluding machinery	3.5 (3)	3.3 (5)	2.5 (5)
Flax, hemp, and jute manufactures, including yarn and cordage	3.4 (4)	3.5 (4)	3.3 (2)
Beer	3.4 (5)	3.6 (3)	3.0 (3)
Machinery, including steam engines and locomotives	3.2 (6)	3.1 (6)	2.4 (7)
Cement	2.6 (7)	2.4 (9)	1.2 (12)
Earthenware and chinaware	2.6 (8)	2.7 (7)	1.9 (9)
Rubber manufactures	2.5 (9)	2.5 (8)	2.0 (8)
Woollen and worsted manufactures, including yarn	2.1 (10)	2.3 (10)	2.7 (4)
Chemicals, including dyestuffs, medicine, and paint	1.6 (11)	1.5 (11)	1.2 (11)
Paper and manufactures thereof	0.9 (12)	1.0 (13)	0.8 (14)
Glass	0.9 (13)	1.0 (14)	0.8 (15)
Leather and manufactures thereof	0.9 (14)	0.9 (15)	0.9 (13)
Musical instruments	0.6 (15)	0.4 (18)	0.4 (17)
Clocks and watches	0.6 (16)	0.4 (17)	0.2 (18)
Silk manufactures	0.5 (17)	0.5 (16)	0.5 (16)
Spirits	0.5 (18)	1.3 (12)	2.5 (6)

Sources: See text.
Note: Rankings of indicators are noted in parentheses.

Table 2. Spearman correlation coefficients of Britain's RCA indicators, 1880-1950

	1890	1899/1900	1913	1929	1937
1880	0.93	0.69	--	--	--
1890	--	0.83	--	--	--
1899/1900	0.83	--	0.77	0.41	0.32
1913	--	0.77	--	0.76	0.70
1929	--	0.41	0.76	--	0.89
1937	--	0.32	0.70	0.89	--
1950	--	0.18	0.38	0.47	0.75

Sources: Coefficients for intervals from 1880-1900 are calculated using data constructed in this article. Coefficients for intervals from 1899-1950 are calculated using data from Crafts (1989b, p. 130).

Table 3. Factor intensities of Britain's manufacturing industries, 1906-7

Industry	Capital intensity	Labour intensity	Material intensity	Human capital intensity
Beer	961	1,263	0.38	0.30
Cement	16,085	3,968	0.48	0.41
Chemicals, including dyestuffs, medicine, and paint	3,845	2,028	0.62	0.40
Clocks and watches	897	8,648	0.36	0.62
Copper manufactures	2,537	1,241	0.83	0.57
Cotton manufactures, including yarn	7,303	3,424	0.72	0.44
Earthenware and chinaware	3,431	8,987	0.38	0.61
Flax, hemp, and jute manufactures, including yarn and cordage	5,377	4,738	0.68	0.18
Glass	4,293	6,489	0.38	0.80
Iron, steel, and manufactures thereof, excluding machinery	8,897	3,263	0.66	0.81
Leather and manufactures thereof	992	3,994	0.68	0.37
Machinery, including steam engines and locomotives	3,218	4,485	0.47	0.61
Musical instruments	1,168	5,416	0.42	0.85
Paper and manufactures thereof	11,080	3,957	0.64	0.50
Rubber manufactures	3,080	2,699	0.67	0.33
Silk manufactures	4,014	6,128	0.62	0.30
Spirits	1,768	865	0.79	0.14
Woollen and worsted manufactures, including yarn	4,656	3,614	0.71	0.34

Sources: See text.
Notes: Capital intensity is horsepower per £1 million gross output. Labour intensity is workers per £1 million gross output. Material intensity is the share of material inputs in gross output. Human capital intensity is the average weekly wage (£) minus the unskilled weekly wage (£). See text and Appendix B.

Table 4. RSCA indicators for Britain's manufacturing industries, 1880-1900

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Capital intensity (1907)	0.19*** (0.06)	0.18*** (0.05)		0.18*** (0.05)	0.19* (0.10)	0.20** (0.09)	0.16* (0.09)
Labour intensity (1907)	-0.26*** (0.09)	-0.24*** (0.08)		-0.24*** (0.07)	-0.15 (0.13)	-0.26** (0.11)	-0.29** (0.11)
Material intensity (1907)	-0.12 (0.21)						
Material intensity, exc. coal and coke (1907)		-0.02 (0.15)					
Human capital intensity (1906)	-0.02 (0.11)	-0.00 (0.10)					
Capital-labour ratio (1870)			0.19*** (0.03)				
Constant	0.67 (0.75)	0.70 (0.75)	0.48*** (0.08)	0.68 (0.63)	-0.08 (1.20)	0.79 (1.07)	1.29 (1.09)
Decade fixed effects	YES	YES	YES	YES	NO	NO	NO
R^2	0.33	0.32	0.44	0.32	0.24	0.39	0.38
Observations	54	54	51	54	18	18	18
Years	1880-1900	1880-1900	1880-1900	1880-1900	1880	1890	1900

Sources: See text and Appendix B.
Notes: The dependent variable is the RSCA indicator. All explanatory variables are expressed in natural logarithms. Standard errors are noted in parentheses. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level. Col. 3 omits the cement industry, as it did not appear in the *Factory Inspectorate Returns* of 1870.

Appendix A. RCA indicators for Belgium, France, Germany, and the United States

Table A.1. RCA indicators for Belgium, 1880-1900

Industry	1880	1890	1900
Glass	9.3 (1)	7.6 (1)	8.9 (1)
Flax, hemp, and jute manufactures, including yarn and cordage	4.7 (2)	5.4 (2)	5.4 (3)
Paper and manufactures thereof	3.0 (3)	1.6 (7)	1.6 (7)
Machinery, including steam engines and locomotives	2.8 (4)	3.6 (3)	2.5 (4)
Cement	2.6 (5)	1.3 (9)	5.6 (2)
Woollen and worsted manufactures, including yarn	2.0 (6)	1.5 (8)	0.9 (10)
Earthenware and chinaware	0.9 (7)	2.0 (5)	1.7 (6)
Chemicals, including dyestuffs, medicine, and paint	0.8 (8)	2.0 (4)	2.2 (5)
Iron, steel, and manufactures thereof, excluding machinery	0.7 (9)	1.7 (6)	1.5 (8)
Spirits	0.6 (10)	0.1 (14)	0.4 (12)
Leather and manufactures thereof	0.5 (11)	0.7 (10)	1.3 (9)
Cotton manufactures, including yarn	0.4 (12)	0.3 (12)	0.4 (11)
Copper manufactures	0.2 (13)	0.4 (11)	0.2 (13)
Rubber manufactures	0.1 (14)	0.1 (16)	0.2 (14)
Musical instruments	0.1 (15)	0.1 (13)	0.1 (15)
Beer	0.1 (16)	0.1 (16)	0.0 (17)
Silk manufactures	0.0 (17)	0.1 (15)	0.1 (16)
Clocks and watches	0.0 (18)	0.0 (18)	0.0 (18)

Sources: See text.
Note: Rankings of indicators are noted in parentheses.

Table A.2. RCA indicators for France, 1880-1900

Industry	1880	1890	1900
Spirits	4.8 (1)	5.3 (1)	3.9 (3)
Leather and manufactures thereof	4.4 (2)	4.0 (4)	3.2 (4)
Clocks and watches	3.9 (3)	4.0 (3)	5.1 (2)
Silk manufactures	3.9 (4)	4.7 (2)	6.0 (1)
Woollen and worsted manufactures, including yarn	2.7 (5)	2.6 (5)	2.3 (5)
Paper and manufactures thereof	2.7 (6)	2.3 (7)	1.9 (8)
Musical instruments	2.1 (7)	1.2 (11)	1.5 (10)
Glass	1.7 (8)	2.3 (6)	2.2 (6)
Earthenware and chinaware	1.4 (9)	1.9 (9)	1.8 (9)
Rubber manufactures	1.2 (10)	0.8 (12)	1.0 (12)
Chemicals, including dyestuffs, medicine, and paint	1.2 (11)	1.2 (10)	1.4 (11)
Flax, hemp, and jute manufactures, including yarn and cordage	0.9 (12)	0.6 (16)	1.0 (13)
Machinery, including steam engines and locomotives	0.5 (13)	0.8 (14)	0.5 (18)
Iron, steel, and manufactures thereof, excluding machinery	0.5 (14)	0.8 (13)	0.6 (16)
Cement	0.4 (15)	2.0 (8)	1.9 (7)
Cotton manufactures, including yarn	0.3 (16)	0.5 (17)	0.8 (14)
Copper manufactures	0.3 (17)	0.6 (15)	0.7 (15)
Beer	0.1 (18)	0.3 (18)	0.6 (17)

Sources: See text.
Note: Rankings of indicators are noted in parentheses.

Table A.3. RCA indicators for Germany, 1880-1900

Industry	1880	1890	1900
Musical instruments	4.8 (1)	7.1 (1)	5.0 (1)
Chemicals, including dyestuffs, medicine, and paint	4.3 (2)	4.5 (3)	3.8 (3)
Silk manufactures	4.0 (3)	3.9 (4)	2.7 (7)
Paper and manufactures thereof	3.2 (4)	4.7 (2)	3.9 (2)
Rubber manufactures	3.1 (5)	3.6 (5)	3.1 (5)
Cement	3.1 (6)	2.8 (7)	2.8 (6)
Beer	2.9 (7)	2.4 (9)	2.4 (8)
Earthenware and chinaware	2.8 (8)	2.2 (12)	3.3 (4)
Clocks and watches	2.3 (9)	2.9 (6)	2.2 (10)
Leather and manufactures thereof	2.2 (10)	2.8 (8)	2.0 (11)
Glass	2.0 (11)	2.4 (10)	1.7 (13)
Spirits	2.0 (12)	1.4 (15)	1.0 (17)
Iron, steel, and manufactures thereof, excluding machinery	2.0 (13)	1.9 (13)	2.0 (12)
Woollen and worsted manufactures, including yarn	1.9 (14)	2.3 (11)	2.2 (9)
Machinery, including steam engines and locomotives	1.3 (15)	1.0 (16)	1.6 (14)
Copper manufactures	1.3 (16)	1.4 (14)	1.2 (15)
Cotton manufactures, including yarn	0.7 (17)	0.9 (17)	1.0 (16)
Flax, hemp, and jute manufactures, including yarn and cordage	0.5 (18)	0.6 (18)	0.5 (18)

Sources: See text.
Note: Rankings of indicators are noted in parentheses.

Table A.4. RCA indicators for the United States, 1880-1900

Industry	1880	1890	1900
Clocks and watches	1.3 (1)	1.7 (1)	1.4 (5)
Spirits	0.8 (2)	0.5 (6)	0.6 (10)
Musical instruments	0.6 (3)	0.6 (5)	1.0 (7)
Machinery, including steam engines and locomotives	0.6 (4)	0.8 (3)	1.6 (2)
Leather and manufactures thereof	0.5 (5)	0.8 (2)	1.6 (3)
Iron, steel, and manufactures thereof, excluding machinery	0.2 (6)	0.4 (8)	1.4 (4)
Rubber manufactures	0.2 (7)	0.7 (4)	1.1 (6)
Paper and manufactures thereof	0.2 (8)	0.2 (12)	0.7 (9)
Chemicals, including dyestuffs, medicine, and paint	0.2 (9)	0.4 (9)	0.6 (11)
Glass	0.2 (10)	0.3 (11)	0.4 (14)
Copper manufactures	0.2 (11)	0.5 (7)	3.7 (1)
Cotton manufactures, including yarn	0.2 (12)	0.2 (14)	0.4 (13)
Beer	0.2 (13)	0.4 (10)	0.9 (8)
Flax, hemp, and jute manufactures, including yarn and cordage	0.2 (14)	0.2 (13)	0.4 (12)
Cement	0.1 (15)	0.1 (15)	0.1 (16)
Earthenware and chinaware	0.0 (16)	0.1 (16)	0.1 (15)
Woollen and worsted manufactures, including yarn	0.0 (17)	0.0 (17)	0.0 (17)
Silk manufactures	0.0 (18)	0.0 (18)	0.0 (18)

Sources: See text.
Note: Rankings of indicators are noted in parentheses.

Appendix B. Industry components of factor intensities

Capital, labour, and material inputs (1907)

The data for calculating the factor intensities (or proxies therefor) of capital, labour, and material inputs are obtained from the *First Census of Production* of 1907. The 18 industries in this article correspond to the following industries and sub-industries in the census:

Beer: Brewing and malting trades

Cement: Cement trade

Chemicals, including dyestuffs, medicine, and paint: Chemicals, coal tar products, drugs, and perfumery trade; Paint, colour, and varnish trades

Clocks and watches: Watch and clock trades

Copper manufactures: Copper and brass trades (smelting, rolling, and casting)

Cotton manufactures, including yarn: Cotton trade; 60.7% of Bleaching, dyeing, printing, and finishing trades

Earthenware and chinaware: China and earthenware trades

Flax, hemp, and jute manufactures, including yarn and cordage: Jute, hemp, and linen trades; 11.2% of Bleaching, dyeing, printing, and finishing trades; Rope, twine, and net trades

Glass: Glass, stone, roofing, felts, and miscellaneous trades

Iron, steel, and manufactures thereof, excluding machinery: Iron and steel, engineering, and shipbuilding trades (all sub-industries thereof), excluding Engineering trades (including electrical engineering), excluding Shipbuilding and marine engineering trades, and excluding Small arms trades

Leather and manufactures thereof: Boot and shoe trades; Glove trade; Leather trade (tanning and dressing); Saddlery and harness trade; Traveling bag and fancy leather goods trade

Machinery, including steam engines and locomotives: Engineering trades (including electrical engineering)

Musical instruments: Musical instruments trades

Paper and manufactures thereof: Paper trade; Cardboard box trade

Rubber and manufactures thereof: Indiarubber trades

Silk manufactures: Silk trades; 1.8% of Bleaching, dyeing, printing, and finishing trades

Spirits: Spirit distilling trade; Spirit compounding, rectifying, and methylating trades

Woollen and worsted manufactures, including yarn: Woollen and worsted trades; 26.4% of Bleaching, dyeing, printing, and finishing trades

Human capital (1906)

The data for calculating the proxy for human capital intensity are obtained from the reports of the *Hours and Earnings Enquiry* of 1906. The 18 industries in this article correspond to the industries and sub-industries listed here. Following each of the 18 industries, the average weekly wage of an adult male working full time, *without* the deduction of the unskilled manufacturing wage (£1.01), is noted in parentheses. The average industry wage reported in parentheses is an employment-share-weighted average of the average wages in the constituent industries and sub-industries. The weights attached to each of the constituent industries and sub-industries are noted in parentheses, as well.

Beer (£1.31): Malting and brewing (1.000)

Cement (£1.42): Lime and cement works (1.000)

Chemicals, including dyestuffs, medicine, and paint (£1.41): Chemical manufacture (0.595); Other chemical industries (0.405)

Clocks and watches (£1.63): Watch and clock making and repairing (1.000)

Copper manufactures (£1.58): Manufacture of brass and allied metal wares (0.389); Smelting, rolling, &c. of metals other than iron (0.611)

Cotton manufactures, including yarn (£1.45): Cotton (0.731); 60.7% of Bleaching, printing, dying, and finishing textile fabrics (0.269)

Earthenware and chinaware (£1.62): Porcelain, china and earthenware manufacture (1.000)

Flax, hemp, and jute manufactures, including yarn and cordage (£1.19): Linen (0.584); 11.2% of Bleaching, printing, dying, and finishing textile fabrics (0.081); Jute (0.229); Hemp (0.106)

Glass (£1.80): Glass bottle manufacture (0.653); Other glass industries (0.347)

Iron, steel, and manufactures thereof, excluding machinery (£1.81): Pig iron manufacture (blast furnaces) (0.128); Iron and steel manufacture (0.463); Tinplate manufacture (0.070); Manufacture of light iron castings, stoves, grates, &c. (0.088); Wire drawing and working (0.054); Manufacture of edge tools, spades, files, &c. (0.023); Cycle making and repairing (0.047); Tube manufacture (0.056); Nails, screws, nuts, &c. manufacture (0.018); Bedstead manufacture (0.014); Farriery and General Smiths' Work (0.014); Needle, fish-hooks, and fishing-tackle manufacture (0.005); Chain, anchor, &c. manufacture (0.010); Lock, latch, key, &c. manufacture (0.005); Typefounding (0.006)

Leather and manufactures thereof (£1.38): Leather tanning and dressing, fellmongering, &c. (0.331); Saddlery, harness, and whip manufacture (0.041); Portmanteau, bag, purse, and miscellaneous leather manufacture (0.040); Boot and shoe (ready made) (0.564); Leather glove (0.025)

Machinery, including steam engines and locomotives (£1.62): Engineering and boilermaking (1.000)

Musical instruments (£1.86): Musical instrument manufacture (1.000)

Paper and manufactures thereof (£1.51): Paper manufacture (0.505); Paper stationery manufacture (0.325); Cardboard, canvas, &c. box manufacture (0.054); Wallpaper, &c. manufacture (0.116)

Rubber and manufactures thereof : Indiarubber, gutta percha, &c. industry (1.000)

Silk manufactures (£1.31): Silk (0.747); 1.8% of Bleaching, printing, dying, and finishing textile fabrics (0.253)

Spirits (£1.15): Spirit distilling (1.000)

Woollen and worsted manufactures, including yarn (£1.35): Woollen and worsted (0.762); 26.4% of Bleaching, printing, dying, and finishing textile fabrics (0.238)

<u>Capital-labour ratio (1870)</u>

The data for calculating the proxy for the capital-labour ratio are obtained from Musson (1976, pp. 437-9), which compiled the data from the *Factory Inspectorate Returns* of 1870. It should be observed that there are no data for the cement industry. The 17 remaining industries in this article correspond to the following industries and sub-industries reported in Musson:

Beer: Breweries

Chemicals, including dyestuffs, medicine, and paint: Miscellaneous chemical works

Clocks and watches: Clocks and watches

Copper manufactures: Copper-mills

Cotton manufactures, including yarn: Cotton factories

Earthenware and chinaware: Potteries; Other earthenware

Flax, hemp, and jute manufactures, including yarn and cordage: Flax factories; Hemp factories; Jute factories; Ropemaking

Glass: Glass-making

Iron, steel, and manufactures thereof, excluding machinery: Blast furnaces and iron-mills; Foundries; Type- and stereotype-founding; Nails and rivets; Cutlery; Files, saws, and tools; Locks

Leather and manufactures thereof: Leather manufactures (all sub-industries thereof); Boot- and shoe-making; Manufacture of gloves

Machinery, including steam engines and locomotives: Manufacture of machinery

Musical instruments: Musical instruments

Paper and manufactures thereof: Paper manufactures (all sub-industries thereof)

Rubber and manufactures thereof: India-rubber and gutta percha

Silk manufactures: Silk factories

Spirits: Distilleries

Woollen and worsted manufactures, including yarn: Woollen factories; Worsted factories

Appendix C. Robustness checks

Table C.1. Robustness checks

	(1)	(2)	(3)	(4)	(5)
Capital intensity	0.16*** (0.06)				
Labour intensity		-0.20*** (0.07)			
Material intensity			0.38** (0.17)		
Material intensity, exc. coal and coke				0.20 (0.14)	
Human capital intensity					-0.13 (0.10)
Constant	-1.05** (0.46)	1.89*** (0.59)	0.44*** (0.13)	0.35*** (0.12)	0.11 (0.12)
Decade fixed effects	YES	YES	YES	YES	YES
R^2	0.15	0.15	0.10	0.05	0.04
Observations	54	54	54	54	54
Years	1880-1900	1880-1900	1880-1900	1880-1900	1880-1900

Sources: See text and Appendix B.
Notes: The dependent variable is the RSCA indicator. All explanatory variables are expressed in natural logarithms. Standard errors are noted in parentheses. ** indicates statistical significance at the 5% level, and *** at the 1% level.