The manufacturing trade of late-Victorian Britain: factor proportion and new trade theoretical explanations*

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Abstract

This paper constructs indicators of revealed comparative advantage for British manufacturing industries for the years 1880, 1890, and 1900. In contrast with previous research, this paper finds that the manufacturing comparative advantages of late-Victorian Britain rested in the relatively labour non-intensive industries, and this finding remains robust even after controlling for human capital intensity. Furthermore, the manufacturing comparative advantages were neutral with respect to material intensity. The share of inter-industry (Heckscher-Ohlin) trade in Britain's total manufacturing trade declined steadily throughout the period, though still accounted for the majority of manufacturing trade in the 1890s.

Keywords: Britain, nineteenth century, manufacturing, comparative advantage, Heckscher-Ohlin, new trade theory

JEL codes: F11, F12, N63, N73

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Introduction

Economic historians have generally settled for the casual understanding that, according to Harley (2014), 'the industries of the Industrial Revolution retained their comparative advantage until the First World War'.[1] Indeed, the staple industries of textiles and iron continued to dominate the composition of British exports through the late-Victorian era.[2] However, it remains uncertain 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 paper contributes to the existing literature by calculating indicators of revealed comparative advantage (RCA) and revealed symmetric comparative advantage (RSCA) for 17 British manufacturing industries for the years 1880, 1890, and, 1900.

These indicators are then extended into the debate over the factor determinants of Britain's manufacturing comparative advantages. Here, the novel finding is that Britain's comparative advantages were in the relatively labour non-intensive manufacturing industries during the late-Victorian era. This finding is inconsistent with that of Crafts and Thomas (1986), who estimated the factor determinants of just (non-normalized) British exports for the year 1880.[3] Even after controlling for human capital, it remains that the comparative advantages of late-Victorian Britain were in the relatively labour non-intensive manufacturing industries.

Broadberry (1997) attributed the comparative *labour productivity* levels of late nineteenth-century British manufacturing industries partly to relative factor endowments. One of the several patterns that emerged was that Britain tended to realize its highest comparative labour productivity levels (vis-à-vis the United States and Germany) in those manufacturing industries that used intensively Britain's relatively abundant supply of human capital.[4] Drawing upon a spectacular range of secondary sources, Broadberry explained the relative performance of various manufacturing industries during the period from 1850-1914. These analyses were, nevertheless, constrained by the unavailability of estimates of comparative

[1] Harley, 'Early start', p. 6.

[2] The staple industries of textiles and iron accounted for fully 66% of British manufactured exports in 1902-4. Schlote, *British overseas trade,* p. 74.

[3] Crafts and Thomas, 'UK manufacturing trade', p. 637.

[4] Broadberry, *Productivity race*, p. 158.

manufacturing labour productivity disaggregated by industry for any year prior to 1907.[5] The unavailability of estimates was due to a deficiency of output data. Here, there emerges an opportunity for this paper. The trade statistics of industrial countries contain data sufficient for calculating RCA indicators of British manufacturing industries for the period before 1907. Of course, comparative advantage is not the same as comparative labour productivity, and this paper avoids any conflation of these concepts. Still, measurements of comparative advantage can provide some indication of the relative performance of British manufacturing industries during the late-Victorian era.

The factor proportions, or Heckscher Ohlin (H-O), model has been favoured by economic historians seeking to explain the pattern of nineteenth-century trade.[6] However, the H-O model does not account for the phenomenon of intra-industry trade, which occurs when a country imports and exports commodities within the same industry. A collection of models known as new trade theory (NTT) offers several explanations of intra-industry trade. There are hardly any applications of NTT to the nineteenth century, Brown (1995) being a rare example that evaluated British and German intra-industry trade in cotton textiles. With respect to NTT, this present paper finds that Britain's manufacturing intra-industry trade was increasing throughout the late-Victorian era. Yet, the majority of the manufacturing trade of late-Victorian Britain remained Heckscher-Ohlinian, i.e. factor-determined, into the 1890s. As might be expected, there was considerable variation among Britain's manufacturing industries, both with respect to the levels and trends in intra-industry trade, and this variation is discussed.

The paper proceeds as follows. The first section presents a review of the literature. In the next section, RCA and RSCA indicators are calculated for Britain's manufacturing industries. The following section identifies the factor determinants of Britain's manufacturing comparative advantages, initially using a three-factor H-O model, and subsequently using a four-factor H-O model that controls for human capital. The following section examines the levels and trends in the intra-industry trade of Britain's manufacturing industries. This analysis is further illuminated, in the next section, by means of a vignette of the British linen yarn industry. The last section offers some concluding remarks.

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[5] For the construction of these estimates, see Broadberry and Fremdling, 'British and German industry'; Broadberry, 'British and American manufacturing'.

[6] For a noteworthy example, see O'Rourke and Williamson, 'Factor-price convergence'.

Literature review

Factor proportions

Under the H-O model of trade, a country exports those commodities which use intensively its relatively abundant factors of production.[7] Thus, relative factor endowments determine the comparative advantages of a country.[8] This model was used by Crafts and Thomas (1986), who 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. The authors employed a three-factor H-O model, with the factors being capital, human capital, and (unskilled) labour. Throughout the period from 1910-35, Britain realized comparative advantages in the relatively human capital non-intensive and in the relatively labour-intensive manufacturing industries, and these comparative advantages were unaffected by capital intensity.[9] The authors then applied the model to late-Victorian Britain, albeit using 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.[10]

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 inferred from 1870 data. The problem 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 British cement exports, yet Britain realized a comparative disadvantage in the former industry and a comparative advantage in the latter industry.[11] This paper improves upon Crafts and Thomas by normalizing British exports for the composition of world exports, i.e. by calculating indicators of comparative advantage.

[7] Ohlin, *International trade*.

[8] The H-O model departs from the earlier Ricardian model, which identifies technological differences between countries as the determinant of comparative advantage. Nevertheless, both models offer explanations for the occurrence of comparative advantages.

[9] Crafts and Thomas, 'UK manufacturing trade', p. 636.

[10] Ibid., p. 637.

[11] *Trade of the United Kingdom* (1900). The RCA indicators for these industries are reported in table 1.

Crafts (1989) did, in fact, calculate RCA indicators for British manufacturing industries, along with the manufacturing industries of 10 other mostly industrial countries, for the years 1899, 1913, 1929, 1937, and 1950. In doing so, he employed the method advanced by Balassa (1965), which is discussed fully in the next section of this paper. For the year 1899, Crafts 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.[12] However, no factor-based explanation for the pattern of Britain's manufacturing comparative advantages was offered.

Crafts and Thomas's portrait of manufacturing in late-Victorian Britain as intensive in labour and non-intensive 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.[13] The work of Harley is not, however, entirely comparable to the work of Crafts and Thomas. Whereas Crafts and Thomas were concerned with the pattern of specialization among industries, Harley was concerned with intra-industry differences between British and American manufacturing, specifically within the industries of shipbuilding, textiles, engineering, and iron and steel.

New trade theory

The phenomenon of intra-industry trade is explained by NTT, which comprises several models. Here, the discussion of NTT is limited to the essential elements of two NTT models: the Chamberlinian-Heckscher-Ohlin (C-H-O) model, put forward by Helpman and Krugman (1985), and the neo-H-O model, put forward by Falvey (1981). Before proceeding to a discussion of these models, it is first necessary to differentiate between two sorts of intra-industry trade: horizontal (HIIT) and vertical (VIIT). HIIT involves commodities differentiated according to attribute, such as colour. VIIT involves commodities differentiated according to quality, such as durability.

The C-H-O model is consistent with the H-O model; inter-industry (net) trade still occurs between countries of differing relative factor endowments.[14] Additionally, however,

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[12] Crafts, 'Revealed comparative advantage', p. 130.
[13] Harley, 'Edwardian industry', pp. 394-5.
[14] Helpman and Krugman, *Market structure,* p. 142.

intra-industry trade of horizontally differentiated commodities occurs between countries of similar relative factor endowments. According to the model, a firm realizing increasing returns to scale and operating under monopolistic conditions satisfies world demand for one variety of a horizontally differentiated commodity.[15] HIIT ensues, since firms producing the different attribute-varieties of the commodity are located in different, but similarly endowed, countries.

Like the C-H-O model, the neo-H-O model is also consistent with the H-O model, with inter-industry trade occurring as the result of differing relative factor endowments between countries. Even still, two countries with broadly similar factor endowments may exhibit moderate differences with respect to their relative endowments of a particular immobile factor, such as capital. If the quality of a commodity varies according to the capital intensity of its production, then VIIT occurs between countries.[16] Hence, large differences in relative factor endowments lead to increased inter-industry trade, while small differences in the relative endowments of the quality-determining factor lead to increased VIIT. Cabral et al. (2013) lent empirical support to these relationships using data on the trade of EU member states with foreign countries. They found that the between-country difference in capital per worker was a statistically significant and positive determinant of VIIT between EU member states and other high-income countries, but that the difference was a statistically significant and negative determinant of VIIT between EU member states and middle-income and developing countries.[17]

Brown (1995) undertook one of the only applications of NTT to the nineteenth century. He found that the share of intra-industry trade in the total cotton textile trades of Britain and Germany nearly tripled between 1883 and 1913.[18] In explaining this growth in intra-industry trade, Brown describes, for example, how Britain imported from Germany cotton textiles in colours that were unavailable domestically.[19] Still, it remains uncertain whether the rising intra-industry trade in cotton textiles conformed more to the C-H-O or neo-H-O model.

[15] Ibid., pp. 131-58.

[16] Falvey, 'Commercial policy', pp. 497-503.

[17] Cabral et al., 'Endowment differences', pp. 409-11.

[18] Brown, 'Cotton textiles', pp. 509-10. The share of intra-industry trade in the total cotton textile trades of Britain and Germany with other current OECD countries more than tripled.

[19] Ibid., p. 503.

Measuring comparative advantage

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 then argued that the pattern of world trade 'revealed' the comparative advantages of countries.[20]

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

$$\mathrm{RCA}_{\mathrm{c,i}} = \frac{\mathrm{X}_{\mathrm{c,i}}}{\mathrm{X}_{\mathrm{n,i}}} \Big/ \frac{\mathrm{X}_{\mathrm{c}}}{\mathrm{X}_{\mathrm{n}}} \qquad (1)$$

Here, *X* refers to the current value of exports, *i* to the manufactured commodity, *c* to the industrial country, and *n* to the whole basket of industrial countries. The RCA indicator is therefore the country-share of world exports of the manufactured commodity normalized for the country-share of world exports of total manufactured commodities. An indicator greater than 1 implies a comparative advantage, an indicator less than 1 a comparative disadvantage. Specialization according to comparative advantage would, theoretically, cause a country's RCA indicators to cluster around X_n/X_c ('complete' comparative advantage) and 0 ('complete' comparative disadvantage).[21] However, empirically, indicators fall anywhere between these two values, oftentimes quite close to the threshold value. 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 is done by Crafts and by the present author. Another reason is that transport costs and preferential tariffs, which distort the pattern of trade, are internalized in the RCA indicator.

This last reason was addressed by Costinot et al. (2012), who sought to correct for such distortions in identifying comparative advantage. The main specification of their model takes the form of a country-pair panel regression, in which the log of pairwise relative

[20] Balassa, 'Trade liberalisation', p. 103.

[21] In the case of complete comparative advantage, the indicator of RCA may be less than X_n/X_c, if country *c* completely satisfies world demand.

productivity in an industry predicts the log of bilateral exports in that industry.[22] An exporter-importer fixed effect accounts for trade costs, such as transport costs and preferential tariffs, among others.[23] The approach undertaken by Costinot et al. could be employed to identify Britain's comparative advantages, vis-à-vis each of her trading partners, for the late nineteenth century, provided bilateral trade data disaggregated by industry actually existed for the years 1880, 1890, and 1900, which is not the case. Furthermore, employing the approach of Costinot et al. would involve the precarious assumption that the elasticity of bilateral exports to pairwise relative productivity was the same in the late nineteenth century as in the late twentieth century.

This paper therefore settles on Balassa's method for identifying comparative advantages. RCA indicators are calculated for 17 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; paper and manufactures thereof; rubber manufactures; silk manufactures; spirits; and woollen and worsted manufactures. These 17 industries differ noticeably from the 16 industries for which Crafts (1989) calculated RCA indicators. Crafts' industries were largely predetermined in the sense that he relied solely on Tyszynski (1951), rather than on the underlying government trade statistics, for data on manufactured exports. Crafts' industries are suitable for the period he considered, which was the early twentieth century. However, several of these industries are obviously unsuitable for the late nineteenth century, such as the electrical industry and the cars and aircraft industry. The textile industry also presents a problem. In 1899, textiles comprised 34 per cent of world manufactured exports and 46 per cent of British manufactured exports.[24] Earlier in the nineteenth century, the share of textiles in British manufactured exports was even higher, at 61 per cent in 1882-4.[25] 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, textiles are divided into four classes: cotton manufactures;

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[22] Costinot et al., 'Ricardo's ideas', p. 595.
[23] Ibid., p. 602.
[24] Tyszynski, 'Manufactured commodities', p. 277.
[25] Schlote, *British overseas trade*, p. 74.

flax, hemp, and jute manufactures; silk manufactures; and woollen and worsted manufactures. In general, the 17 industries included in this study mirror the industry classifications in the *Trade of the United Kingdom*, which is the source for data on the value of British manufactured exports.

It might be argued that these 17 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 per cent of the *manufactured* exports of Britain and slightly more than 1 per cent of the *manufactured* exports of Germany, a leader in the Second Industrial Revolution.[26] On the whole, the 17 industries offer generally adequate coverage of world manufactured exports in 1900, even despite the emergence of some commodities that were inexistent in earlier decades.

Having obtained data on British manufactured exports per industry, the next step in calculating the 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 trade statistics.[27] This step is immensely challenging due to the varying classifications of industries in the trade statistics of the different countries. Using British and American trade statistics, Crafts and Thomas (1986) matched British and American industries, in order to compare the factor determinants of British and American exports for a single benchmark year. They referred to this process as a 'problematic and protracted exercise'.[28] When the trade statistics of five countries are involved, the process of matching industries is considerably more problematic and protracted. For example, the British trade statistics keep leather and manufactures thereof separate from saddlery and harnesses, whereas the trade statistics of other countries do not. Such inconsistencies are, however, generally reconcilable, since the finest levels of disaggregation in the trade statistics usually permit the 'reconstruction' of industries. Where inconsistencies are ultimately irreconcilable, such

[26] Calculated from Tyszynski, 'Manufactured commodities', p. 277. By 1913, the shares of these industries in manufactured exports of Britain and Germany had increased to 4% and 7%, respectively.

[27] The American data are for the years 1879/80, 1889/90, and 1899/1900, the fiscal year having spanned from 1 July to 30 June.

[28] Crafts and Thomas, 'UK manufacturing trade', p. 632.

inconsistencies 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, these values are converted to sterling using the exchange rates reported in Mitchell (1988).[29]

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 per cent of the manufactured exports of the 11 countries considered by Tyszynski.[30] A coverage rate of 87 per cent would suggest a rescaling factor (γ) of 1.15 for the value of manufactured exports, per industry, of the five industrial countries ($X_{n,i}$). Balassa's original method, represented in Equation 1, is therefore modified to include a rescaling factor:

$$RCA_{UK,i} = \frac{X_{UK,i}}{\gamma X_{n,i}} \Big/ \frac{X_{UK}}{X_n} \qquad (2)$$

However, a constant rescaling factor for all industries wrongly implies that the industry-composition of manufactured exports was identical between the basket of five industrial countries and the basket of excluded countries. The excluded countries were in an earlier stage of industrialization, which was often characterized by light manufacturing, particularly textiles.[31] Consequently, the five industrial countries likely accounted for more than 87 per cent of the exports of heavy manufacturing industries and less than 87 per cent of the exports of light manufacturing industries. A slightly reduced rescaling factor of 1.1 is applied to the heavy manufacturing industries of cement; chemicals; copper manufactures; iron, steel, and manufactures thereof; and paper and manufactures thereof. A slightly more generous rescaling factor of 1.2 is applied to the remaining industries. Although the rescaling factors of 1.1 and 1.2 are based upon data from 1899, these rescaling factors are applied to the calculations for 1880, 1890, and 1900, since annual data on world manufactured exports pre-1899 is not available.

The next step is to normalize the British share of world manufactured exports per industry ($X_{UK,i}/\gamma X_{n,i}$) by, according to Balassa's method, the British share of world manufactured exports in total (X_{UK}/X_n). Normalizing by the country-share of only secondary-sector world exports provoked criticism from Vollrath (1991), who argued for the inclusion

[29] Mitchell, *Historical statistics*, p. 702. Because the Belgian franc traded at par with the French franc during the classical gold standard, Belgian francs are converted to sterling using the (French) franc-sterling exchange rate.

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

[31] See Hoffman, *Industrial economies*; Maizels, *Industrial growth*, pp. 339-40.

of the primary sector in determining comparative advantage.[32] Because the British share of secondary-sector world exports exceeded the British share of total world exports, the exclusion of the primary sector from the normalization factor reduces the levels of the RCA indicators for British manufacturing industries.[33] Balassa's procedure for normalization, which was employed by Crafts, risks misidentifying a comparative advantage as a comparative disadvantage. Because the objective of this study is not to identify Britain's *intra-sector* industrial comparative advantages, but rather her *multi-sector* industrial comparative advantages, the normalization factor includes both the primary and secondary sectors. Of course, 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 total world exports for these years come from Lewis (1981).[34]

Table 1 presents the resulting RCA indicators for British manufacturing industries, with their ranks indicated in parentheses. Given the data assembled, calculating indicators of RCA for the manufacturing industries of the other four industrial countries is simple. Since these indicators might be of interest to future economic historians, corresponding tables for Belgium, France, Germany, and the United States are supplied in Appendix A.

As evident from the table, the RCA indicators for textiles differed greatly depending upon the particular class. By 1890, the industry of cotton manufactures held pride of place, not just among textiles, but among all British manufacturing industries. The industry of silk manufactures, on the other hand, was the only textile industry for which Britain realized a consistent comparative disadvantage. Other industries in which the 'workshop of the world' had a consistent comparative disadvantage were clocks and watches; glass; and leather and manufactures thereof. Of the 17 industries, the sharpest movements were in copper manufactures (downward) and spirits (upward).[35] Britain also advanced its comparative

[32] Vollrath, 'Theoretical evaluation', p. 269.

[33] In contrast, the American share of secondary-sector world exports (11%) was less than the American share of total world exports (14%) 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. *Foreign commerce* (1900).

[34] Lewis, 'World trade', pp. 54-7.

[35] For some of the reasons behind these movements, consult Broadberry, *Productivity race*, pp. 174-5, 196-7.

Table 1. *Britain, RCA indicators, 1880-1900*

Industry	1880	1890	1900
Beer	3.2 (5)	3.3 (3)	2.9 (3)
Cement	2.7 (7)	2.4 (8)	1.2 (12)
Chemicals, including dyestuffs, medicine, and paint	1.6 (11)	1.5 (11)	1.2 (11)
Clocks and watches	0.5 (15)	0.4 (17)	0.2 (17)
Copper manufactures	4.3 (1)	3.9 (2)	1.5 (10)
Cotton manufactures, including yarn	4.3 (2)	4.1 (1)	4.1 (1)
Earthenware and chinaware	2.4 (8)	2.4 (7)	1.8 (9)
Flax, hemp, and jute manufactures, including yarn and cordage	3.2 (4)	3.2 (5)	3.1 (2)
Glass	0.9 (13)	0.9 (14)	0.7 (15)
Iron, steel, and manufactures thereof, excluding machinery	3.6 (3)	3.3 (4)	2.6 (4)
Leather and manufactures thereof	0.8 (14)	0.9 (15)	0.9 (13)
Machinery, including steam engines and locomotives	3.0 (6)	2.8 (6)	2.2 (7)
Paper and manufactures thereof	1.0 (12)	1.0 (13)	0.8 (14)
Rubber manufactures	2.3 (9)	2.3 (9)	1.9 (8)
Silk manufactures	0.5 (16)	0.5 (16)	0.5 (16)
Spirits	0.5 (17)	1.2 (12)	2.3 (6)
Woollen and worsted manufactures, including yarn	1.9 (10)	2.1 (10)	2.5 (5)

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

advantage in woollen and worsted manufactures considerably, even in spite of the heavy protection that this industry received in other industrial countries.[36]

There is a well-defined scholarly debate over the international competitiveness of the British engineering (machinery) industry in the late 1890s, when the American engineering industry greatly increased its exports, especially its exports to Britain.[37] 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 domestic supply.[38] Irwin (2003), however, attributed the phenomenon to the increasing international competitiveness of American machinery, driven by the declining price of American iron ore.[39] Although the RCA indicator for the British machinery industry was slightly eroded between 1890 and 1900, the indicator for 1900 hardly suggests a loss of comparative advantage. Though, in fairness, 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 correlation coefficients are calculated for various intervals, following the approach undertaken by Crafts. Table 2 presents coefficients for the intervals covered in this paper, 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 reshuffling of Britain's comparative advantages in the

[36] See especially Saul, *British overseas trade*, p. 151. While Britain's comparative advantage in woollen and worsted manufactures would not be affected by foreign protection *per se*, if such protection enabled foreign manufactures to become internationally competitive, as per the infant industry argument, then Britain's comparative advantage would be affected.

[37] Though, Clapham 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' in *Modern Britain*, p. 36.

[38] Nicholas, 'Export invasion', p. 581.

[39] Irwin, 'America's surge', p. 369. In turn, Irwin attributed the declining price of American iron ore to the opening of the Mesabi Range in 1892.

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

	1890	1899/1900	1913	1929	1937
1880	0.95	0.66	--	--	--
1890	--	0.80	--	--	--
1899/1900	0.80	--	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 spanning the years 1880, 1890, and 1900 are calculated using data from this article. Coefficients for intervals spanning the years 1899, 1913, 1929, 1937, and 1950 are calculated using data from Crafts, 'Revealed comparative advantage', p. 130.

1890s may have been influenced by Continental infant industries having attained international competitiveness.

Before proceeding to the next section, it is necessary to recognize a certain fundamental feature of the RCA indicators. With Balassa's measurement, the range for comparative disadvantage is between 0 and 1, while the range for comparative advantage is between 1 and the reciprocal of the country-share of world exports, which would be 6.8 for Britain in 1900. Such asymmetry is benign when the objective is to ascertain whether or not a country had a comparative advantage, or when the objective is to rank the RCA indicators. However, as Laursen observed, this asymmetry would tend to violate the assumption in regression analysis of normally distributed error terms, and it must therefore be corrected.[40] Laursen proposed the following transformation to symmetrize the indicators:

$$\text{RSCA} = \frac{\text{RCA}-1}{\text{RCA}+1} \tag{3}$$

The next section relies on Laursen's RSCA indicators, not Balassa's RCA indicators, when estimating the factor determinants of Britain's comparative advantages.

Factor determinants

Three-factor model

This section begins with a three-factor H-O model of Britain's comparative advantages, with the factors being capital, labour, and material inputs. Factor intensities or proxies thereof for the 17 British manufacturing industries are calculated from the *Census of production* of 1907, which collected a limited amount of data on British manufacturing activity for the year

[40] Laursen, 'International specialization', p. 105.

1906/7. Conveniently, the data is disaggregated at the industry and sub-industry level, thereby permitting the 'reconstruction' of industries so that they are consistent with the industries in the previous section of this paper. 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.[41]

Capital intensity is proxied by horsepower per £1 million of gross output. Labour intensity is proxied by employees per £1 million of gross output. Both of these proxies resemble the ones employed by Crafts and Thomas (1986) when they estimated the factor determinants of British exports for 1880, although their source of data was the cruder *Factory inspectorate returns* of 1870, as compiled by Musson (1976).[42] Because the *Census of production* reported the value of material inputs, material intensity is measured directly as the share of material inputs in gross output. Factor intensities per industry are reported in Table 3. It should be observed that the coefficient of variation differs considerably depending upon the factor intensity, with capital intensity per industry being the most disperse of the factors.

Imposing Edwardian factor proportions on late-Victorian manufacturing industries is, recognizably, far from ideal. This approach is mostly necessitated by the availability of systematically collected data across a range of industries. Britain was a relative latecomer among industrial countries in collecting data on manufacturing output, and the *Census of production* of 1907 was the first such exercise.[43] The error of backdating the factor portions is perhaps not so grave in the context of 'mature' industrial Britain. Matthews et al. (1982) have pointed to the similar growth rates of capital and output in the British manufacturing sector during the 1880s and 1890s, suggesting more or less constant capital intensity, though labour intensity likely declined during these decades.[44] Of course, the factor proportions of individual industries may have changed to a much greater extent than suggested by the manufacturing sector as a whole. Nevertheless, without dismissing the possibility of such changes, the foregoing analysis relies on the data from the *Census of production*, which represents the best available source for the given purpose.

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[41] In 1906/7, the output of this sub-industry was £17.9 million, or about 6% of the entire textile industry. *Census of production*.

[42] See Musson, 'Motive power', pp. 437-9.

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

[44] Matthews et al., *British economic growth*, pp. 377-82.

Table 3. *Factor intensities of British industries, 1906/7*

Industry	Capital intensity (horsepower per £1mn output)	Labour intensity (employees per £1mn output)	Material intensity (share of material inputs in output)
Beer	961	1,263	0.38
Cement	16,085	3,968	0.48
Chemicals, including dyestuffs, medicine, and paint	3,845	2,028	0.62
Clocks and watches	897	8,648	0.38
Copper manufactures	2,537	1,241	0.83
Cotton manufactures, including yarn	7,407	3,397	0.72
Earthenware and chinaware	10,360	8,659	0.36
Flax, hemp, and jute manufactures, including yarn and cordage	5,300	4,846	0.68
Glass	4,293	6,489	0.38
Iron, steel, and manufactures thereof, excluding machinery	8,688	3,863	0.63
Leather and manufactures thereof	992	3,994	0.68
Machinery, including steam engines and locomotives	3,218	4,485	0.47
Paper and manufactures thereof	11,080	3,957	0.64
Rubber manufactures	3,080	2,699	0.67
Silk manufactures	3,760	6,376	0.62
Spirits	1,768	865	0.79
Woollen and worsted manufactures, including yarn	4,472	3,607	0.71
Median	3,845	3,957	0.63
Coefficient of variation	0.81	0.56	0.26

Source: Calculated from *Census of production* of 1907.

Table 4. *Three-factor H-O model of RSCA indicators, 1880-1900*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Capital intensity (1906/7)	0.20*** (0.05)	0.20*** (0.05)		0.19*** (0.05)	0.20* (0.10)	0.20** (0.08)	0.17* (0.08)
Labour intensity (1906/7)	-0.28*** (0.08)	-0.35*** (0.09)		-0.25*** (0.06)	-0.17 (0.13)	-0.28** (0.11)	-0.31** (0.11)
Material intensity (1906/7)	-0.11 (0.17)	-0.32 (0.20)					
Textile		0.20* (0.11)					
Capital/labour ratio (1870)			0.18*** (0.03)				
Constant	0.80 (0.57)	1.22** (0.60)	0.45*** (0.05)	0.71 (0.55)	0.01 (1.13)	0.84 (0.92)	1.29 (0.96)
R^2	0.33	0.38	0.44	0.33	0.24	0.41	0.40
Observations	51	51	48	51	17	17	17
Years	all years	all years	all years	all years	1880	1890	1900

Sources: See text.
Notes: * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level. Standard errors are noted in parentheses. All variables, except for the dependent variable and the textile dummy, are expressed in natural logarithms. Col. 3 omits the cement industry, as it did not appear in the *Factory inspectorate returns* of 1870.

Table 4 presents the results of a semi-log OLS regression that estimates the determinants of Britain's comparative advantages. The dependent variable, the RSCA indicator, is expressed in levels. All of the continuous explanatory variables are expressed in natural logarithms. Columns 1-4 pool the data for all three benchmark years. Column 1 clearly indicates that Britain's comparative advantages were in the relatively capital-intensive manufacturing industries and, inconsistent with Crafts and Thomas, in the relatively labour non-intensive manufacturing industries. The coefficients imply that a doubling of the capital intensity in an industry would increase its RSCA indicator by 0.20 and that a doubling of the labour intensity of an industry would decrease its RSCA indicator by 0.28. Based upon these coefficients, Britain would have realized a comparative advantage in the glass industry in 1880, for example, if its capital intensity was at least 40 per cent higher or if its labour intensity was at least 29 per cent lower.

That the coefficient of material intensity is not statistically significant may seem surprising, given Britain's limited natural resource endowments. There are three potential explanations for this finding. First, Victorian Britain espoused 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 close to 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.[45] 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 considerable duty on this imported material input. Following the passage of the McKinley Tariff of 1890, the *ad valorem* equivalent tariff on wool exceeded 40 per cent.[46] The divergent trade policies of Britain and the United States may account, at least in part, for why the RCA indicator of 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, which represents another potential explanation for the material neutrality of Britain's manufacturing comparative advantages. 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.[47] Following a different empirical strategy, Jacks et al. (2010) estimated that membership in the British Empire reduced intra-Empire bilateral trade costs by half.[48] Indeed, recourse to a resource-rich empire mitigated the effects of Britain's relatively unfavourable natural resource endowments on its manufacturing sector.

A third 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. Surely, the factor proportion of this material input varied greatly across industries. In the British iron and steel industry, it can be estimated that the factor proportion of this material input was on the order of 11 per cent in 1887.[49] While the factor proportion of coal would have been lower in most other industries, it was hardly negligible.[50]

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[45] Deane and Cole, *British economic growth*, p. 196.

[46] *Foreign commerce* (1892).

[47] Mitchener and Weidenmier, 'Trade and empire', pp. 1813-4.

[48] Jacks et al., 'Trade costs', p. 135.

[49] The British iron and steel industry consumed an estimated 27 million tonnes of coal in 1887 (Mitchell, *British coal industry*, p. 12). In that year, the export price of coal was £0.41 per tonne, as calculated from *Trade of the United Kingdom* (1887). The estimated average annual gross output at current value of the British iron and steel industry was £103 million during the interval from 1885-9

Returning now to Table 4, column 2 includes a dummy variable for the four textile industries, in order to test whether factor endowments adequately explain Britain's notoriously persistent comparative advantages in these industries of the (first) Industrial Revolution, the silk industry notwithstanding. The coefficient of this dummy variable is expectedly positive, and it is statistically significant at the 10 per cent level, suggesting some element of hysteresis in the textile industries.

As already mentioned, the regression imposes Edwardian factor proportions on late-Victorian comparative advantages. Given this inter-temporal mismatch, it would be advisable to perform a robustness check using the earlier, more rudimentary data from the *Factory inspectorate returns* of 1870. As was done for the *Census of production,* industries are 'reconstructed' to match the RSCA indicators, and the components are listed in Appendix B. The *Factory inspectorate returns* reported the amounts of horsepower and employees 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 3 regresses the RSCA indicators against the log of the 1870 capital-labour ratio. The coefficient is statistically significant and positive, as expected. However, the relative contributions of capital intensity and labour intensity cannot be discerned from this single variable.

Did the factor determinants of Britain's manufacturing comparative advantages change throughout the 1880s and 1890s? Does pooling the data for all three benchmark years obscure an instability in the magnitudes (or possibly signs) of the factor coefficients? These questions are answered by estimating separate regressions for each of the three benchmark years. Due to the small number of industries (17) observed in any single year, the explanatory variables are limited to just capital and labour intensity. Column 4 regresses the RSCA indicators against the logs of these variables using the pooled data. Columns 5-7 estimate the same regression for each of the three benchmark years. While the signs of the coefficients do not change, it is noteworthy that the coefficient of labour intensity increases from 1880-90 and again from 1890-1900. Moreover, this coefficient is statistically insignificant at any conventional level in the regression for 1880.

The increasing (in absolute value) coefficient of labour intensity reflects an increasing relative scarcity of labour in Britain. This relative labour scarcity has often been viewed in an

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(Deane and Cole, *British economic growth*, p. 225). Accordingly, the factor proportion of coal in the British iron and steel industry is estimated at 11%.

[50] In 1887, the British iron and steel industry accounted for substantially less than half of the coal consumed in the manufacturing sector. Mitchell, *British coal industry*, p. 12.

American mirror. With respect to the late nineteenth century, Habakkuk (1962) 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'.[51] By the closing decades of the nineteenth century, the archetypes of labour-utilizing British manufacturing and labour-economizing American manufacturing had become compromised by an Anglo-American real wage convergence. According to Williamson and O'Rourke (1994), the British unskilled wage had increased from 60-69 per cent of the American unskilled wage between 1870 and 1895.[52]

It is likely the manufacturing comparative advantages of *mid*-Victorian Britain would have tended less toward the relatively labour non-intensive manufacturing industries. But by 1890, a labour-economizing regime in British manufacturing had clearly emerged. To fully appreciate the relative labour non-intensity of late-Victorian Britain's manufacturing comparative advantages, it is necessary to consider the factor endowments of Continental Europe, which supplied more than half of world manufactured exports in 1899.[53] On the Continent, labour was relatively more abundant than in Britain. Moreover, as Williamson (1995) pointed out, the Anglo-French and Anglo-German real wage differentials had actually widened (slightly) in the late nineteenth century.[54] On the whole, the relative labour endowment of Britain was moving closer to that of the United States and farther from those of industrial Europe. It would not be disingenuous to argue that, in the late nineteenth century, the starker contrast is between the factor determinants of manufacturing in the Anglosphere and on the Continent, rather than between the factor determinants of manufacturing in Britain and the United States.

Four-factor model

Harley (1974) argued that, for Edwardian Britain, labour as a single factor cannot sufficiently explain the pattern of comparative advantages. Rather, skilled labour ought to be differentiated from unskilled labour because Edwardian Britain was relatively abundant in the former and relatively scarce in the latter.[55] In this vein, the present study considers whether

[51] Habakkuk, *American and British technology*, pp. 194-5.

[52] O'Rourke and Williamson, 'Factor-price convergence', p. 895.

[53] Calculated from Tyszynski, 'Manufactured commodities', p. 277.

[54] Williamson, 'Global labor markets', p. 155. Between 1870 and 1900, the French unskilled real wage declined from 72 to 68% of the British, while the German declined from 84 to 83% of the British.

[55] 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 may

human capital was a determinant of Britain's manufacturing comparative advantages using a four-factor H-O model of trade.

Human capital intensity per industry is proxied by the industry wage standardized for the wage of unskilled labour. The source for data on industry wages is the *Returns of wages* of 1887. This publication presents the weekly wage data that the British Board of Trade solicited from local chambers of commerce on an intermittent basis since 1830, the three most recent wage 'censuses' having occurred in the years 1877, 1880, and 1883. This paper makes use of just the wage data from 1883. The wage observations are disaggregated by occupation, locality, and industry. For example, a 'mill man' in the Macclesfield silk manufacturing industry earned a (quite low) wage of 18s. per week. Occasionally, the *Returns of wages* reports a range, rather than a single amount, for an occupation-locality-industry wage observation. In these instances, the midpoint is used. Additionally, only the wages of adult men are used in calculating the proxy. In total, there are 737 occupation-locality-industry wage observations across 13 industries. Some industries enjoy more observations than do others, and the numbers of wage observations per industry are reported in Appendix C. There are no observations for the industries of cement; clocks and watches; copper manufactures; and rubber manufactures; and so these industries are unavoidably excluded from the four-factor H-O model.

Within each industry, which specific wage observation best captures the human capital attainment of its labour? Here, it is worth mentioning that almost all industries had high-paid foremen and low-paid warehousemen and general labourers. The variation in human capital attainment is unlikely to manifest itself at the upper and lower endpoints of the wage scale in each industry. Instead, the ideal proxy for human capital falls somewhere between these endpoints. Without any pre-existing knowledge of where along the wage scale human capital attainment is best captured, this paper constructs three separate proxies for human capital intensity for each industry, corresponding to the first, second, and third quartile wage observations. These three wage observations per industry are then each standardized by the unskilled wage, taken to be the lowest of the 737 wage observations. The lowest observation is 13s. per week, the wage of a general labourer in the Belfast linen textile industry. All three proxies are presented in Appendix C.

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have been a Leontief paradox in Edwardian British trade, whereby labour-scarce Britain exported labour-intensive manufactured commodities. While he did not quite advance such an assertion, he did claim that the two-factor (capital and labour) H-O model was inadequate. Harley, 'Edwardian industry', pp. 411-3.

Table 5. *Four-factor H-O model of RSCA indicators, 1880-1900*

	(1)	(2)	(3)	(4)
Capital intensity	0.17**	0.14*	0.18**	0.13
	(0.08)	(0.08)	(0.08)	(0.08)
Labour intensity	-0.22**	-0.20*	-0.24**	-0.22**
	(0.10)	(0.10)	(0.10)	(0.10)
Material intensity	-0.27	-0.35	-0.25	-0.30
	(0.20)	(0.21)	(0.20)	(0.19)
Human capital intensity		-0.71		
(first quartile)		(0.70)		
Human capital intensity			0.42	
(second quartile)			(0.46)	
Human capital intensity				0.83**
(third quartile)				(0.41)
Constant	0.43	0.82	0.27	0.14
	(0.66)	(0.75)	(0.68)	(0.64)
R^2	0.16	0.18	0.18	0.25
Observations	39	39	39	39

Sources: See text.
Notes: * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level. Standard errors are noted in parentheses. All variables, except for the dependent variable, are expressed in natural logarithms.

Table 5 provides the results of the four-factor H-O model. The first column of Table 5 simply reproduces the first column of Table 4, but for the reduced sample of 13 industries. The loss of four industries does not alter the signs of the coefficients, but does reduce their statistical significance from the 1 to 5 per cent level. Columns 2-4 introduce the proxies for human capital intensity. Only the coefficient of the third-quartile proxy for human capital intensity is statistically significant, and at the 5 per cent level. This finding suggests that Britain's manufacturing comparative advantages were in those industries that required a high degree of human capital attainment to be possessed by a small share of labourers. To be sure, such an interpretation begs for qualitative substantiation, which would far exceed the scope of this paper. Nevertheless, this finding does call into doubt the assertion by Crafts and Thomas that Britain's manufacturing comparative advantages were in the relatively human capital non-intensive manufacturing industries.

What is perhaps more remarkable is how, even after controlling for human capital, Britain's manufacturing comparative advantages remain labour non-intensive. The claim by Crafts and Thomas that Britain's manufacturing comparative advantages were labour intensive finds no confirmation here. In using a dependent variable normalized for the composition of world exports, this study finds the opposite.

Intra-industry trade

Grubel and Lloyd (1971) advanced what has become the conventional measure of intra-industry trade, the Grubel-Lloyd index (GL_i).[56] It is calculated as follows:

$$GL_i = 1 - \frac{|X_i - M_i|}{X_i + M_i} \quad (4)$$

with *X* referring to exports, *M* to imports, and *i* to the industry. The index offers a standardized measure of intra-industry trade that is comparable across industries and time. Complete intra-industry trade, whereby per-industry exports equals per-industry imports, would yield an index of 1. Complete inter-industry (H-O) trade, involving an absence of either per-industry exports or per-industry imports, would yield an index of 0.

Here, annual G-L indices are calculated for 24 British manufacturing industries. Unlike the calculation of Balassa's RCA indicator, the calculation of the G-L index requires data from just a single country. Free from the need to reconcile the British trade statistics with the trade statistics of other countries, it is possible to expand the number of manufacturing industries under consideration from 17 to 24. Three of the additional industries result from the extrication of textile yarns from the textile industries, with the residual industries (cotton, linen, and woollen and worsted manufactures) now consisting mainly of cloth.[57] It is not possible to extricate silk yarn from silk manufactures. Due to inconsistencies between the export and import data reported in the British trade statistics, other industries are either redefined or excluded altogether, as evident from a comparison of Table 1 and Table 6.[58] One change worth mentioning explicitly is that the machinery industry is now included within the industry of iron, steel, and manufactures thereof, as necessitated by the more limited disaggregation of the import data for iron, steel, and manufactures thereof. Owing to a substantial rearrangement of the British trade statistics in 1895, the foregoing analysis is confined to the interval from 1870-94, which corresponds to the late-Victorian era *sans* the economic recovery of the late 1890s. The G-L indices for the 24 industries are reported annually in Appendix D and at eight-yearly intervals in Table 6.

[56] Grubel and Lloyd, 'Intra-industry trade', pp. 495-9.

[57] The residual textile industries encompass a number of non-cloth manufactures, including, for example, carpets and laces. It should also be noted that the industry of linen manufactures excludes manufactures of hemp and jute.

[58] The industries of beer and cement are excluded because they are not disaggregated in the import data. These net-export industries were subject to nearly complete inter-industry trade. Thus, the sample of 24 industries is slightly biased against Heckscher-Ohlinian industries.

Table 6. *Grubel-Lloyd indices for British manufacturing industries, 1870-94*

Industry	1870	1878	1886	1894	1870-94 (mean)
Alkali	0.19	0.06	0.06	0.12	0.08
Books	0.32	0.31	0.34	0.35	0.32
Caoutchouc manufactures*	0.11	0.27	0.53	0.56	0.33
Chemical products and preparation, n. e. s.	0.65	0.96	0.95	0.79	0.86
Copper manufactures*	0.85	0.94	0.85	[0.85]	0.86
Cordage and twine*	[0.93]	[0.81]	[0.87]	[0.82]	0.86
Cotton manufactures, excluding yarn+	0.04	0.08	0.06	0.09	0.07
Cotton yarn+	0.02	0.09	0.08	0.08	0.06
Drugs and medicinal preparations	0.67	0.77	0.90	0.90	0.86
Earthenware and chinaware	0.17	0.39	0.54	0.49	0.38
Glass	[0.94]	[0.54]	[0.77]	[0.46]	0.73
Hats	0.82	0.28	0.24	0.29	0.27
Iron, steel, and manufactures thereof*	0.11	0.26	0.26	0.29	0.22
Jute yarn	0.49	0.27	0.63	0.25	0.45
Lead manufactures*	[0.96]	[0.52]	[0.60]	[0.51]	0.61
Leather manufactures	0.88	[0.93]	0.95	[0.91]	0.92
Linen manufactures, excluding yarn+	0.04	0.08	0.11	0.17	0.10
Linen yarn+	0.05	0.49	0.70	0.81	0.49
Painters' colours and materials	0.65	0.78	0.76	0.80	0.76
Paper and manufactures thereof	[0.95]	[0.92]	[0.99]	[0.69]	0.93
Silk manufactures+	[0.17]	[0.26]	[0.35]	[0.17]	0.30
Spirits	[0.11]	[0.29]	[0.58]	[0.76]	0.46
Woollen and worsted manufactures, exc. yarn+	0.27	0.52	0.58	0.82	0.51
Woollen and worsted yarn+	0.49	0.58	0.72	0.54	0.59

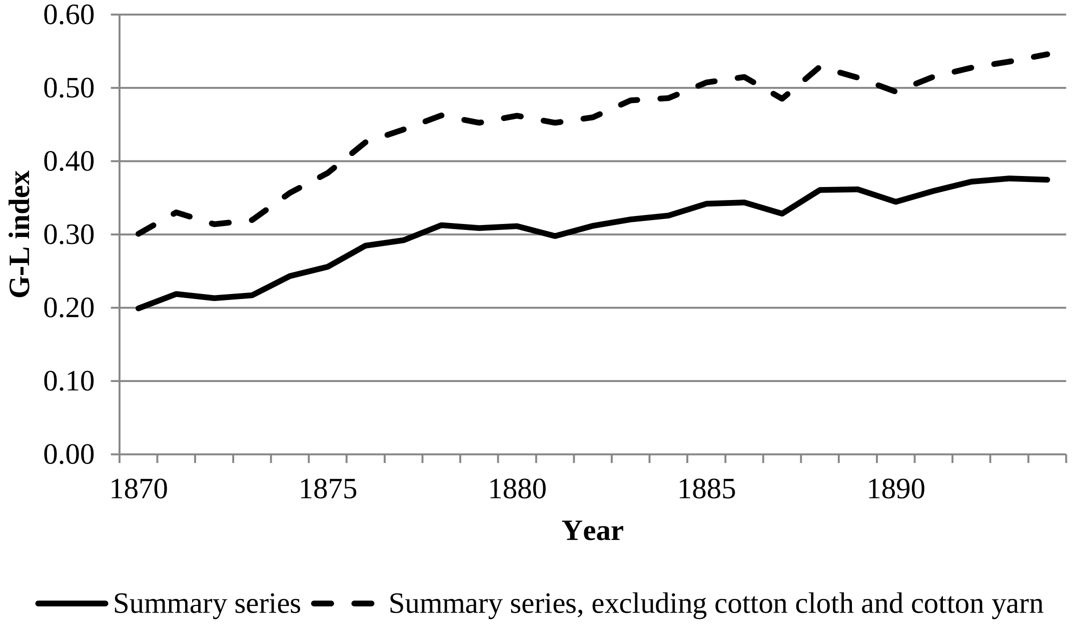
Source: Calculated from *Trade of the United Kingdom.* See text.
Note: * indicates a capital goods industry. + indicates a textile industry. Grubel-Lloyd indices for net-import industries are noted in brackets.

A summary series of intra-industry trade, plotted in Figure 1, is calculated as the trade-weighted average of the per-industry G-L series. What is immediately observable is the increase in Britain's intra-industry manufacturing trade, with the summary series rising, without any major interruption, from 0.20-0.37 between 1870 and 1894. That intra-industry manufacturing trade increased at all in the late nineteenth century constitutes a novel finding. Yet, the magnitude of the increase was not especially great, as Britain realized a considerably greater absolute increase in its summary series of intra-industry manufacturing trade, from 0.51-0.75, in just the single decade (1962-72) prior to its entering the European Economic Community.[59] Of course, comparing the growth of intra-industry manufacturing trade

[59] At best, it is only possible to offer an impressionistic comparison of Britain's manufacturing intra-industry trade between these two periods, given the immense changes in the composition of world trade in manufactured goods. Any such comparison would require that the industry definitions are of a broadly consistent degree of disaggregation in both periods, as one often-criticised feature of the G-L index is that it decreases at finer degrees of disaggregation.

The industry definitions employed in this section of the paper are well suited to the late nineteenth century. The 24 industries cover almost all of Britain's manufacturing trade. Furthermore,

Figure 1. *Trade-weighted summary series of Britain's manufacturing intra-industry trade, 1870-94*



between the first and second eras of globalization is an exercise fraught with qualifications, including the emergence of new manufacturing industries, the dislocation of trade caused by the Second World War, multilateral trade liberalization under GATT, and, due to the boundedness of the G-L index, the more limited potential for absolute increases at higher levels.

Evaluating the contours of late-Victorian Britain’s growth in intra-industry manufacturing trade does not require an implicit standard for comparison, and can therefore be done with greater certainty. To what extent is the variation in the trends and levels of the per-industry G-L series explicable in terms of NTT? According to NTT, intra-industry trade occurs in products differentiated according to attribute (HIIT) or according to quality (VIIT). In general, it would be expected that consumption goods industries would present greater scope for product differentiation than would capital goods industries, as intra-industry trade in the latter category of industries would be mostly confined to VIIT. It would follow that the

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there is not an excessive concentration of trade in a small number of industries, although the industry of cotton manufactures represents an unavoidable exception, in this regard. In terms of the degree of disaggregation, the industry definitions in this section roughly correspond to the two-digit level of the Standard Industrial Trade Classification, which came into use after the Second World War.

Trade-weighted summary G-L indices of British manufacturing intra-industry trade are calculated for the years 1962 and 1972, using industries defined at the two-digit level of the 1st Rev. SITC. There are 26 two-digit manufacturing industries, or roughly the same number of industries as defined for the nineteenth century. The codes for the twentieth-century industries are as follows: 11, 51-6, 59, 61-9, 71-3, and 81-6. The export and import data are obtained from the United Nations Comtrade Database.

Grubel-Lloyd indices for capital goods industries would be lower. However, the late-Victorian capital goods industries were not subject to systematically lower levels of intra-industry trade, and this finding is consistent with what Culem and Lundberg (1986) observed for the intra-industry trade of developed countries in 1980.[60] For the interval from 1870-94, the mean G-L indices for copper manufactures (0.86); cordage and twine (0.86); and lead manufactures (0.61) were among the upper half of industries, while the mean G-L indices for caoutchouc manufactures (0.33) and iron, steel, and manufactures thereof (0.22) were among the lower half.[61]

An even stronger expectation is that the textile industries would exhibit high levels of intra-industry trade, given the tremendous potential for product differentiation. Colour and pattern offer scope for HIIT. Thread-count and weave offer potential for VIIT. In explaining the nearly threefold increase in Britain's intra-industry trade in finished cotton cloth, from 0.05 in 1883 to 0.14 in 1913, Brown (1995) identified elements of both HIIT and VIIT, though he did not invoke these concepts explicitly. Compared to the other manufacturing industries in Table 6, however, the level of Britain's intra-industry trade in cotton manufactures was especially low. Thus, the large percentage increase in the G-L series for this industry did not amount to a large absolute increase.

Given the immense weight attached to cotton manufactures, the contribution of this industry to the trade-weighted summary series was to reduce its level and dampen its growth. If the industry of cotton manufactures was excluded, the summary series would have increased from 0.27-0.51, rather than from 0.20-0.37. If both the industries of cotton manufactures and cotton yarn were excluded, the summary series would have increased from 0.30-0.55. An alternative summary series, excluding cotton manufactures and cotton yarn, is plotted in Figure 1. In late-Victorian Britain, cotton manufactures and cotton yarn were overwhelmingly Heckscher-Ohlinian industries, despite the small increases in intra-industry trade documented, though not contextualized, by Brown.

Still, other textile industries presented similar potential for product differentiation. With respect to levels and growth, were the industries of cotton manufactures and cotton yarn representative of all textile industries? Is it possible to advance some generalizations about the textile industries, the mainstay of nineteenth-century British manufacturing? An industry-panel regression, with a dependent variable of GL_i and with year fixed effects, is estimated

[60] Culem and Lundberg, 'Product pattern', p. 118.

[61] While other industries contain capital goods, such as windows (glass) and machine belting (leather manufactures), these five industries are characteristically capital goods industries.

Table 7. *Textile convergence in G-L indices, 1870-94*

	(1)	(2)
Textile industry	-39.25***	-39.25***
	(12.27)	(12.27)
Textile industry x time	0.87***	0.88***
	(0.14)	(0.14)
Time		0.24***
		(0.08)
Constant	56.53***	55.12***
	(6.95)	(6.63)
Year fixed effects	YES	NO
Overall R^2	0.19	0.19
Observations	600	600

Sources: See text.
Notes: *** indicates statistical significance at the 1% level. Standard errors are noted in parentheses. All coefficients and standard errors have been rescaled by a factor of 100. The dependent variable is expressed in levels. There are seven textile industries: cotton manufactures (non-yarn); cotton yarn; linen manufactures (non-yarn); linen yarn; silk manufactures (including yarn); woollen and worsted manufactures (non-yarn); and woollen and worsted yarn.

for the entire sample of 24 industries. The results are presented in Table 7. In column 1, the first explanatory variable is a textile dummy, assigned to the industries of cotton manufactures (non-yarn); cotton yarn; linen manufactures (non-yarn); linen yarn; woollen and worsted manufactures (non-yarn); woollen and worsted yarn; and silk manufactures (including yarn). The statistically significant and negative coefficient of the dummy variable indicates that the textile industries were, in fact, subject to systematically lower levels of intra-industry trade. The G-L index for the 'average textile industry' was less than one-third that of the 'average non-textile industry'.

The second explanatory variable interacts the textile dummy with time. The statistically significant and positive coefficient of the interaction variable indicates that intra-industry trade in the average textile industry grew faster than in the average non-textile industry. To determine how much faster, column 2 replaces the year fixed effects with a trend variable. In the average non-textile industry, the G-L series increased by 0.0024 per annum. Meanwhile, in the average textile industry, the G-L series increased by 0.0112 (0.0024+0.0088) per annum, or nearly five times as fast. With lower levels and faster growth, it is possible to discuss a late-Victorian 'textile convergence' in intra-industry trade. Such a phenomenon must be substantially qualified, however. Cotton manufactures, cotton yarn, and silk manufactures all contributed to the lower levels, but not to the faster growth.[62]

[62] The trend rates of growth for the per-industry G-L series are 0.0018*** for cotton manufactures (non-yarn), 0.0031*** for cotton yarn, and -0.0001 for silk. *** indicates statistical significance at the 1% level.

In the net-import industry of silk manufactures, there was no increase in intra-industry trade, whatsoever. Among the greatest casualties of nineteenth-century British manufacturing, the silk industry could not withstand French competition following the elimination of duties on silk manufactures under the Cobden-Chevalier Treaty of 1860. Domestic output declined throughout the 1860s as imports from France flooded the British market.[63] That Britain exported silk manufactures at all was due to its competitiveness within a very narrow range of commodities. In the 1880s, Britain was early to implement the use of machinery in the formerly labour-intensive production of silk pile fabrics.[64] Additionally, Britain specialized in the production of silk fabrics that incorporated other textile yarns. In 1890, 48 per cent of Britain's exports of silk manufactures were composed 'of silk and other materials'.[65] In this way, the proximity of the Cheshire silk-textile industry to the (internationally competitive) Lancashire cotton-textile industry helped Britain to retain a small niche in the world export trade of silk manufactures. Thus, a small degree of VIIT persisted in the British silk industry.

The textile convergence was due to the linen and woollen and worsted industries. The G-L series for the industries of linen manufactures (non-yarn); linen yarn; woollen and worsted manufactures (non-yarn); and woollen and worsted yarn all exhibit a statistically significant upward trend that exceeds the trend for the average non-textile industry (0.0024).[66] The most impressive trend rate of growth, 0.0375 per annum, was in the linen yarn industry, which is the subject of the next section of this paper.

The rapidly increasing intra-industry trade in linens and woollens was due to HIIT and VIIT, certainly, but also to the moderate factor proportions that characterized these textile classes, compared to cottons and silks. As evident from Table 3, the industry of cotton manufactures had the highest capital intensity and the lowest labour intensity of the four textile classes. Conversely, the industry of silk manufactures had the lowest capital intensity and the highest labour intensity. Linen manufactures (including yarn) and the woollen and worsted manufactures (including yarn) were of intermediate factor intensity, both with

[63] For rough estimates of the declining output of the British silk industry in the wake of the Cobden-Chevalier Treaty, see Deane and Cole, *British economic growth*, p. 210.

[64] Rawlley, *Silk industry*, pp. 282-3.

[65] Calculated from *Trade of the United Kingdom* (1890).

[66] The trend rates of growth for the per-industry G-L series are 0.0051*** for linen manufactures (non-yarn); 0.0375*** for linen yarn; 0.0209*** for woollen and worsted manufactured (non-yarn); and 0.0098*** for woollen and worsted yarn. *** indicates statistical significance at the 1% level.

respect to capital and labour.[67] The intermediate factor intensities of these industries made them amenable to increasing VIIT. Britain exported the more capital-intensive commodities within these industries and imported the less capital-intensive commodities within these industries, as per Falvey's (1981) neo-H-O model. Yet, in the cotton and silk industries, more extreme factor requirements militated against growth in intra-industry trade, and Britain's distinctly net-export position in cotton manufactures and net-import position in silk manufactures continued largely unaltered.

Given that late-Victorian Britain was a net exporter in the majority of manufacturing industries, it might be expected that the summary series of Britain's manufacturing intra-industry trade would follow a pro-cyclical course. As Bordo and Helbling (2011) have found, business cycles were highly desynchronized in the late nineteenth century, compared to in the late twentieth century.[68] Because late-Victorian Britain exported to numerous markets undergoing asynchronous business cycles, imports represented the channel through which the business cycle would have exerted its greatest affect upon intra-industry trade. Increased (decreased) imports during upswings (downswings) in the British business cycle would raise (lower) intra-industry trade. To determine whether such a pro-cyclical relationship existed, the cyclical components of the summary series and of real net national income per capita, as obtained using the Hodrick-Prescott filter, are correlated.[69] The correlation coefficient of the cyclical components is -0.40, and this coefficient is statistically significant at the 5% level.

The counter-cyclicality of the summary series is partly attributable to the phenomenon of the Long Depression of 1873-9, when the industrial economies of the world were in a generally protracted decline, but a decline that was less acute in Britain than elsewhere, at least until 1877.[70] During the years from 1873-7, Britain's export markets contracted severely, with exports to the United States declining by more than half, from £33.6 million to £16.4 million.[71] Meanwhile Britain's imports of manufactured commodities actually increased, as capital otherwise invested overseas was instead invested domestically, financing

[67] Obviously, the factor intensities of yarn and cloth production, within the same textile industry, would differ. However, reliable proxies for the factor intensities of these different stages of textile production are unavailable. It is therefore unavoidable that comparisons of the factor intensities of the textile industries must aggregate the yarn-spinning and cloth-weaving stages of production.

[68] Bordo and Helbling, 'International business cycle', p. 212. From 1880-1913, the average bilateral output coefficient between countries was 0.03. From 1986-2008, this coefficient was 0.35, indicating a substantially higher degree of business-cycle synchronization.

[69] The data for real net national income per capita are obtained from Mitchell, *British historical statistics*, p. 367.

[70] Rostow, *British economy*, pp. 179-80.

[71] *Trade of the United Kingdom* (1877).

a spate of residential construction.[72] Indeed, the fastest growth in Britain's manufacturing intra-industry trade occurred during the relatively mild, early depression years of 1873-7, when the summary series increased from 0.22-0.29. That the high level of manufacturing intra-industry trade continued to increase thereafter, however, was due to more fundamental causes, such as overseas industrialization and increasing demand for differentiated products.

The linen yarn industry

The British linen yarn industry, as a component of the overall linen industry, had fallen into absolute decline during the late-Victorian era, with the peak of nineteenth-century production having occurred in 1871.[73] By 1900, Britain's output of linen yarn had fallen by nearly half.[74] There are two principal explanations for the decline. First, consumption of linen textiles was falling, as domestic and foreign consumers substituted toward cheaper cotton textiles.[75] Second, the British linen textile industry increasingly relied upon imported linen yarn, mainly from Belgium.

The decline in the British linen yarn, or flax spinning, industry was most prominent in England, where the number of flax spindles fell from 270,000 to 118,000 between 1871 and 1885.[76] The demise of the English (and Scottish) flax-spinning industries was indicative of an emerging scarcity of labour in late-Victorian Britain, though not necessarily Ireland. The English flax-spinning industry, centred in Lancashire and Yorkshire, competed with the higher-productivity cotton and woollen industries for labour.[77] In Scotland, the flax-spinning

[72] Habakkuk, 'Fluctuations in house-building', p. 204. Consistent with the mid-1870s boom in residential construction, the G-L series for the industry of iron, steel, and manufactures thereof increased very rapidly, from 0.11 in 1873 to 0.23 in 1877.

[73] Hoffman, *British industry*, foldout appendix table.

[74] Ibid.

[75] Patterson, 'Linen industry', p. 135. Moreover, linen textiles were a victim of changes in fashion during the late nineteenth century.

[76] *Depression of trade*, p. 261.

[77] Ibid., p. 268. Mr. R. H. Reade, a managing director at a Belfast flax-spinning firm, stated in his testimony before the Royal Commission on the Depression of Trade Industry, 'The linen manufacture was confined to the counties of Yorkshire and Lancashire, in both which you had got those other great textile industries of cotton and wool, which were very much larger, which expanded at a very much greater rate, and could afford to pay higher wages'.

industry of Dundee was largely displaced by the jute-spinning and jute-weaving industries, which catered to the large demand for burlaps in the United States.[78]

The British flax-spinning industry became consolidated in Ireland, where output remained generally stable. By 1890, 73 per cent of Britain's flax spindles were located in Ireland.[79] The consolidation of the British flax-spinning industry in Ireland, already well underway by the mid-nineteenth century, can be attributed to the relatively more abundant labour supply there. Whereas flax-spinning firms in England competed against other manufacturing industries for labour, flax-spinning firms in Ireland could draw upon a large supply of low-productivity agricultural labour. Though, as O'Rourke and Williamson (1999) have argued, Irish outward migration, from the middle of the nineteenth century onwards, was a forceful Heckscher-Ohlinian current that rendered the factor price of Irish labour increasingly dear.[80] The Irish flax-spinning industry enjoyed one slight advantage that the English flax-spinning industry did not, and that was the local production of flax. Flax was a labour-intensive crop, and its cultivation was therefore unprofitable in England. However, the lack of English flax was only a minor, if any, disadvantage to the English flax-spinning industry, which simply imported cheap flax from the Baltic region.[81] By the end of the nineteenth century, even Ireland had become a substantial net importer of flax.[82] Altogether, the British flax-spinning industry aligns with the material-neutral pattern of Britain's manufacturing comparative advantages, identified earlier in this paper.

There is no indication that the Irish flax-spinning industry was unduly deprived of capital. Arguably, flax-spinning in Ireland was more capital-intensive than in England. Whereas firms in England and Scotland remained small, firms in Ireland were large, and their operation more closely resembled mass production. In 1890, the average flax-spinning firm in Ireland contained 14,070 spindles, compared to 7,857 in England and 3,158 in Scotland.[83] Undoubtedly, Irish firms realized economies of scale to a far greater degree than English and Scottish firms, of which the numbers were steadily declining.

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[78] In 1885, 107 million of the 215 million yards of 'jute piece goods' exported by Britain were destined for the United States. *Trade of the United Kingdom* (1885). Ironically, much of these exports to the United States returned to Britain in the form of burlap sacks containing raw cotton. In this way, the Scottish jute industry was bolstered by the success of the English cotton industry.

[79] Calculated from *Factory inspectorate returns* (1890).

[80] O'Rourke and Williamson, *Globalization and history*, pp. 148-52.

[81] Rimmer, *Marshalls of Leeds*, p. 246.

[82] Patterson, 'Linen industry', p. 130.

[83] Calculated from *Factory inspectorate returns* (1890).

The capital-intensity of Irish flax-spinning was manifest in the volume and type of machinery it employed. The flax-spinning firms of Belfast invested heavily in additional machinery during the Cotton Famine of the early 1860s, when substitution toward linen cloth engendered an extreme demand for linen yarn.[84] During the 1870s and 1880s, when leaner demand conditions prevailed, the Irish firms pulled technologically ahead of their English counterparts, which failed to adopt machine methods for heckling flax.[85] Altogether, the Irish flax-spinning industry was subject to a comparatively high degree of capital-deepening and technological progress; incidentally, these were the main determinants of rising per capita income in Ireland, according to Geary and Stark (2002).[86]

Regardless of how well-adjusted the Irish flax-spinning industry might have been, British weavers of linen cloth became increasingly reliant upon imported linen yarn throughout the late-Victorian era. The G-L series for linen yarn rose from a predominantly inter-industry level of 0.05 in 1870 to a predominantly intra-industry level of 0.81 in 1894. In 1894, 85 per cent of Britain's linen yarn imports came from Belgium. How did the Belgian linen yarn compare to the British linen yarn?

The textual evidence suggests that Britain's growing intra-industry trade in linen yarn was a growing VIIT, or trade in linen yarn differentiated by quality. Testimony before the Royal Commission on the Depression of Trade and Industry (1886) describes the pattern of Britain's intra-industry trade in linen yarn with Belgium: 'The exports to Belgium in 1885 had increased 25 per cent. over the preceding five years, and our imports from Belgium are also increasing…we spin a finer yarn than they do, and they spin the coarse yarns cheaper than we can'.[87]

One way to ascertain, quantitatively, whether Britain's intra-industry trade in linen yarn constituted VIIT is to impose a unit-value dispersion criterion, as was done by Greenaway et al. (1995). Assuming that price varies according to quality, then vertical intra-industry trade should exhibit different unit values of exports and imports. In their empirical analysis of British intra-industry trade in 1988, Greenaway et al. treated intra-industry trade as vertical when the unit value of exports deviated from the unit value of imports by +/- 15 per cent.[88] Since the British trade statistics report both quantities and values for both exports and imports of linen yarn, it is possible to calculate the unit-value dispersion for this industry.

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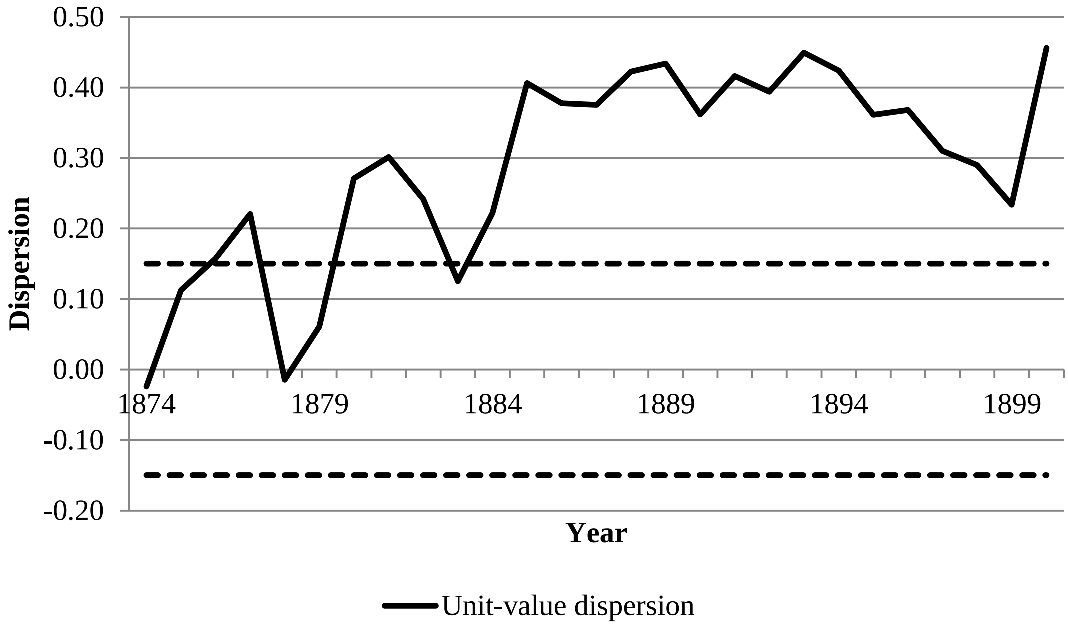
[84] Ollerenshaw, 'Industry', pp. 77-8.
[85] Rimmer, *Marshalls of Leeds*, p. 252.
[86] Geary and Stark, 'Post-famine economic growth'.
[87] *Depression of trade*, p. 268.
[88] Greenaway et al., 'Vertical and horizontal', p. 1508.

Figure 2. *Unit-value dispersion for British linen yarn exports and imports, 1874-1900*



The unit-value dispersion is presented, along with the 15 per cent criterion bands, in Figure 2. A positive value indicates British exports of superior quality, while a negative value indicates British exports of inferior quality. Britain's intra-industry trade in linen yarn was, from 1884 onward, a distinctly vertical one, in which Britain exported high-quality yarn and imported low-quality yarn.

The reason why the small amount of intra-industry trade prior to the 1880s was not vertical was because Britain continued to export low-quality yarn to several traditional markets, including the United States and the Empire. In 1875, when the unit-value dispersion was less than 15 per cent, the average value of Britain's linen yarn exports was £0.067/lb (£0.059/lb for imports).[89] However, the average values of bilateral linen yarn exports varied greatly: £0.076/lb for exports to Belgium, £0.092/lb for exports to Germany, but only £0.022/lb for exports to the United States.[90] The British export of low-quality yarns to non-Continental markets caused the unit-value dispersion to fall under 15 per cent in certain years prior to the mid-1880s.

Surely by the 1890s, a pattern of linen yarn production (and trade) had established itself in Europe, with Britain producing and exporting fine yarn and the Continent producing

[89] Calculated from *Trade of the United Kingdom* (1875).
[90] Ibid.

Table 8. *British and Belgian flax spindles per worker, 1878-96*

	Spindles	Workers	Spindles per worker
Britain			
1878	922,693	46,983	19.6
1890	993,192	47,667	20.8
1896 (extrapolated)	--	--	21.4
Belgium			
1896	292,000	14,935	19.6

Sources: Britain: *Factory inspectorate returns* of 1878 and 1890 for the numbers of spindles and workers. Belgium: Milward and Saul, *Continental Europe,* p. 161, for the number of spindles; *Recensement générale des industries* of 1896 for the number of workers.
Notes: For Britain, the numbers of spindles and workers consist only of those spindles and workers in mills engaged solely in flax-spinning. The data excludes spindles and workers in the so-called 'integrated mills', though these mills were very few in number.

and exporting coarse yarn.[91] This pattern conforms exactly to Falvey's (1981) neo-H-O model of trade. Recall that, in this model, vertical intra-industry trade results from quality differentials, which are determined by differing (though not extremely differing) relative endowments of a particular immobile factor of production.[92] Britain, with its greater relative endowment of capital, exported relatively capital-intensive, high-quality yarn. In contrast, Belgium, with its greater relative endowment of labour, exported relatively labour-intensive, low-quality yarn.

One crude measurement for comparing the factor-proportions of the Belgian and British flax-spinning industries is spindles per worker, as presented in Table 8. The earliest reliable data for the Belgian flax-spinning industry is from the *Recensement générale des industries* of 1896, as earlier Belgian industrial censuses do not distinguish between spinning and weaving labourers. The latest reliable data for the British flax-spinning industry is the *Factory inspectorate returns* of 1890.[93] In 1896, the number of spindles per worker in Belgium was on par with the number of spindles per worker in Britain nearly two decades earlier, in 1878. A rough comparison for the year 1896 can be made by extrapolating forward the growth in spindles per worker in Britain between the *Factory inspectorate returns* of 1878 and 1890. This extrapolation results in 21.4 spindles per worker in Britain, compared to 19.6 spindles per worker in Belgium. While these numbers should not be overemphasized, it

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[91] Outside of Belgium, Continental flax-spinning was likely even more labour-intensive. In Germany, thousands of labourers continued to spin flax by hand, in a manner little changed since medieval times, into the 1870s. Clapham, *Economic development,* p. 290.

[92] In Falvey, 'Commercial policy', the immobile factor of production was capital, but another factor (e.g. labour) could instead determine quality. Greenaway and Milner, *Intra-industry trade,* pp. 10-11.

[93] The *Census of production* of 1907 does not sufficiently distinguish between flax-spinning and flax-weaving.

is nevertheless unsurprising that they reveal a moderately higher capital-intensity in British flax-spinning.

Obviously, the findings of this paper with respect to the linen yarn industry cannot possibly be generalized for Britain's manufacturing sector as a whole. Still, it can be claimed that late-Victorian Britain's manufacturing intra-industry trade was not wholly confined to HIIT. The linen yarn industry conformed to the neo-H-O model of intra-industry trade in products differentiated by quality, rather than the C-H-O model of products differentiated by attribute. Indeed, further exploration of VIIT in the late nineteenth century is certainly warranted, but very much complicated by the inadequate reporting of export and import quantities in the trade statistics of most countries.

Conclusions

In the 1890s, the manufacturing trade of late-Victorian Britain was mostly Heckscher-Ohlinian, even despite a persistent growth in intra-industry trade during the prior quarter-century. If the industries of cotton manufactures (non-yarn) and cotton yarn were excluded, then the composition of Britain's manufacturing trade would have been roughly balanced between inter-industry and intra-industry by the closing decade of the nineteenth century. The levels of intra-industry trade in the linen and woollen and worsted industries were initially low, but grew very rapidly throughout the late-Victorian era, resulting in a 'textile convergence' in intra-industry trade. Still, the cotton and silk industries did not contribute to this convergence, due to their more extreme factor requirements.

Indeed, the cotton and silk industries are emblematic of the pattern of Britain's manufacturing comparative advantages in the late-Victorian era. In the relatively capital-intensive, labour non-intensive industry of cotton manufactures, Britain realised one of its greatest comparative advantages. In the relatively labour-intensive, capital non-intensive industry of silk manufactures, Britain was at a pronounced comparative disadvantage. The finding that Britain's manufacturing comparative advantages were labour non-intensive opposes the prevailing view advanced by Crafts and Thomas. Furthermore, this finding was unaffected after controlling for human capital. Another surprising finding was the material neutrality of Britain's manufacturing comparative advantages, for which there are several possible explanations, including coal, free trade, and the Empire.

The effect of the Empire on the composition of Britain's manufacturing trade has gone largely unexamined in this paper, and it represents a fascinating area for future research. Given the well-documented 'empire effect' on trade, and given that Britain's trade with the Empire was largely an exchange of manufactured goods for primary goods, the Empire was tantamount to a Heckscher-Ohlin bias in Britain's manufacturing trade. Britain's largest bilateral trade, with the United States, conformed to the same pattern, although increasing American manufactured exports to Britain was a distinguishing feature of the Edwardian years.

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Appendix A

Belgium, *RCA indicators, 1880-1900*

Industry	1880	1890	1900
Beer	0.1 (15)	0.1 (16)	0.0 (16)
Cement	2.6 (5)	1.3 (8)	5.8 (2)
Chemicals, including dyestuffs, medicine, and paint	0.9 (7)	2.0 (4)	2.3 (5)
Clocks and watches	0.0 (17)	0.0 (17)	0.0 (17)
Copper manufactures	0.3 (13)	0.4 (11)	0.3 (13)
Cotton manufactures, including yarn	0.3 (12)	0.3 (12)	0.3 (11)
Earthenware and chinaware	0.8 (8)	1.8 (5)	1.5 (8)
Flax, hemp, and jute manufactures, including yarn and cordage	4.4 (2)	4.9 (2)	5.1 (3)
Glass	8.7 (1)	7.0 (1)	8.3 (1)
Iron, steel, and manufactures thereof, excluding machinery	0.7 (9)	1.7 (6)	1.5 (7)
Leather and manufactures thereof	0.5 (11)	0.6 (10)	1.2 (9)
Machinery, including steam engines and locomotives	2.6 (4)	3.3 (3)	2.3 (4)
Paper and manufactures thereof	3.1 (3)	1.6 (7)	1.7 (6)
Rubber manufactures	0.1 (14)	0.1 (15)	0.2 (14)
Silk manufactures	0.0 (16)	0.1 (14)	0.1 (15)
Spirits	0.5 (10)	0.1 (13)	0.3 (12)
Woollen and worsted manufactures, including yarn	1.8 (6)	1.3 (9)	0.8 (10)

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

France, *RCA indicators, 1880-1900*

Industry	1880	1890	1900
Beer	0.1 (17)	0.3 (17)	0.5 (16)
Cement	0.4 (14)	2.0 (8)	1.9 (7)
Chemicals, including dyestuffs, medicine, and paint	1.2 (9)	1.2 (10)	1.4 (10)
Clocks and watches	3.6 (3)	3.6 (3)	4.8 (2)
Copper manufactures	0.3 (15)	0.6 (14)	0.7 (13)
Cotton manufactures, including yarn	0.3 (16)	0.4 (16)	0.7 (14)
Earthenware and chinaware	1.4 (8)	1.9 (9)	1.8 (9)
Flax, hemp, and jute manufactures, including yarn and cordage	0.8 (11)	0.5 (15)	1.0 (12)
Glass	1.6 (7)	2.1 (7)	2.1 (6)
Iron, steel, and manufactures thereof, excluding machinery	0.5 (13)	0.8 (11)	0.6 (15)
Leather and manufactures thereof	4.1 (2)	3.6 (4)	3.0 (4)
Machinery, including steam engines and locomotives	0.5 (12)	0.7 (13)	0.5 (17)
Paper and manufactures thereof	2.7 (5)	2.3 (6)	1.9 (8)
Rubber manufactures	1.2 (10)	0.8 (12)	1.0 (11)
Silk manufactures	3.6 (4)	4.3 (2)	5.6 (1)
Spirits	4.5 (1)	4.8 (1)	3.7 (3)
Woollen and worsted manufactures, including yarn	2.5 (6)	2.4 (5)	2.2 (5)

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

Germany, *RCA indicators, 1880-1900*

Industry	1880	1890	1900
Beer	2.7 (6)	2.2 (8)	2.2 (7)
Cement	3.1 (4)	2.8 (5)	2.8 (4)
Chemicals, including dyestuffs, medicine, and paint	4.4 (1)	4.5 (2)	3.8 (2)
Clocks and watches	2.2 (8)	2.7 (6)	2.1 (9)
Copper manufactures	1.3 (14)	1.4 (13)	1.2 (14)
Cotton manufactures, including yarn	0.7 (16)	0.9 (16)	1.0 (15)
Earthenware and chinaware	2.5 (7)	1.9 (11)	2.8 (5)
Flax, hemp, and jute manufactures, including yarn and cordage	0.5 (17)	0.5 (17)	0.5 (17)
Glass	1.9 (11)	2.2 (9)	1.6 (12)
Iron, steel, and manufactures thereof, excluding machinery	2.0 (10)	1.9 (12)	2.0 (10)
Leather and manufactures thereof	2.0 (9)	2.6 (7)	1.9 (11)
Machinery, including steam engines and locomotives	1.2 (15)	0.9 (15)	1.5 (13)
Paper and manufactures thereof	3.2 (3)	4.7 (1)	4.0 (1)
Rubber manufactures	2.9 (5)	3.2 (4)	2.9 (3)
Silk manufactures	3.7 (2)	3.6 (3)	2.5 (6)
Spirits	1.9 (12)	1.2 (14)	0.9 (16)
Woollen and worsted manufactures, including yarn	1.8 (13)	2.1 (10)	2.1 (8)

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

United States, *RCA indicators, 1880-1900*

Industry	1880	1890	1900
Beer	0.1 (12)	0.4 (9)	0.9 (7)
Cement	0.1 (14)	0.1 (15)	0.1 (15)
Chemicals, including dyestuffs, medicine, and paint	0.2 (7)	0.4 (8)	0.6 (10)
Clocks and watches	1.2 (1)	1.6 (1)	1.4 (5)
Copper manufactures	0.2 (9)	0.5 (6)	3.6 (1)
Cotton manufactures, including yarn	0.2 (11)	0.2 (13)	0.4 (12)
Earthenware and chinaware	0.0 (15)	0.1 (14)	0.2 (14)
Flax, hemp, and jute manufactures, including yarn and cordage	0.1 (13)	0.2 (12)	0.4 (11)
Glass	0.2 (10)	0.2 (11)	0.4 (13)
Iron, steel, and manufactures thereof, excluding machinery	0.3 (5)	0.4 (7)	1.4 (4)
Leather and manufactures thereof	0.5 (4)	0.8 (2)	1.6 (3)
Machinery, including steam engines and locomotives	0.5 (3)	0.8 (3)	1.6 (2)
Paper and manufactures thereof	0.2 (6)	0.2 (10)	0.7 (8)
Rubber manufactures	0.2 (8)	0.6 (4)	1.1 (6)
Silk manufactures	0.0 (17)	0.0 (17)	0.0 (17)
Spirits	0.7 (2)	0.5 (5)	0.6 (9)
Woollen and worsted manufactures, including yarn	0.0 (16)	0.0 (16)	0.0 (16)

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

Appendix B

<u>Industry components, *Census of production* of 1907</u>

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; 61% of Bleaching, dyeing, printing, and finishing trades
Earthenware and chinaware: Bricks and fireclay trades; China and earthenware trades
Flax, hemp, and jute manufactures, including yarn and cordage: Jute, hemp, and linen trades; 11% 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; 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)
Paper and manufactures thereof: Paper trade; Cardboard box trade
Rubber and manufactures thereof: Indiarubber trades
Silk manufactures: Silk trades; 2% 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% of Bleaching, dyeing, printing, and finishing trades

<u>Industry components, *Factory inspectorate returns* of 1870</u>

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; Bricks and tiles
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; 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
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

Human capital proxies, 1883

Industry	N	First quartile	Second quartile	Third quartile
Beer	6	1.69	1.74	1.92
Chemicals, including dyestuffs, medicine, and paint	19	1.46	1.97	2.38
Cotton manufactures, including yarn	85	1.62	1.92	2.77
Earthenware and chinaware	10	1.63	1.85	2.17
Flax, hemp, and jute manufactures, including yarn and cordage	46	1.46	1.82	2.11
Glass	29	1.92	2.28	2.54
Iron, steel, and manufactures thereof, excluding machinery	164	1.77	2.31	2.62
Leather and manufactures thereof	56	1.83	2.15	2.35
Machinery, including steam engines and locomotives	112	1.72	2.34	2.60
Paper and manufactures thereof	32	1.60	1.83	2.32
Silk manufactures	11	1.58	1.69	1.82
Spirits	4	1.66	1.82	2.06
Woollen and worsted manufactures, including yarn	164	1.49	1.78	2.31

Source: Returns of wages (1887).
Notes: See text.

Appendix D

Grubel-Lloyd indices for British manufacturing industries, 1870-94

	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879
Alkali	0.19	0.15	0.12	0.10	0.12	0.11	0.10	0.09	0.06	0.07
Books	0.32	0.36	0.29	0.32	0.33	0.31	0.29	0.30	0.31	0.30
Caoutchouc manufactures*	0.11	0.11	0.15	0.19	0.19	0.21	0.22	0.20	0.27	0.21
Chemical products and preparations, not elsewhere specified	0.65	0.92	0.88	0.89	0.80	0.83	0.94	0.95	0.96	0.77
Copper manufactures*	0.85	0.86	[0.84]	0.98	[0.98]	[0.96]	[0.95]	[1.00]	0.94	0.98
Cordage and twine*	[0.93]	[1.00]	[0.76]	[0.80]	[0.79]	[0.82]	[0.65]	[0.73]	[0.81]	[0.87]
Cotton manufactures, excluding yarn+	0.04	0.05	0.05	0.05	0.05	0.04	0.06	0.06	0.08	0.08
Cotton yarn+	0.02	0.01	0.01	0.01	0.03	0.03	0.03	0.06	0.09	0.07
Drugs and medicinal preparations	0.67	0.72	0.78	0.66	0.79	0.77	0.90	0.82	0.77	0.94
Earthenware and chinaware	0.17	0.20	0.22	0.28	0.33	0.34	0.37	0.33	0.39	0.39
Glass	[0.94]	[0.94]	[0.96]	[0.96]	[0.85]	[0.77]	[0.66]	[0.62]	[0.54]	[0.66]
Hats	0.82	0.28	0.21	0.15	0.20	0.27	0.30	0.28	0.28	0.29
Iron, steel, and manufactures thereof, including machinery*	0.11	0.11	0.11	0.11	0.15	0.20	0.23	0.23	0.26	0.24
Jute yarn	0.49	0.39	0.36	0.44	0.62	0.39	0.42	0.30	0.27	0.55
Lead manufactures*	[0.96]	[0.76]	[0.74]	[0.66]	[0.74]	[0.63]	[0.63]	[0.62]	[0.52]	[0.54]
Leather manufactures	0.88	0.77	0.82	0.79	0.93	[0.89]	[0.94]	[0.94]	[0.93]	0.99
Linen manufactures, excluding yarn+	0.04	0.04	0.05	0.06	0.06	0.06	0.08	0.09	0.08	0.07
Linen yarn+	0.05	0.21	0.22	0.05	0.13	0.19	0.23	0.36	0.49	0.51
Painters' colours and materials	0.65	0.62	0.64	0.70	0.67	0.74	0.81	0.78	0.78	0.84
Paper and manufactures thereof	[0.95]	0.94	0.97	0.99	[0.96]	0.99	[0.89]	[0.91]	[0.92]	[0.99]
Silk manufactures+	[0.17]	[0.39]	[0.38]	[0.31]	[0.30]	[0.25]	[0.26]	[0.23]	[0.26]	[0.23]
Spirits	[0.11]	[0.13]	[0.18]	[0.12]	[0.11]	[0.17]	[0.14]	[0.27]	[0.29]	[0.26]
Woollen and worsted manufactures, excluding yarn+	0.27	0.29	0.22	0.26	0.30	0.33	0.42	0.46	0.52	0.52
Woollen and worsted yarn+	0.49	0.32	0.39	0.45	0.45	0.45	0.56	0.65	0.58	0.55

Source: Calculated from *Trade of the United Kingdom*. See text.

Notes: * indicates a capital goods industry. + indicates a textile industry. G-L indices for net-import industries are noted in brackets.

Grubel-Lloyd indices for British manufacturing industries, 1870-94 (continued)

	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889
Alkali	0.06	0.07	0.08	0.07	0.06	0.05	0.06	0.05	0.06	0.04
Books	0.31	0.28	0.28	0.29	0.30	0.31	0.34	0.32	0.33	0.35
Caoutchouc manufactures*	0.26	0.24	0.27	0.33	0.41	0.61	0.53	0.46	0.41	0.44
Chemical products and preparations, not elsewhere specified	0.76	0.80	0.92	0.96	0.99	0.97	0.95	0.91	0.88	0.84
Copper manufactures*	0.89	0.79	0.88	0.82	0.80	0.80	0.85	0.68	[0.90]	0.80
Cordage and twine*	[0.88]	[0.91]	[0.90]	[0.89]	[0.89]	[0.92]	[0.87]	[0.92]	[0.99]	[0.87]
Cotton manufactures, excluding yarn+	0.08	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.07	0.08
Cotton yarn+	0.09	0.07	0.07	0.06	0.06	0.08	0.08	0.07	0.08	0.08
Drugs and medicinal preparations	0.90	0.95	0.94	[0.90]	0.94	0.97	0.90	0.85	0.98	0.91
Earthenware and chinaware	0.37	0.40	0.41	0.41	0.44	0.44	0.43	0.43	0.44	0.44
Glass	[0.68]	[0.73]	[0.79]	[0.81]	[0.79]	[0.74]	[0.77]	[0.76]	[0.74]	[0.78]
Hats	0.24	0.23	0.24	0.29	0.23	0.29	0.24	0.23	0.23	0.25
Iron, steel, and manufactures thereof, including machinery*	0.23	0.24	0.22	0.25	0.28	0.29	0.26	0.22	0.23	0.22
Jute yarn	0.83	0.47	0.27	0.31	0.42	[0.96]	0.63	0.45	0.59	0.38
Lead manufactures*	[0.54]	[0.65]	[0.63]	[0.60]	[0.51]	[0.56]	[0.60]	[0.59]	[0.57]	[0.58]
Leather manufactures	[0.93]	0.94	0.98	[0.96]	0.99	0.95	0.95	0.95	0.92	0.93
Linen manufactures, excluding yarn+	0.08	0.08	0.09	0.12	0.12	0.10	0.11	0.13	0.14	0.14
Linen yarn+	0.43	0.32	0.35	0.42	0.32	0.38	0.70	0.74	0.89	0.95
Painters' colours and materials	0.83	0.82	0.79	0.79	0.76	0.79	0.76	0.78	0.77	0.80
Paper and manufactures thereof	0.99	0.92	0.91	0.94	0.97	0.94	[0.99]	[0.96]	1.00	[0.96]
Silk manufactures+	[0.26]	[0.36]	[0.39]	[0.37]	[0.33]	[0.32]	[0.35]	[0.37]	[0.41]	[0.35]
Spirits	[0.41]	[0.61]	[0.55]	[0.59]	[0.56]	[0.58]	[0.58]	[0.64]	[0.74]	[0.74]
Woollen and worsted manufactures, excluding yarn+	0.61	0.50	0.48	0.51	0.51	0.56	0.58	0.54	0.61	0.63
Woollen and worsted yarn+	0.71	0.59	0.68	0.76	0.65	0.63	0.72	0.70	0.68	0.72

Source: Calculated from *Trade of the United Kingdom*. See text.

Notes: * indicates a capital goods industry. + indicates a textile industry. G-L indices for net-import industries are noted in brackets.

Grubel-Lloyd indices for British manufacturing industries, 1870-94 (continued)

	1890	1891	1892	1893	1894	1870-94 (mean)
Alkali	0.03	0.04	0.04	0.08	0.12	0.08
Books	0.34	0.33	0.33	0.33	0.35	0.32
Caoutchouc manufactures*	0.46	0.45	0.50	0.48	0.56	0.33
Chemical products and preparations, not elsewhere specified	0.77	0.81	0.86	0.76	0.79	0.86
Copper manufactures*	0.79	0.79	0.64	0.81	0.85	0.86
Cordage and twine*	[0.95]	[0.87]	[0.90]	[0.89]	[0.82]	0.86
Cotton manufactures, excluding yarn+	0.07	0.09	0.10	0.09	0.09	0.07
Cotton yarn+	0.07	0.09	0.09	0.08	0.08	0.06
Drugs and medicinal preparations	0.90	0.87	0.90	0.92	0.90	0.86
Earthenware and chinaware	0.40	0.44	0.45	0.45	0.49	0.38
Glass	[0.68]	[0.61]	[0.53]	[0.48]	[0.46]	0.73
Hats	0.26	0.24	0.23	0.23	0.29	0.27
Iron, steel, and manufactures thereof, including machinery*	0.21	0.24	0.26	0.27	0.29	0.22
Jute yarn	0.40	0.44	0.31	0.29	0.25	0.45
Lead manufactures*	[0.56]	[0.48]	[0.53]	[0.46]	[0.51]	0.61
Leather manufactures	0.92	0.96	[0.96]	[0.94]	[0.91]	0.92
Linen manufactures, excluding yarn+	0.14	0.16	0.14	0.14	0.17	0.10
Linen yarn+	0.88	0.92	0.94	0.85	0.81	0.49
Painters’ colours and materials	0.79	0.75	0.80	0.82	0.80	0.76
Paper and manufactures thereof	[0.92]	[0.89]	[0.79]	[0.77]	[0.69]	0.93
Silk manufactures+	[0.33]	[0.27]	[0.25]	[0.23]	[0.17]	0.30
Spirits	[0.70]	[0.69]	[0.74]	[0.74]	[0.76]	0.46
Woollen and worsted manufactures, excluding yarn+	0.63	0.69	0.71	0.77	0.82	0.51
Woollen and worsted yarn+	0.65	0.65	0.64	0.55	0.54	0.59

Source: Calculated from *Trade of the United Kingdom*. See text.

Notes: * indicates a capital goods industry. + indicates a textile industry. G-L indices for net-import industries are noted in brackets.