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## Abstract

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JEL Classification: E01, N13, N14

Keywords: Ireland, Industrial Production, Famine, historical national accounts



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Seán Kenny, Jason Lennard and Kevin Hjortshøj O'Rourke*

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## 1. Introduction

The question of how well the Irish economy fared during the Union with Great Britain has always been politically fraught. On the one hand, Irish nationalists blamed the British connection for Ireland's relative underdevelopment, and in particular its failure to industrialize. To Arthur Griffith, founder of Sinn Féin, manufacturing was essential for prosperity, protection was required for Irish manufacturing to develop, and independence was needed to make protection possible (Griffith, 1918). On the other hand, optimists at the time and subsequently pointed to improvements in living standards after the Famine. The more data we have that can speak to such debates, the better.

Despite many significant advances in recent years, quantifying the 19th century Irish economy remains a work in progress. We lack annual or even decennial national accounts of the sort now available for most Western European countries. There have been estimates for individual years: the eve of the Famine (Mokyr, 1985); 1907 (Bielenberg and O'Mahony, 1998); 1911 (Cullen, 1995); and 1914 (Ó Gráda, 1994). There have also been a series of proxy estimates: O'Rourke (1998) uses monetary data and econometrically-estimated velocity figures to guesstimate Irish GDP from 1864 to 1913 (but stresses the fragility of the series); Andersson and Lennard (2019) use a wide range of economic time series and dynamic factor methods to estimate real GDP between 1842 and 1913; and Geary and Stark (2002; 2015) use decadal census information on employment by broad sector (agriculture, industry, and services) and sectoral wages (assumed proportional to sectoral productivities) to distribute UK GDP across its constituent regions (including Ireland) for the period 1861-1911. But none of these contributions spans the entire period of the Union, and none of the

multi-year estimates are based on the detailed quantification of either output, expenditure or income that is standard in the literature.

Ongoing efforts to produce more systematic evidence on a par with that produced for other countries have largely focussed on the income approach (Begley et al., 2010). But there are good reasons to also focus on output, since from the Famine on the Irish administration produced official agricultural statistics that were high-quality in the context of the time (Turner, 1996; but see also Solar, 1998). Indeed, several of the afore-mentioned point estimates used output data; it also bears mentioning that Broadberry et al. (2015) have used output data to push British GDP estimates back far beyond the 19th century, into periods much less well documented statistically than 19th century Ireland.

In a series of publications Andrew Bielenberg has highlighted the wealth of industrial data available for Ireland under the Union (Bielenberg, 1994, 2003a, 2003b, 2008, 2009; Bielenberg and Johnson, 1998; Bielenberg and O'Mahony, 1998; Bielenberg and Solar, 2007), and he and Geary have used these to calculate long-run manufacturing growth rates during the first two quarters of the 19th century (Bielenberg and Geary, 2006). Such estimates are essential in adjudicating long-standing debates about Irish economic performance both before and after the Famine. How good, or bad, was it, both before and after the Famine, relative to other periods of Irish history? Relative to Britain? Relative to the experiences of other small, agricultural countries close to Britain, such as Denmark? And does the answer depend on whether you look at growth in absolute, or per capita, terms?

The mainstream nationalist view, associated not just with politicians like Griffith but with traditional historians like George O'Brien (1921), was that the Act of Union was devastating for Irish economic development since it exposed Irish industry to the full force of British competition, making it impossible for the country to adopt trade or industrial policies that were suited to its particular stage of development. Overall growth was disappointing, and this was driven above all by a poor industrial performance. Louis Cullen (1972) took issue with O'Brien: the lack of a national trade policy was not crucial, and in any event deindustrialization was not a general phenomenon, but limited to textiles. Mokyr (1985) disagreed with Cullen, arguing that pre-Famine Ireland did in fact experience deindustrialization; Ó Gráda (1994) agreed that industrial decline across much of the country was a problem, but doubted that trade policy had much to do with this. The question of whether or not Ireland de-industrialized before the Famine has thus taken on considerable analytical, as well as purely factual, significance in the literature.

Irish industrial growth is also important in assessing the country's post-Famine economic performance. There is little doubt that Irish living standards converged dramatically on British ones between the Famine and World War I: this emerges from the per capita GDP point estimates cited earlier, and it emerges even more strongly from the available real wage evidence (Williamson, 1994; Hatton and Williamson, 1994; O'Rourke and Williamson, 1999). The question is why. An obvious candidate is emigration: post-Famine Ireland was unique in seeing a continuous decline in population that lasted until well into the 20$^{th}$ century. Per capita improvement that was due to a fall in the number of capitas would obviously appear less impressive than growth based on agricultural improvement or industrialization. Hatton, O'Rourke, Williamson and others attribute the bulk of the real

wage convergence to migration; Begley et al. (2016) dispute the extent of the convergence and downplay the role of emigration in bringing it about. According to them, TFP change, capital accumulation and structural change – the sorts of factors driving growth in other European economies at the time – were more important. This argument would be strengthened if Irish industry grew rapidly between the Famine and World War I.

We make use of many of the series collected by Bielenberg and others, as well as series collected by ourselves, to create a compendium of industrial data that is as comprehensive as possible for Ireland under the Union. We then discuss these series' coverage and reliability. Based on that, we have restricted ourselves to constructing an annual industrial output index spanning the period 1840-1913. However, in an appendix we present the underlying individual series for all the years they are available, in the hope that this may prove useful for future researchers.

We begin by outlining the methodology used to construct our index, before presenting the main results in Section 3. After a brief discussion of the robustness of our results we place Ireland's 19$^{th}$ century industrial performance in a comparative perspective, asking what our results mean for the debate about Irish performance, or under-performance, after the Famine.

## 2. Data and methodology

### *A. Data*

We have collected data on the output of 30 industries. This involved collecting new data, such as the output of biscuits, gas, and newspapers, and collating existing data, such as the production of spirits. The series, coverage, sources, and transformations are outlined in Appendix I.

The series measure the domestic output of Irish industries. However, in some cases these data were not directly available, as is common when constructing historical industrial production indices. We therefore use a number of indirect measures. First, imports are sometimes used to proxy domestic output when the major input into the industry in question was imported, as in the case of cotton or cocoa (Davis, 2004; Bielenberg and Solar, 2007). Second, exports are sometimes used as a proxy if the bulk of domestic output was exported, as in the case of mackerel (P.P., 1906). Third, we use the output of a major firm if it produced a significant fraction of domestic output (Davis, 2004). For example, we use the output of Jacob's, which was "by far the largest-biscuit making firm in Ireland" (Bielenberg, 2009, p. 73). Where we use a substitute instead of a direct measure of output, we not only make this clear but also provide supporting evidence to justify our choice. However, we do not resort to wholesale prices, equity prices, other financial variables, or employment figures. Romer (1991), Calomiris and Hanes (1994), and Davis (2004) stress the importance of avoiding such series.

A handful of series are measured in nominal, as opposed to real, terms: bread and biscuits; canals, docks, etc.; local authorities; tramway/light rail; and water (public). In the case of bread and biscuits, we deflated nominal output using a specific bread and biscuits deflator (Mitchell, 1988, p. 771). In the other cases, an industry-specific deflator was not available. In such cases, we deflated nominal output using a new industrial price index, which is shown (for the years 1840-1913) in Figure 1. The index is based on the prices of 25 individual items, which are described in Appendix II. These individual items are aggregated into an industrial price index using the same procedures as are applied to the industrial production index (see below).

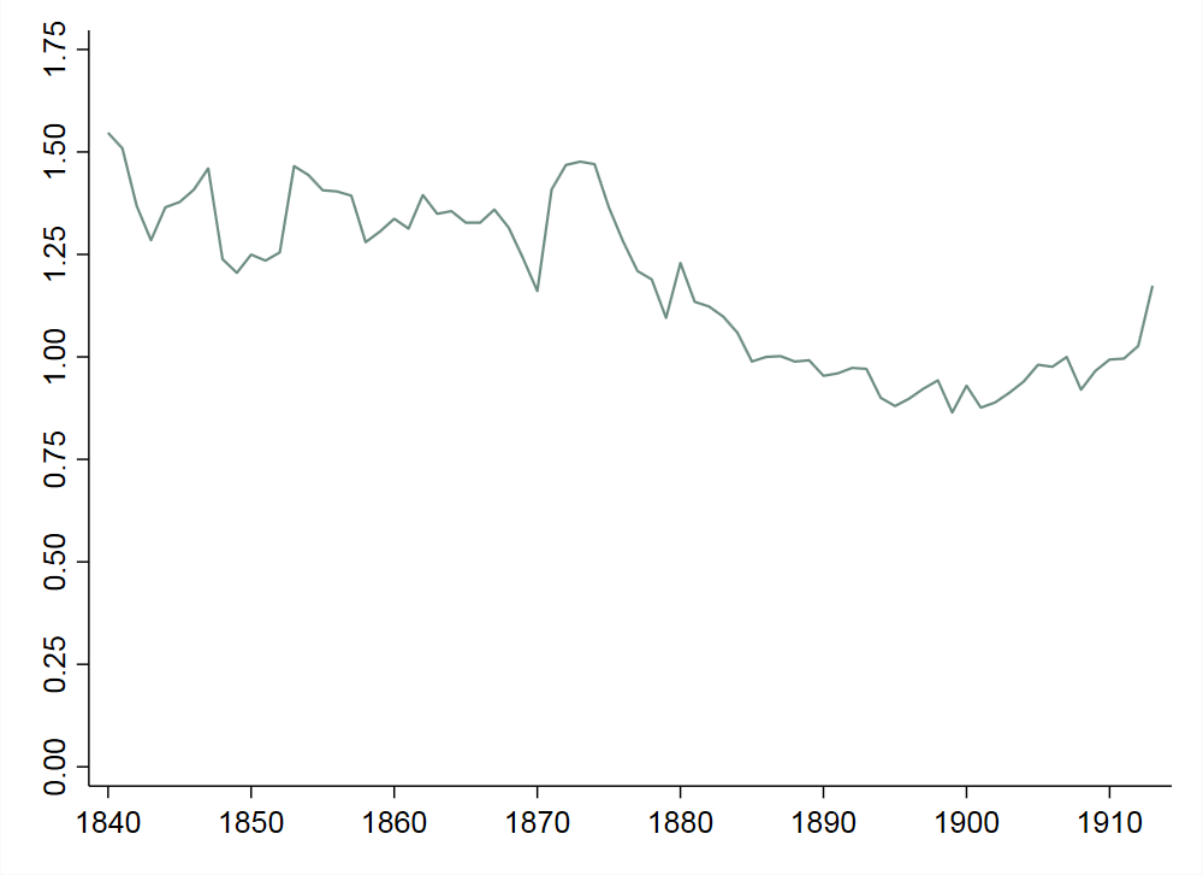


**Figure 1. New annual index of Irish industrial prices, 1840-1913 (1907 = 1)**

*Source:* See text.

**Table 1. Value-added weights (%)**

| | Industry group | Industry | | Industry group | Industry |
|---|---|---|---|---|---|
| **Food and drink** | 29.96 | | **Building and contracting** | 5.62 | |
| Brewing | | 15.49 | Building and contracting | | 4.30 |
| Bread and biscuits | | 4.21 | Glass/stone/roof felt/etc. | | 0.66 |
| Grain milling | | 3.07 | Brick and fireclay trades | | 0.38 |
| Spirits | | 2.25 | Works/public buildings | | 0.17 |
| Butter, cheese, marg. etc. | | 1.56 | Other trades | | 0.09 |
| Aerated waters, etc. | | 1.08 | Naval buildings | | 0.02 |
| Bacon curing | | 0.95 | **Papers, newspapers, etc.** | 4.51 | |
| Bottling | | 0.63 | Printing/bookbinding | | 1.99 |
| Cocoa, confectionery, etc. | | 0.42 | Newspapers/periodicals | | 1.88 |
| Other food and drink | | 0.22 | Paper trade | | 0.26 |
| Fish curing | | 0.06 | Stationery | | 0.18 |
| Sugar and glucose | | 0.00 | Cardboard boxes | | 0.17 |
| **Textiles** | 23.83 | | Other paper, newspapers etc. | | 0.03 |
| Jute, hemp, linen | | 19.19 | **Timber trades** | 2.38 | |
| Bleach, dyeing, printing etc. | | 1.80 | Timber trades | | 1.11 |
| Woollen and worsted | | 1.09 | Furniture/furnishing | | 0.68 |
| Rope, twine, net | | 0.77 | Carriages/carts, etc. | | 0.35 |
| Cotton trade | | 0.35 | Wooden crates/cases | | 0.16 |
| Flax scutching | | 0.32 | Other timber trades | | 0.08 |
| Hosiery | | 0.14 | **Chemicals, etc.** | 1.58 | |
| Silk | | 0.13 | Fertilizer/disinfectants | | 0.80 |
| Other textiles | | 0.03 | Soap/candles | | 0.38 |
| **Iron, shipbuilding, etc.** | 11.50 | | Chemical trades | | 0.22 |
| Shipbuilding/other | | 6.01 | Other chemicals, etc. | | 0.18 |
| Railways | | 2.74 | **Mining/quarrying** | 0.83 | |
| Engineering trades | | 2.20 | Limestone quarries, etc. | | 0.26 |
| Iron and steel | | 0.18 | Other quarries | | 0.22 |
| Govt yards/lighthouses | | 0.14 | Coal and ironstone | | 0.18 |
| Cycle/motor trades | | 0.11 | Other mining/quarrying | | 0.11 |
| Blacksmithing trade | | 0.08 | Slate quarries | | 0.06 |
| Tools/implements | | 0.04 | Coke works | | 0.00 |
| **Clothing** | 9.47 | | Oil shale mines | | 0.00 |
| Clothing, handkerchiefs, and millinery | | 7.88 | **Leather** | 0.35 | |
| Laundry, cleaning and dyeing | | 0.99 | Leather | | 0.13 |
| Boots and shoe trades | | 0.51 | Saddlery/harness | | 0.13 |
| Hats, caps, and bonnets | | 0.05 | Other leather | | 0.09 |
| Other clothing | | 0.05 | **Other metals** | 0.22 | |
| **Utilities** | 8.36 | | **Miscellaneous** | 0.12 | |
| Local authorities | | 4.19 | Other miscellaneous | | 0.09 |
| Gas | | 2.42 | Musical instruments | | 0.03 |
| Water (public) | | 0.80 | **Excluded residual** | 1.26 | |
| Electricity | | 0.49 | | | |
| Tramway/light rail | | 0.20 | | | |
| Telephone | | 0.16 | | | |
| Water (companies) | | 0.08 | | | |
| Canals, docks, etc. | | 0.02 | | | |

*Source:* Bielenberg (2008).

*B. Industrial structure*

In order to construct an index of industrial production, the output of individual industries must be weighted to reflect their relative importance. A number of historical industrial production indices weight by employment (Harley, 1982; Bielenberg and Geary, 2006). However, the best practice is to weight by value added (Davis, 2004). Our weights are based on Bielenberg's revisions to the *First census of production of the United Kingdom* (P.P., 1912; Bielenberg, 2008). Among other things, the census recorded the value added in 77 Irish industries in 1907, which is the base year of our index. Table 1 shows the value added in these 77 industries.

An interesting feature of Irish industry was how concentrated in a few major industries it was. The top four industries (jute, hemp, and linen; brewing; clothing, handkerchiefs, and millinery; and shipbuilding/other) accounted for 48.6 per cent of industrial value added in 1907; the equivalent figure in the UK as a whole was just 34.4 per cent. More systematically, using the Herfindahl index we can compute the degree of industrial concentration as the sum of squares of the value-added shares for each of the 77 industries reported in Table 1 ($H = \sum_{i=1}^{N} v_{i0}^2$, where $v_{i0}$ is the value-added share of industry $i$ in 1907). We can also do this for the UK as a whole, since Bielenberg also reports the UK value-added shares for the same industries. The Herfindahl index for Ireland was 0.0819, while for the UK it was 0.0507, implying a much higher degree of concentration in Ireland. Figure 2 shows the cumulative share of value added for the 77 industries in Ireland and the UK. Again, concentration was much higher in Ireland. The practical implication is that a few, high value-added industries

account for a significant share of total industrial output in Ireland. A more diffuse industrial concentration, such as Britain's, requires more series to achieve the same coverage. We do not have output series for all 77 industries. Nevertheless, at 30 series our index is not light on data, and the 30 series account for 78.5 per cent of industrial value added in 1907. The oft-cited Miron-Romer and Davis indices of US industrial production are based on 13 and 41 series respectively (Miron and Romer, 1990; Davis, 2004).

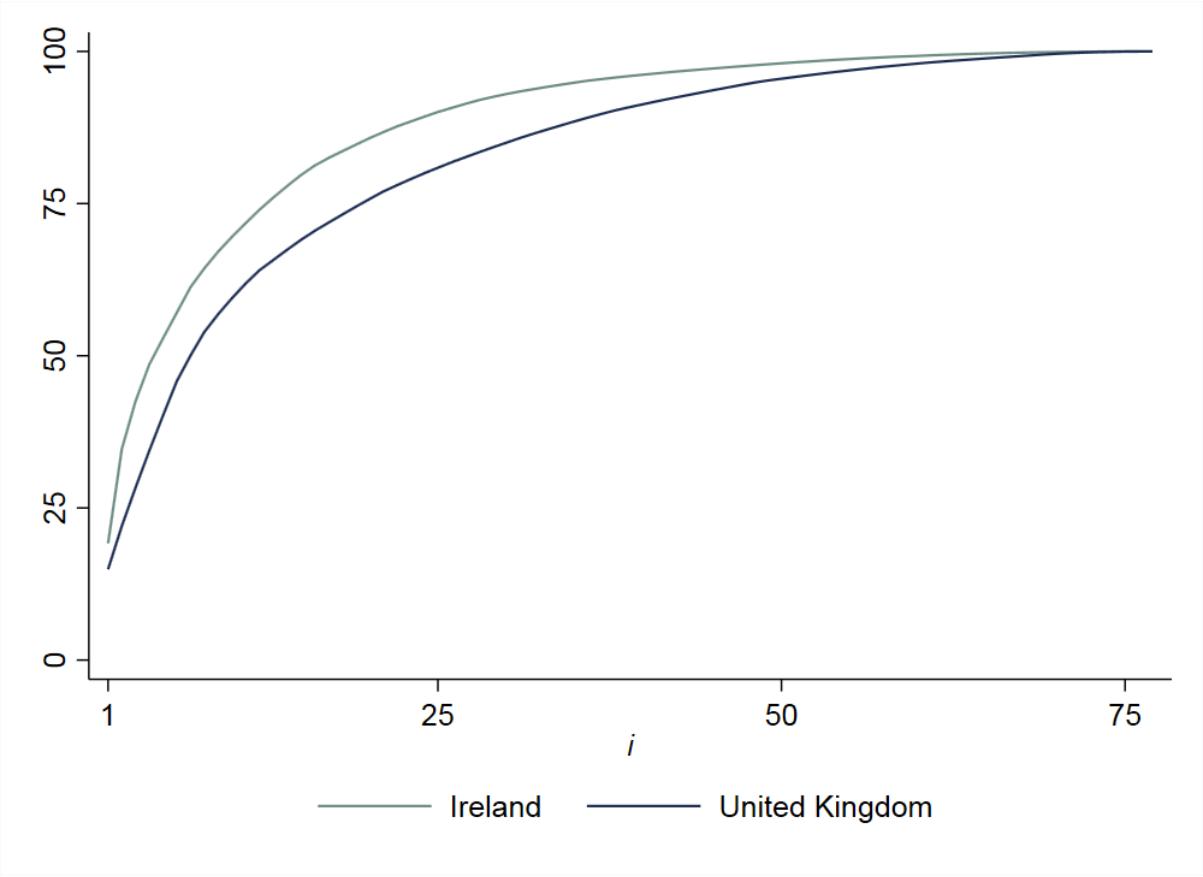


**Figure 2. Cumulative share of value added in Irish and UK industries (%)**

*Note and source:* Calculated from Bielenberg (2008).

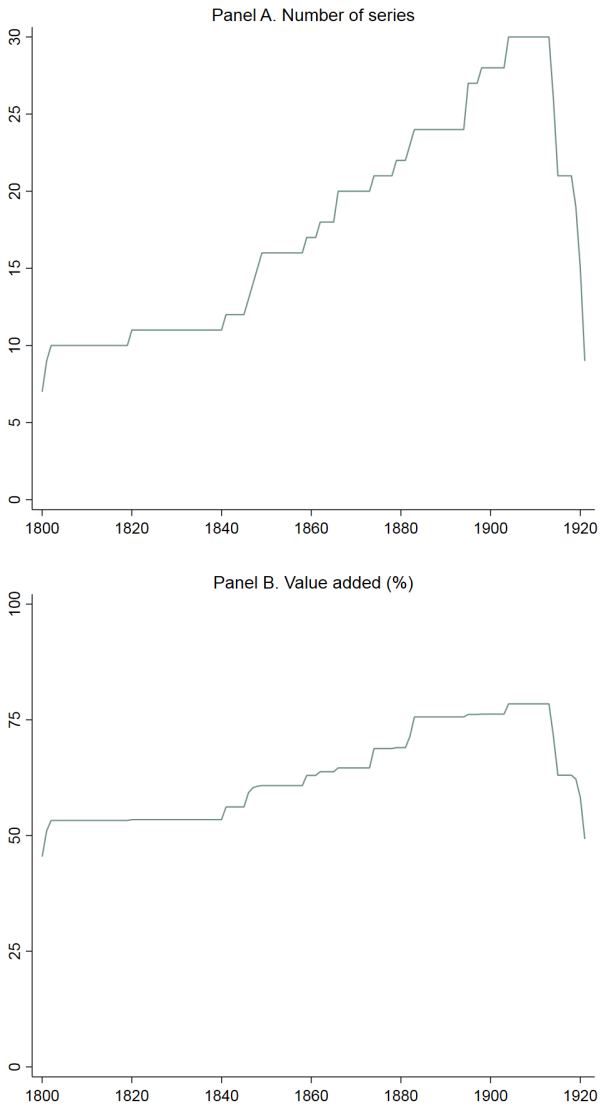


**Figure 3. The quantity of data, 1800-1921**

*Source:* See text.

*C. The quantity and quality of data*

As stated above, our objective was to collect as much data as possible for the period during the Union with Great Britain (1800-1921). The question then is to determine how reliable these data are, and how good is the coverage which they provide. In terms of quantity, panels A and B of Figure 3 show the number of series available in each year (the maximum

being 30) and their share of 1907 value added. The results suggest that the coverage is quite poor both before 1840 and after 1913, as the First World War and the struggle for independence disrupted the flow of economic statistics. Our series capture an average of 53 per cent of 1907 value added prior to 1840, but this figure then rises steadily, reaching a peak of 78 per cent between 1904 and 1913, before plunging to just 49 per cent in 1921.

In terms of quality, the margins of error associated with the series can be conveyed with reliability grades, which should help to indicate the periods in which the data are strongest and weakest. The classification system, based on Feinstein's (1972) classic work, is set out in Table 2. The grades run from A (firm figures of less than ±5 per cent) to D (conjectures of more than ±25 per cent). As Feinstein (1972, p. 20) noted, these grades are "no more than the investigator's 'best guess' as to the likely margins of error."

**Table 2. Reliability grades**

| Reliability grade | | Margin of error |
|---|---|---|
| A | Firm figures | ± less than 5% |
| B | Good estimates | ± 5% to 15% |
| C | Rough estimates | ± 15% to 25% |
| D | Conjectures | ± more than 25% |

Figure 4 plots the number of series by grade between 1800 and 1921. The quality of the series is relatively low before 1840 and after 1913. As a result, in this paper we have chosen to present an index only for the relatively reliable middle years between 1840 and 1913. All of our individual industry data are being made available to other researchers, however, in

the hope that future research will be able to extend our index forward and backward in time.[1]

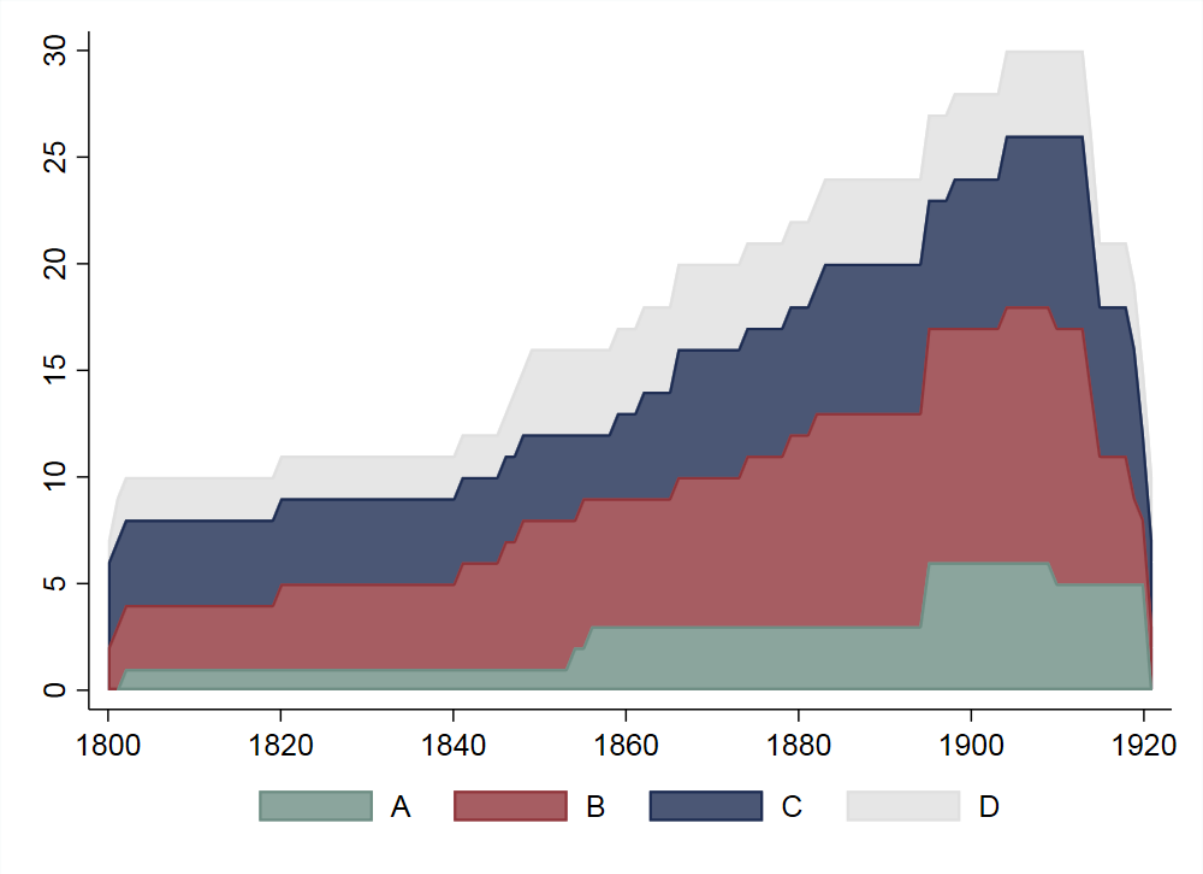


**Figure 4. The quality of data, 1800-1921**

*Source:* See text.

*D. Methodology*

Armed with the output and value added of individual industries, we can calculate a Laspeyres quantity index:

[1] The data are available at https://nyuad.nyu.edu/en/research/faculty-labs-and-projects/social-science-history-lab/data.html.

$$IP_t = \sum_{i=1}^{N} ip_{it} v_{i0} \quad (1)$$

where $ip_{it}$ is the output of industry $i$ at time $t$ relative to 1907 and $v_{i0}$ is again the value-added share of industry $i$ in 1907 (Davis, 2004).

*E. Challenges*

Constructing a historical industrial production index for any country involves a number of challenges. The first is a lack of data for all industries at all times, as discussed above. One way we address this is to use "imputed weighting" (Frickey, 1947, p. 25; Davis, 2004). This involves reallocating the weight of a missing industry to the other industries in the group. For example, for the industry group "leather", which includes leather; saddlery/harness; and other leather, we have data for leather but not for saddlery/harness or other leather. We therefore allow our series for leather to stand in for the entire industry group, assigning it the entire weight of the latter (0.35 per cent). If data for an industry group is missing, we reallocate its weight to the groups that we have data for. In order to avoid jumps in the series, for each year that the data coverage changes, we splice our index with an alternative index excluding the industry for which there is no data (Miron and Romer, 1990; Davis, 2004). To explore the robustness of our imputed weighting procedure, in Section 4 we cap the weight of Ireland's leading industries so that, where value added is reallocated, it is not reallocated to the largest industries, which may be unrepresentative of industries in general and dissimilar to those that are missing. Another way of addressing missing data is that for a

small number of observations, we log-linearly interpolate to fill the gaps that are listed in Appendix I.

A second challenge concerns changes in relative prices over time. In periods of rapid technological change the prices of goods in fast-growing industries often fall relative to those in other industries, meaning that the value-added shares calculated in one period are poor proxies for the value added in others (Harley, 1982). Ideally, this can be overcome by using multiple value-added benchmarks. Unfortunately, the 1907 census was the first to report net output in Irish industries. In order to gauge the importance of this issue, we use two alternative estimates of value added in Section 4, one in 1840-5 and another in 1907, for a coarser set of industry groups (Bielenberg, 1994, p. 226).

Another challenge is "survivorship bias", which can occur when the output of a major firm is used to proxy the output of the industry: these firms may suffer idiosyncratic shocks or not resemble smaller or defunct firms in the industry (Davis, 2004). Given our relatively light use of such series it is unlikely that this is a major problem in our index, but Section 4 explores the impact of dropping brewing, for which Guinness is used as a proxy (but only from 1910 to 1913).

A final challenge is conceptual: which industries should be included in an index of industrial production? There are two possibilities. The first is to use contemporary classifications so that we include the industries covered by the *First census of production of the United Kingdom* (P.P., 1912). The second is to use modern classifications such as the Standard Industrial Classification (SIC). In this context, the main difference between the two is that

local authorities are included in the contemporary definition but excluded from modern classifications. While the provision of government services is not included in an index of industrial production, the category captured by the *First census of production* focuses on works done on public buildings, highway and bridges, street and road lighting, tunnels and subways, etc. Therefore, it is closer to industry than to services. In addition, this definition is also in keeping with the historiography (Bielenberg, 2008). On balance, we opt to base our index on the contemporary classification. However, in Section 4 we recalculate the index on a modern footing by excluding local authorities.

**3. Results**

We now turn to the results. Figure AIII.1 shows the estimates of output by industry for the entire 1800-1921 period. Figure 5 presents new sub-indices of industrial production between 1840 and 1913, for four broad categories: mining and quarrying; manufacturing; building and construction; and utilities. Panels A and B of Figure 6 plot the new aggregate industry index in levels and logs. Between 1840 and 1913, industrial production grew by 1.4 per cent on average, the same rate as manufacturing.[2] On this basis, output doubled roughly every 50 years, implying a 180 per cent increase over almost 75 years.

[2] The average growth rates reported in the text are compounded.

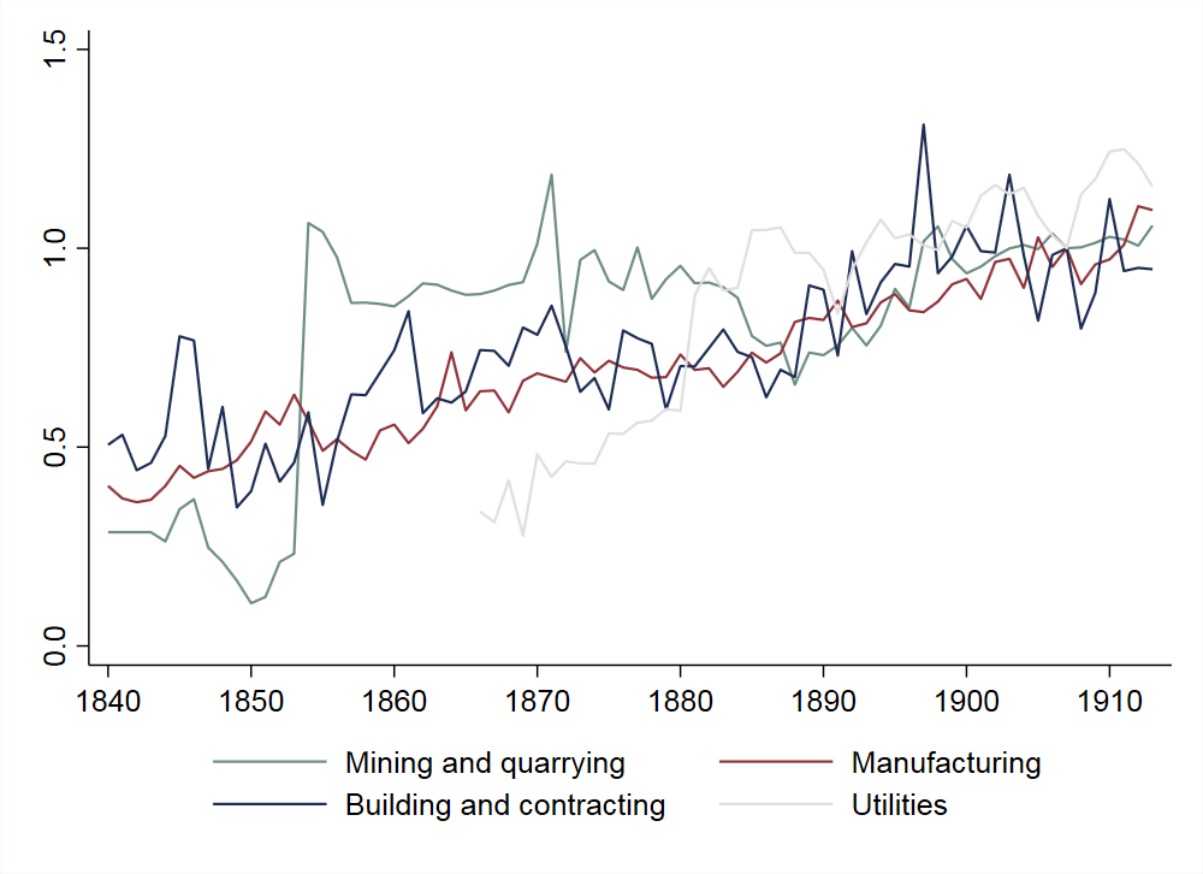


**Figure 5. New annual sub-indices of Irish industrial production, 1840-1913 (1907 = 1)**

*Source:* See text.

The overall pace of industrial expansion between 1845 and 1907 (1.3 per cent) is a little slower than that reported by Bielenberg (1994, p. 254) (1.5-1.7 per cent). Industrial growth between the Famine and World War I (1851-1913) averaged 1.1 per cent per annum. Since population was falling during the period, this absolute growth rate translated into a significantly faster per capita growth rate of 1.8 per cent per annum.[3]

[3] The average growth rate of manufacturing output per capita between 1851 and 1913 was 1.8 per cent per annum.

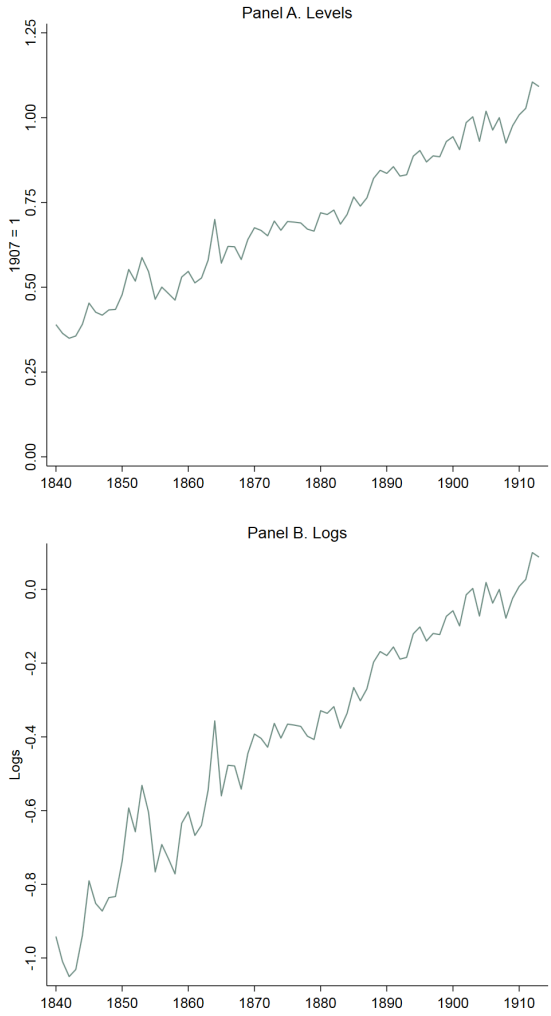


**Figure 6. New annual index of Irish industrial production, 1840-1913**

*Source:* See text.

What accounted for the growth of Irish industry? While it is not possible to compile a full set of growth accounts without information on the capital stock, we can decompose industrial production ($IP_t$) into a term that measures industrial labour productivity ($IP_t/L_t$), a term that captures industrial labour force participation ($L_t/N_t$) and a term that accounts for population ($N_t$) using the following identity:

$$IP_t = \frac{IP_t}{L_t}\frac{L_t}{N_t}N_t \quad (2)$$

where $IP_t$ is industrial production, $L_t$ is the number of industrial employees and $N_t$ is population at time $t$. The results are reported in Table 3 for the census years between 1841 and 1911, indexing industrial production, industrial labour productivity and population to be equal to 1 in 1841. The growth in industrial production, which increased by a factor of 2.8, was due to remarkable labour productivity growth, which rose by 3 per cent per year on average.[4] The strong productivity growth in industry does not depend on the new data. If we relied on the growth rates from Bielenberg (1994), we would find that productivity improved by 3 to 3.2 per cent a year in this period. Weighing against this though was two factors. First, a decline in industrial labour force participation, as the share of the population working in industry declined from 13.4 per cent in 1841 to 9.2 per cent in 1911, a fall of almost a third. Second, a decrease in population, which fell by 47 per cent.

These results have important implications for the debate on deindustrialization. On one hand, focusing on employment (Geary, 1998) suggests that industry was dwindling. On the other hand, studying industrial production (Bielenberg and Geary, 2006) leads to the conclusion that industry was flourishing. Table 3 reconciles these views. The output of Irish industry expanded despite a shrinking industrial labour force due to the productivity growth of those that remained. But the fact that the share of the labour force employed in industry declined means that higher Irish living standards growth, relative to growth in Britain, the US and elsewhere, was not due to the structural transformation associated with

[4] Table AIII.1 shows that labour productivity growth was faster in Ireland than in the United Kingdom.

industrialization that was driving catch-up growth in other countries during this and subsequent periods (see Broadberry, 1998 and Temin, 2002 among many others).

**Table 3. Growth accounting (1841 = 1)**

| | Industrial production | Industrial labour productivity | Industrial labour force participation (%) | Population |
|---|---|---|---|---|
| 1841 | 1.00 | 1.00 | 13.39 | 1.00 |
| 1851 | 1.52 | 2.09 | 12.23 | 0.79 |
| 1861 | 1.41 | 2.34 | 11.39 | 0.71 |
| 1871 | 1.83 | 3.48 | 10.72 | 0.66 |
| 1881 | 1.96 | 4.47 | 9.36 | 0.63 |
| 1891 | 2.35 | 5.42 | 10.17 | 0.57 |
| 1901 | 2.49 | 6.07 | 10.12 | 0.54 |
| 1911 | 2.82 | 7.72 | 9.15 | 0.53 |

*Sources:* Industrial production: see text. Industrial employees: Geary (1998) and Geary and Stark (2002). Population: Mitchell (1988, pp. 11-3).

An interesting question is whether the strong labour productivity growth was simply due to a declining labour force or due to total factor productivity growth and/or capital deepening. To answer this question, we first decompose the labour productivity term, ($IP_t/L_t$), into:

$$\frac{IP_t}{L_t} = A_t {K_t}^{\alpha} {L_t}^{-\alpha} \quad (3)$$

where $A_t$ is industrial total factor productivity, $K_t$ is industrial capital, $L_t$ is industrial employees and $\alpha$ is the elasticity of industrial production with respect to industrial capital. We then rewrite equation (3) in terms of the rate of growth of labour productivity:

$$\Delta \ln \left(\frac{IP_t}{L_t}\right) = \Delta \ln A_t + \alpha \Delta \ln K_t - \alpha \Delta \ln L_t \quad (4)$$

Despite not observing total factor productivity or capital, we can explore the counterfactual of what would have happened to labour productivity given the actual fall in the industrial labour force but holding total factor productivity and capital fixed. The difference between the actual and counterfactual outcomes is due to efficiency gains and/or capital deepening. Table 4 reports the results for three values of the elasticity: a medium value of $\alpha = 0.4$ that is standard in the literature (Broadberry and de Pleijt, 2021), a low value of $\alpha = 0.3$ and a high value of $\alpha = 0.5$.

**Table 4. Decomposing labour productivity growth, 1841-1911**

| | Actual change in log labour productivity | Counterfactual change in log labour productivity | Due to change in employees (%) | Due to total factor productivity growth and capital deepening (%) |
|---|---|---|---|---|
| $\alpha = 0.3$ | 2.04 | 0.30 | 14.78 | 85.22 |
| $\alpha = 0.4$ | 2.04 | 0.40 | 19.71 | 80.29 |
| $\alpha = 0.5$ | 2.04 | 0.50 | 24.63 | 75.37 |

*Source*: See text.

The results suggest that there was a boost to labour productivity as a result of the fall in the industrial labour force during and after the Famine. All else equal, a falling labour force will increase the capital-labour ratio, which will raise labour productivity. This is similar to the jump in productivity in Britain following the Black Death (Broadberry and de Pleijt, 2021). However, this was only a small part of the productivity boom. The decline in the industrial labour force only explains between 15 and 25 per cent of the growth in labour productivity, whereas efficiency gains and capital accumulation explain 75 to 85 per cent. Even at the limits, with $\alpha = 1$ or $\alpha = 0$, total factor productivity growth and capital deepening account for between 51 per cent and 100 per cent of the productivity gains.

**4. Robustness**

As noted above constructing historical industrial production indices is challenging for a number of reasons. The first challenge is missing data series. While we have tried to source

as much primary and secondary data on the output of Ireland's various industries as possible, we do not have complete coverage. One way in which we deal with this is as previously stated imputed weighting, which proxies the growth of a missing industry with that of its industry group. On this basis, our index covers a minimum of 78 per cent of 1907 value added and a maximum of 88 per cent.[5]

As we have less than 100 per cent coverage, the value added of the missing industry groups is reallocated to the observed industry groups. In practice, this means that the weights of observed groups are scaled by a factor of up to $1.29 = 1/0.78$. If there was a selection bias, where we had data for the fast-growing, dynamic industries but not for the slow-growing, traditional industries, the growth rate would be upwardly biased. In order to gauge the sensitivity of our results to this issue, we restrict the weights of the three leading industry groups of food and drink; textiles; and iron, shipbuilding, etc by leaving their weights unchanged and adding the value added of the missing industry groups to other observed industry groups.

Figure 7 plots the baseline index alongside the index based on the alternative weights. As can be seen, the two indices are very similar with a correlation in first differences of 0.96 ($p < 0.01$). Growth is precisely the same in both series, averaging 1.4 per cent per year over the period as a whole. This robustness is unsurprising since expansion was not limited to a few superstar industries but was "widespread" (Bielenberg and Geary, 2006).

[5] This is higher than Figure 3 due to imputed weighting.

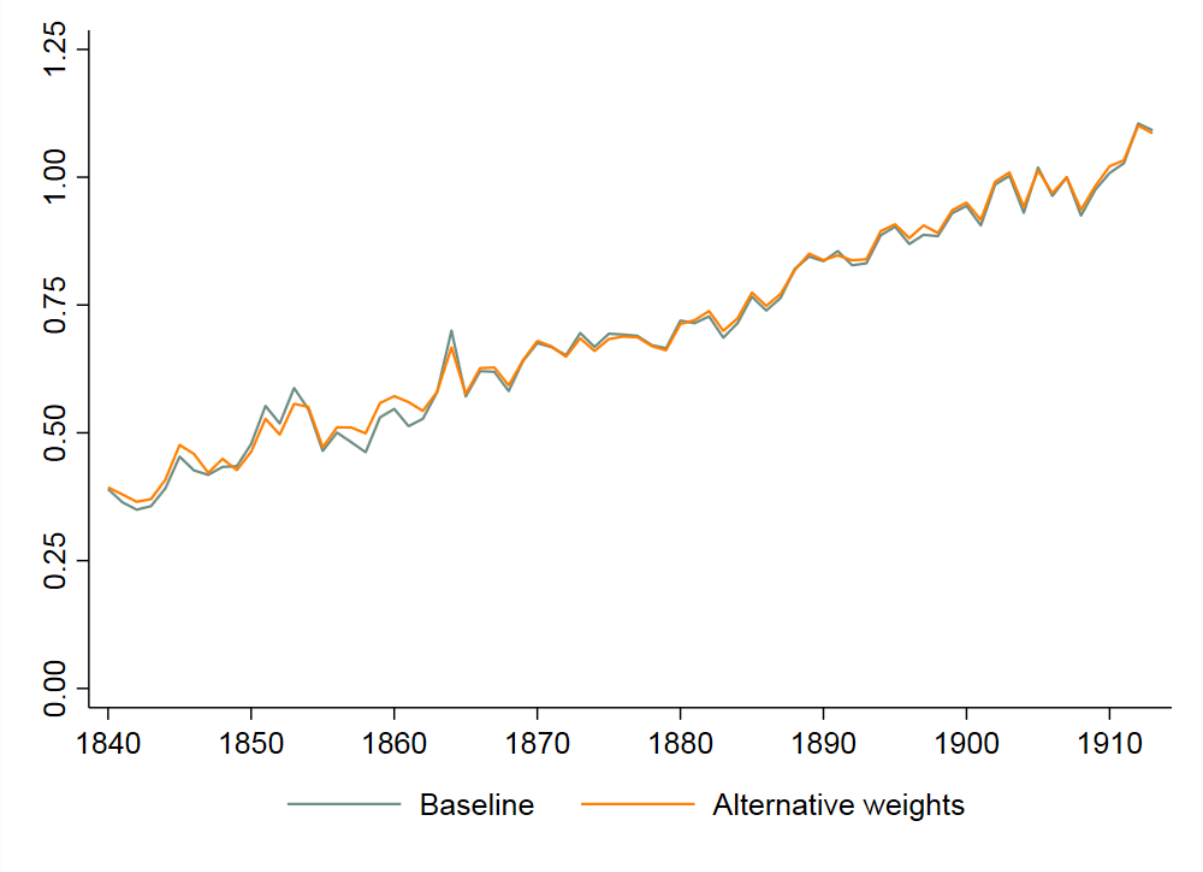


**Figure 7. New annual index of Irish industrial production, 1840-1913: Sensitivity to alternative weights (1907 = 1)**

*Source:* See text.

The second challenge is changes in relative prices. If relative prices changed dramatically over time, the value-added shares from the base year will deteriorate as a measure of relative importance in other periods. The best way to address this issue is to employ multiple benchmarks of value added. Unfortunately, as noted above the first Census of Production was not until 1907. However, Bielenberg (1994) has constructed rough estimates of the value added in current prices for 13 broader industry groups for the years 1840-5 and 1907.

**Table 5. Alternative value-added weights (%)**

| Industry group | 1840-5 | 1907 |
|---|---|---|
| Textiles | 32.2 | 18.1 |
| Food processing | 3.5 | 6.8 |
| Clothing and millinery | 10.7 | 13.5 |
| Brewing | 2.0 | 11.7 |
| Distilling | 5.9 | 3.8 |
| Grain milling | 8.8 | 2.3 |
| Tobacco | 1.0 | 3.8 |
| Construction | 12.1 | 14.5 |
| Shipbuilding | 0.0 | 3.5 |
| Tanning and leather goods | 1.8 | 0.7 |
| Paper printing and stationary | 3.0 | 3.6 |
| Mines and quarries | 1.6 | 0.7 |
| Engineering, timber, chemicals, glass and all other trades | 17.3 | 17.1 |

*Note and source:* Calculated from Bielenberg (1994, p. 226).

The value-added shares for these 13 groups are shown in Table 5. In order to construct an index based on these multiple benchmarks, we first reallocate the series described in Appendix I to the appropriate industry groups and construct industry group indices as unweighted averages. We then calculate aggregate indices based on these industry group indices and either the 1840-5 weights, where 1845 is the base year, or the 1907 weights, where 1907 is the base year. These are then combined into a final index using the method described by Davis (2004). If $x_t^{1840-5}$ is the growth rate of the index based on 1840-5

weights and $x_t^{1907}$ is the growth rate of the index based on 1907 weights, then $x_t^{final} = (1 - w_t)x_t^{1840-5} + w_t x_t^{1907}$, where $w_t = 0 \forall \leq 1845$, $w_t = ((t - 1845)/(1907 - 1845)) \forall 1845 < t < 1907$ and $w_t = 1 \forall \geq 1907$. $x_t^{final}$ is then cumulated to produce an index where 1907 = 1.

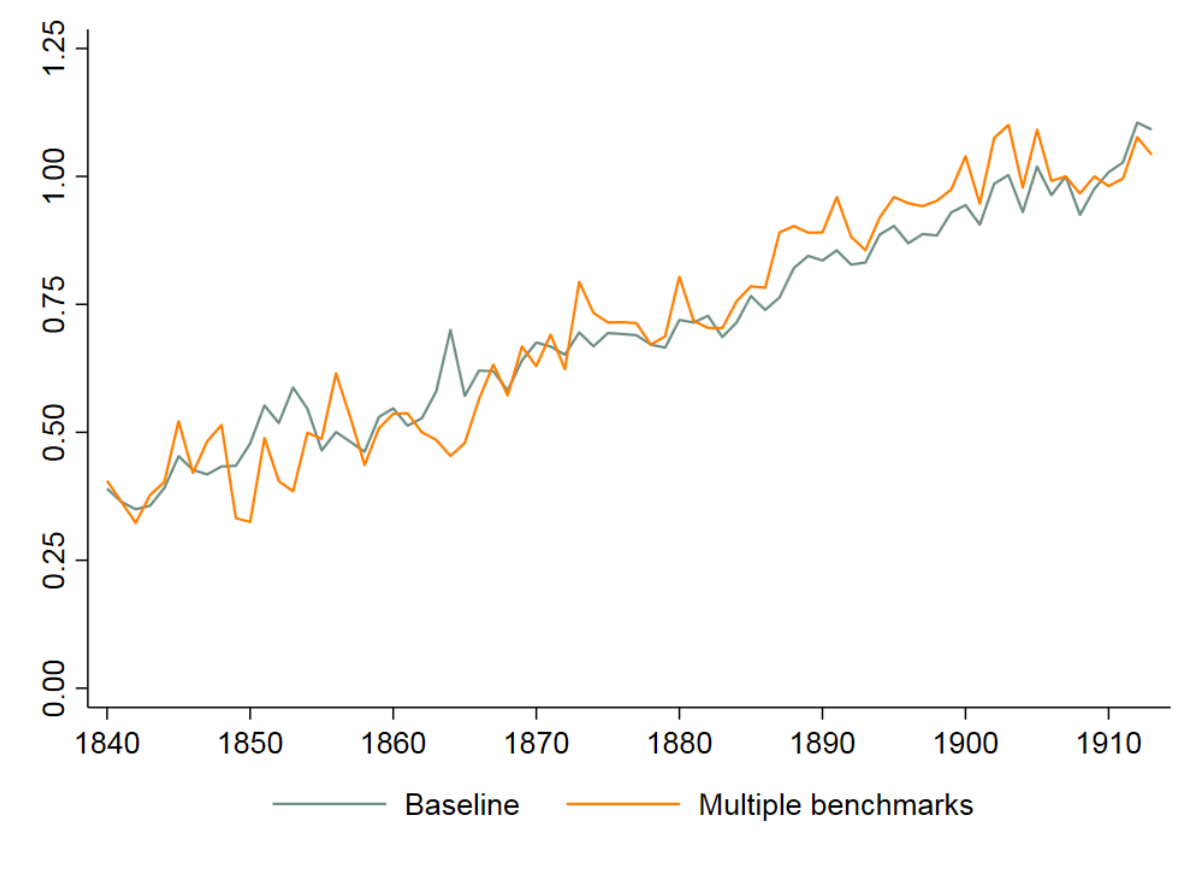


**Figure 8. New annual index of Irish industrial production, 1840-1913: Sensitivity to multiple benchmarks (1907 = 1)**

*Source:* See text.

Figure 8 shows the baseline index alongside the series based on multiple benchmarks of value added. The two indices are similar with a correlation in differences of 0.49 ($p < 0.01$). The average rate of growth for the period as a whole is slightly lower, at 1.3 per cent per

annum, using multiple benchmarks. While it is useful to have these benchmarks as a cross-check, they are not as comprehensive as those based on the *First census of production*, aggregating away industry-level information into industry groups and omitting important industry groups altogether, such as utilities. It is for these reasons that we do not use these weights in our baseline index.

Beyond such general challenges facing those constructing historical industrial production indices, there is an issue specific to Ireland. As Guinness was so large, there is a risk that the index may say more about the performance of Guinness than of Irish industry generally (Grossman et al., 2014). This issue may be exacerbated because the output of Guinness is used as a proxy for brewing between 1910 and 1913.

Figure 9 shows that excluding brewing, of which Guinness was an important part, reduces the growth of industrial production to 1.3 per cent between 1840 and 1913. The fluctuations are similar with a correlation in first differences of 0.98 ($p < 0.01$). While the overall trend is shallower, it should be noted that it is entirely correct to include Guinness and brewing in the index and that the growth of any economic statistic will be reduced when its large, fast-growing components are removed.

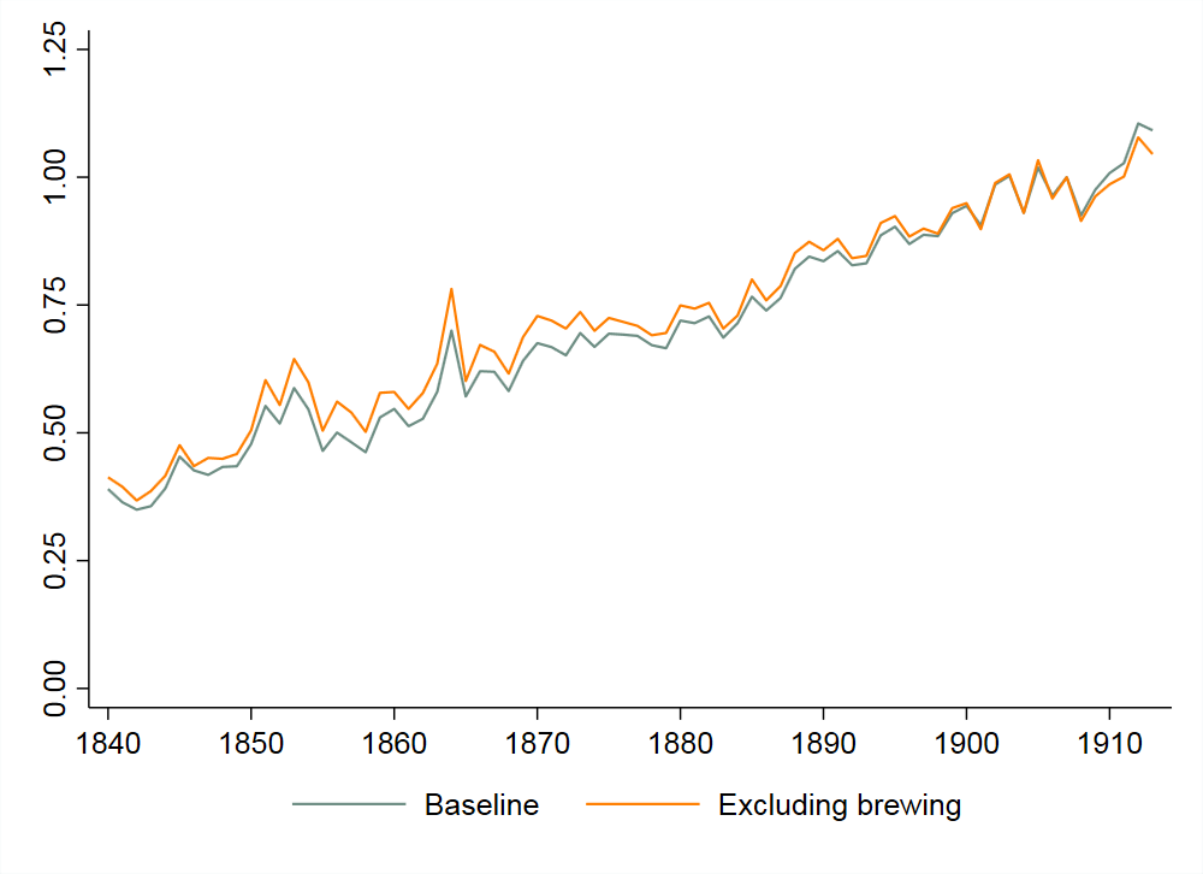


**Figure 9. New annual index of Irish industrial production, 1840-1913: Sensitivity to excluding brewing (1907 = 1)**

*Source:* See text.

Figure 10 shows that altering our definition of industry so that local authorities are excluded has little effect on the index. The average growth rate for 1840-1913 is unchanged and the correlation in first differences between the two series is 0.996 ($p < 0.01$).

In summary, we have gauged the robustness of our index in four ways: holding constant the value-added weights of Ireland's leading industries rather than adjusting them upwards to account for missing data; using two benchmarks for value added; excluding brewing; and

removing local authorities. Our index appears to be robust to reasonable methodological alternatives.

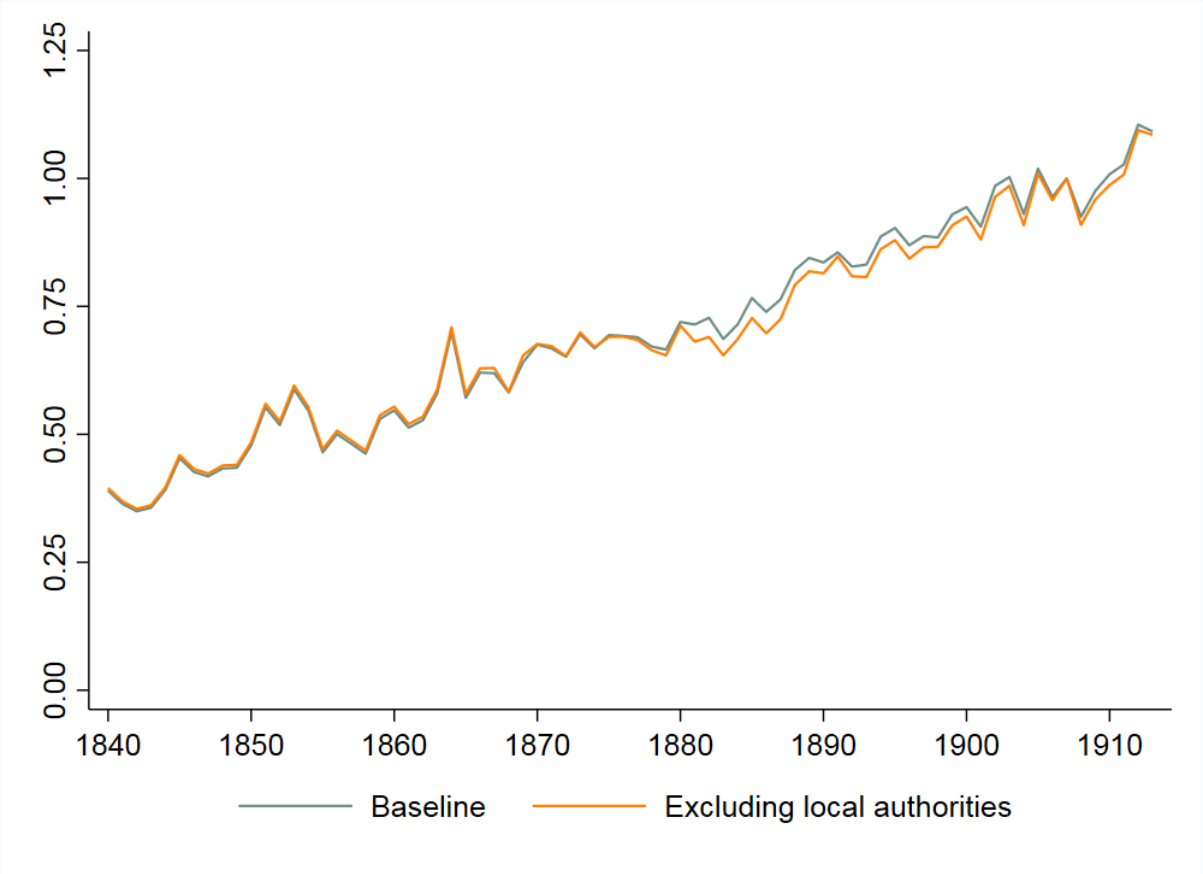


**Figure 10. New annual index of Irish industrial production, 1840-1913: Sensitivity to excluding local authorities (1907 = 1)**

*Source:* See text.

**5. Irish industrial growth in comparative perspective**

Irish industry grew substantially after the Famine, albeit at a slower pace than was previously thought. It grew even more rapidly in per capita terms as a result of emigration. Industrial growth clearly played a role in driving overall Irish growth during this period. But

did it also help to explain that (modest) fraction of Ireland's per capita growth that *exceeded* growth in richer countries (i.e. Irish convergence on Britain, the US and elsewhere)? This seems doubtful. Figure 11 compares Irish industrial growth with growth in Britain, the US, and Denmark, another small, largely agricultural economy of the time. As can be seen, industry grew less rapidly in Ireland than in any of the other three economies. Between 1840 and 1913, Irish industrial growth of 1.4 per cent per annum was slow compared with growth of 3.5 per cent in Denmark, 2.6 per cent in Britain, and 5.4 per cent in the US.[6] Not only that, it was slower in every individual decade during the period.

[6] As Figure AIII.2 shows, slower growth in Ireland relative to Great Britain implies that the Irish share of industrial production in the United Kingdom declined.

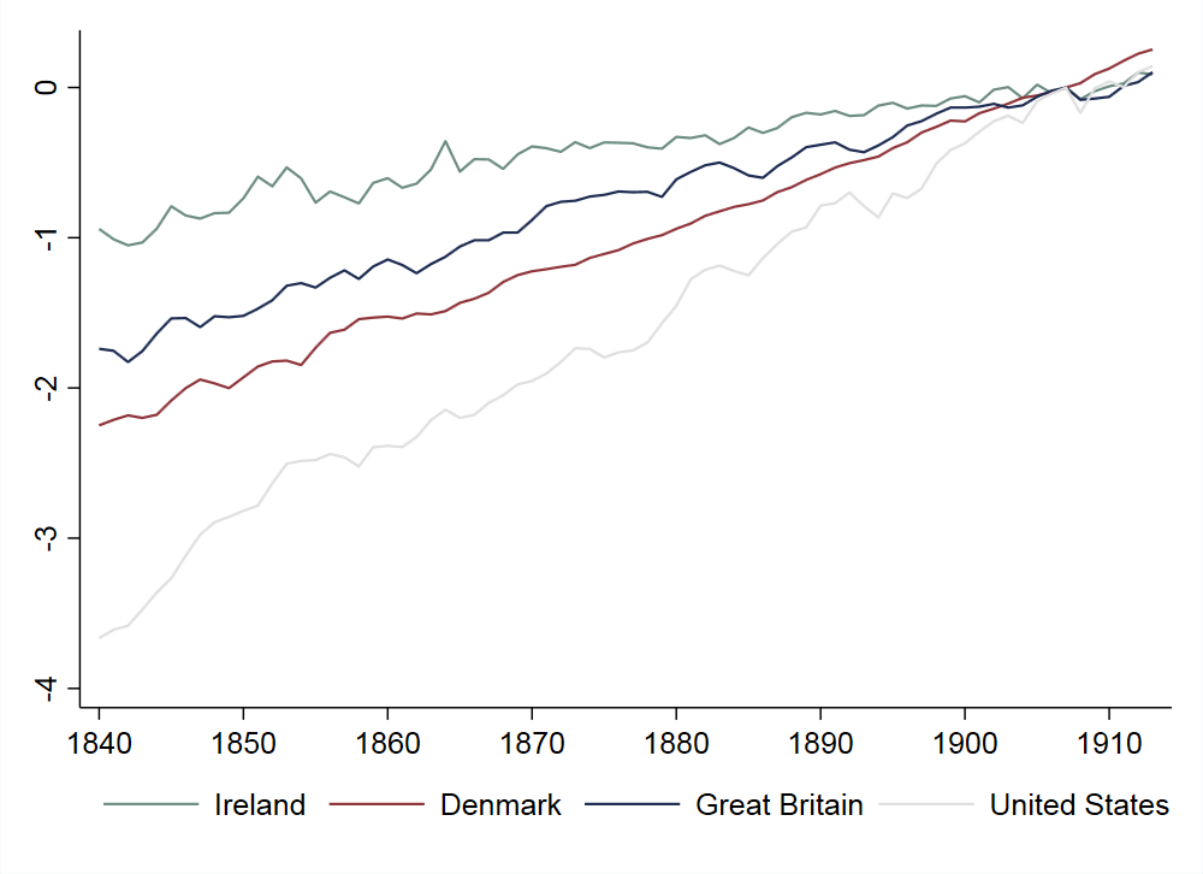


**Figure 11. Industrial production in four economies, 1840-1913 (log scale)**

*Sources:* See text and Hansen (1974), Feinstein (1972), Broadberry et al. (2015), and Davis (2004).

**Table 6. Manufacturing growth, 1870-1913 (% per annum)**

| Groups | Country | 1870-1896 | 1896-1913 |
|---|---|---|---|
| Rich core | Belgium | 1.6 | 2.7 |
| | France | 2.4 | 2.0 |
| | Germany | 3.1 | 3.6 |
| | Netherlands | 2.9 | 2.9 |
| | Switzerland | 2.6 | 4.5 |
| | United Kingdom | 1.9 | 1.5 |
| | United States | 4.6 | 4.9 |
| Scandinavia | Denmark | 4.7 | 4.5 |
| | Norway | 2.3 | 3.4 |
| | Sweden | 3.8 | 5.4 |
| European | Austria | 5.0 | 3.8 |
| Periphery | Bosnia and Herzegovina | 12.4 | 8.0 |
| | Bulgaria | 2.9 | 4.8 |
| | Finland | 4.4 | 4.2 |
| | Hungary | 5.0 | 3.8 |
| | **Ireland (industry)** | **0.9** | **1.1** |
| | **Ireland (manufacturing)** | **0.7** | **1.2** |
| | Italy | 2.1 | 4.0 |
| | Portugal | 2.1 | 2.5 |
| | Romania | 3.9 | 4.5 |
| | Russia | 5.5 | 3.9 |
| | Serbia and Montenegro | | 7.0 |
| | Spain | 2.7 | 1.7 |

*Source:* For the Irish data, see the text. The other data are taken from Bénétrix et al. (2015), updated using the growth rates in Bénétrix et al. (2017).

Table 6 broadens the comparison, giving average manufacturing growth rates over two sub-periods, 1870-96 and 1896-1913, for a wide range of European countries as well as the United States. We include both manufacturing and industrial growth rates for Ireland.[7] Standard convergence logic suggests that manufacturing growth should have been more

[7] The non-Irish data are taken from Bénétrix et al. (2015), updated using the annual growth rates in Bénétrix et al. (2017). They calculate average growth rates over these sub-periods by regressing the log of output on a time trend, and we do the same for Ireland in this table. While Bénétrix et al. tried to collect manufacturing data wherever possible, in some cases they were obliged to use industrial output.

rapid across the European periphery than in rich countries such as the United States or Belgium, and by and large those expectations are borne out by the evidence. Irish industry stands out, however, as having grown unusually slowly during the late 19th century. Not only were Irish growth rates slower than anywhere else in the European periphery, they were slower than anywhere in the core as well. Since Ireland's population was shrinking during this period, in per capita terms its underperformance is not so stark (Table 7). Even so, Irish per capita growth remains extremely unimpressive in a comparative perspective. Among the countries listed here, only Spain, and the UK as a whole, registered slower per capita growth after 1896.

It is hard to argue that relatively slow industrial growth contributed to a relatively rapid growth in Irish living standards. To that extent, the argument of O'Rourke and Williamson (1999) and others, that Irish real wage *convergence* was largely due to emigration, rather than to more rapid economic development – which during this period tended to be associated with industrialization and structural change – seems vindicated.[8] On the other hand, the evidence in Table 4 also supports authors like Begley et al. (2016), who emphasize that Irish per capita *growth* during this period was for the most part due to capital accumulation and technological change. The two conclusions are not inconsistent: convergence refers not to total growth, but to that modest portion of total Irish growth in excess of growth elsewhere. And for a labour-abundant economy like Ireland, experiencing mass emigration, real wage growth should have exceeded growth in GDP per capita.

[8] Irish industrial output growth does not even stand out in per capita terms (Figure AIII.3), except vis à vis Britain. Between 1851 and 1913 the average per capita growth rates are: Ireland 1.8 per cent; Denmark 2.3 per cent; United States 2.5 per cent; and Britain 1.4 per cent.

**Table 7. Manufacturing per capita growth, 1870-1913 (% per annum)**

| Groups | Country | 1870-1896 | 1896-1913 |
|---|---|---|---|
| Rich countries | Belgium | 0.7 | 1.7 |
| | France | 2.1 | 1.8 |
| | Germany | 2.1 | 2.2 |
| | Netherlands | 1.7 | 1.5 |
| | Switzerland | 2.0 | 3.3 |
| | United Kingdom | 1.0 | 0.6 |
| | United States | 2.4 | 3.0 |
| Scandinavia | Denmark | 3.7 | 3.3 |
| | Norway | 1.6 | 2.6 |
| | Sweden | 3.2 | 4.7 |
| European | Austria | 4.1 | 2.8 |
| Periphery | Bulgaria | 1.5 | 3.6 |
| | Finland | 3.0 | 3.1 |
| | Hungary | 4.5 | 3.0 |
| | **Ireland (industry)** | **1.3** | **1.3** |
| | **Ireland (manufacturing)** | **1.2** | **1.4** |
| | Italy | 1.4 | 3.2 |
| | Portugal | 1.3 | 1.7 |
| | Romania | 9.3 | 6.7 |
| | Russia | | 1.8 |
| | Spain | 2.2 | 1.1 |

*Source*: See Table 6.

## 6. Conclusion

We hope that we have convinced the reader that there are abundant data available for Irish industry during the Union. While we have only presented aggregate indices for the 1840-1913 sub-period, the data for individual industries remain useful in assessing performance at other times. We hope that this paper will advance the quantification of the 19$^{th}$ century Irish economy, and that future research will not only improve and extend our industrial indices forwards (and maybe even backwards) in time, but combine these with other output

indicators so as to obtain a more accurate overview of trends in Irish GDP during a tumultuous period in the country's history.

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## APPENDIX I. CONSTRUCTING AN INDUSTRIAL PRODUCTION INDEX

This appendix documents the sources, transformations and reliability grades for the series underlying the aggregate industrial production index.

### Series 1: Limestone quarries, etc.

*Coverage*: 1895-1920

*Details*: Limestone quarried, in tons, from Bielenberg (2009, p. 168).

*Reliability grade:* A.

### Series 2: Other quarries

*Coverage*: 1895-1920

*Details*: Sum of gravel/sand, clay, sandstone, and igneous rocks quarried, in tons, from Bielenberg (2009, p. 168).

*Reliability grade:* A.

### Series 3: Coal and ironstone

*Coverage*: 1820-1920

*Details*: Coal production, in tons, from Bielenberg (2009, pp. 185-6; 1854-1920), linked backwards with Minerals Ireland (2017; 1820-54).

*Reliability grade:* B (1820-53) and A (1854-1920).

**Series 4: Slate quarries**

*Coverage*: 1895-1920

*Details*: Slate quarried, in tons, from Bielenberg (2009, p. 168).

*Reliability grade:* A.

**Series 5: Jute, hemp, linen**

*Coverage*: 1800-1921

*Details*: Net flax supply to linen industry, in tons, from Bielenberg (2009; 1848-1921), spliced backwards with linen goods exports, in cwts, from Solar (1990b, 2005; 1800-48).

*Reliability grade:* C.

**Series 6: Bleach, dyeing, printing etc.**

*Coverage*: 1904-1919

*Details*: Imports in unclassified dyes, in cwts, from the *Report on the trade in imports and exports at Irish ports* (various years).

*Reliability grade:* C.

**Series 7: Woollen and worsted**

*Coverage*: 1847-1914

*Details*: Wool, in lbs, calculated from Turner (1996, pp. 232-3). Following Broadberry et al. (2015, p. 144), we use the input of raw wool as a proxy for the output of woollen and worsted textiles. The annual fleece is calculated as 5 lb per sheep over the age of 1 (Turner, 1996, p. 276). 1848 log-linearly interpolated as missing.

*Reliability grade:* D.

**Series 8: Cotton trade**

*Coverage*: 1800-1914

*Details*: Imports of raw cotton (1800-65), in lbs, spliced forward using net imports of Beflast cotton wool and yarn (1865-1914), from Bielenberg and Solar (2007). Bielenberg and Solar (2007) noted that "production can be estimated direct from imports of raw cotton and cotton yarn", while the vast majority of raw cotton was imported through Belfast (*Annual statement of the trade of the United Kingdom with foreign countries and British possessions*, various years; Monaghan, 1942).

*Reliability grade:* B.

**Series 9: Flax scutching**

*Coverage*: 1848-1921

*Details*: Net flax supply to Iinen industry, in tons, from Bielenberg (2009).

*Reliability grade:* B.

**Series 10: Building and contracting**

*Coverage*: 1801-1921

*Details*: Timber imports (1904-21), in loads, spliced backwards with foreign timber imports (1823-1904), then linked backwards with total timber imports (1801-22) from Bielenberg (2009, pp. 194-6). Bielenberg (2009, p. 145) notes that "construction used much more timber than all other sources of demand, so the series is responsive to the general trends in Irish construction", while the use of imports is not problematic as domestic forestry "was too depleted to make a significant contribution to supplying the construction industry by the beginning of the nineteenth century" (Bielenberg, 2009, p. 144). However, this approach assumes that the share of timber imports used as a construction input was constant. From the late 19th century, information on other building materials is available (Bielenberg, 2009, p. 168). Timber imports are highly correlated with the volume of slate ($r = 0.73$) and limestone ($r = 0.74$) quarried between 1895 and 1920, which suggests that timber imports are a fair gauge of construction, at least at the turn of the century. Proxying building activity with timber imports is also the approach followed by Broadberry et al. (2015, p. 186) in the case of Great Britain.

*Reliability grade:* D.

**Series 11: Shipbuilding/other**

*Coverage*: 1800-1921

*Details*: Shipping launched, in tonnage, from Bielenberg (2009, pp. 189-92).

*Reliability grade:* C (1800-54), B (1855-1913) and D (1914-21).

**Series 12: Railways**

*Coverage*: 1841-1921

*Details*: Steam locomotives built from Rowledge (1993).

*Reliability grade:* B.

**Series 13: Engineering trades**

*Coverage*: 1859-1921

*Details*: Machinery exports from Belfast, in tons, from Bielenberg (2009, pp. 187-8). 1879-83 log-linearly interpolated as missing.

*Reliability grade:* C.

**Series 14: Newspapers/periodicals**

*Coverage*: 1800-1921

*Details*: Number of newspapers in circulation compiled from the Irish and British Newspaper Archives. If there was a discrepancy for the start and end dates of a title between the two archives, the date which points to a longer existence was preferred. This approach is based on Davis (2004).

*Reliability grade:* D.

**Series 15: Fertilizer/disinfectants**

*Coverage*: 1862-1919

*Details*: Deliveries of manufactured manures, in tons, from the "principal fertilizer firm in the Country" of "superphosphate manufactured" (Walsh et. al., 1957; 1862-90), spliced forward using imports of phosphate rock in tons (comprising the primary component of superphosphate) into the ports of Belfast, Cork and Dublin from the *Annual statement of the trade of the United Kingdom with foreign countries and British possessions* (various years; 1890-1919). 1873-76 and 1878-9 log-linearly interpolated as missing.

*Reliability grade:* C.

**Series 16: Brewing**

*Coverage*: 1800-1921

*Details*: Beer brewed, in gallons, from Bielenberg (2009, pp. 183-4; 1856-1909), spliced forwards with sales of Guinness from Bielenberg (2009, p. 86; 1909-21) and spliced backwards with malt charged with duty from Mitchell (1988, p. 402; 1800-56). From the beginning of the 19th century, Guinness had established itself as "the leading brewer in Dublin" (Lynch and Vaizey, 1960, p. 80). By the eve of the First World War, Guinness "accounted for about two-thirds of Irish brewing output" (Bielenberg, 2009, p. 77). The series for Guinness output are highly correlated with total production between 1886 and 1909 ($r = 0.98$). 1854 and 1869-70 log-linearly interpolated as missing.

*Reliability grade:* B (1800-55), A (1856-1909) and C (1910-21).

**Series 17: Bread and biscuits**

*Coverage*: 1883-1913

*Details*: Jacob's biscuit factory gross sales from Jacob's Archive (DCLA/JAC/03/006), deflated by the bread and biscuits deflator. The firm was "by far the largest-biscuit making firm in Ireland" (Bielenberg, 2009, p. 73).

*Reliability grade:* C.

**Series 18: Grain milling**

*Coverage*: 1846-1921

*Details*: Flour production, in 1000 cwts, from Bielenberg (2003a, pp. 85-6).

*Reliability grade:* B.

**Series 19: Spirits**

*Coverage*: 1802-1920

*Details*: Distilling output, in proof gallons, from Bielenberg (2003b, pp. 309-12).

*Reliability grade:* A.

**Series 20: Butter, cheese, marg. etc.**

*Coverage*: 1800-1914

*Details*: Butter exports, in cwts, from *Report on the trade and imports and exports at Irish ports* (various years; 1904-14), spliced backwards (Solar, 1990a; P.P., 1826; 1820-1904). According to Solar (1990a), "most of milk output was exported in this form."

*Reliability grade:* C.

**Series 21: Bacon curing**

*Coverage*: 1800-1919

*Details*: Bacon exported, in cwts, from *Report on the trade and imports and exports at Irish ports* (various years; 1904-19), spliced backwards with Solar's (1987, pp. 151, 155; 1825-1904) series for bacon and ham exports and official trade figures on bacon exports (P.P., 1826; 1800-25). According to Bielenberg (2009, p. 56), "growing meat consumption in Britain appears to have remained the main driver of the Irish bacon industry throughout the Union […] most Irish bacon was exported to Great Britain."

*Reliability grade:* C.

**Series 22: Cocoa, confectionery, etc.**

*Coverage*: 1904-1919

*Details*: Cocoa imports, in lbs, from the *Report on the trade in imports and exports at Irish ports* (various years).

*Reliability grade:* B.

**Series 23: Fish curing**

*Coverage*: 1898-1921

*Details*: Mackerel cured for exportation, in barrels, from *Thom's official directory* (various years). According to a contemporary report, "Irish mackerel is sold entirely in America" (P.P., 1906).

*Reliability grade:* C.

**Series 24: Local authorities**

*Coverage*: 1866-1914

*Details*: Expenditure on new works, alterations and maintenance of public buildings from *Thom's official directory* (various years), deflated by the industrial price index. 1898, 1906, and 1912 log-linearly interpolated as missing. Adjusted to calendar year where necessary.

*Reliability grade:* B.

**Series 25: Gas**

*Coverage*: 1882-1913

*Details*: Gas produced, in cubic feet, from *Returns relating to all authorised gas undertakings in the United Kingdom* (various years). Sum of local authority and other production. 1884, 1889 and 1893 log-linearly interpolated as missing. Adjusted to calendar year where necessary.

*Reliability grade:* B.

**Series 26: Water (public)**

*Coverage*: 1866-1918

*Details*: Revenue from total water supplied by Irish local authorities from *Returns of local taxation in Ireland* (various years; 1895-1918), spliced backwards using revenue earned by the Belfast City and District Water Commissioners (1866-95; other local authorities were not reported in the source prior to this), deflated by the industrial price index. 1873, 1899 and 1901 log-linearly interpolated as missing. Adjusted to calendar year where necessary.

*Reliability grade:* C (1866-94) and B (1895-1918).

**Series 27: Tramway/light rail**

*Coverage*: 1879-1913

*Details*: Traffic expenses from *Returns of street and road tramways* (various years), deflated by the industrial price index. Includes expenditure on general repairs and maintenance (or renewals out of revenue) on permanent way; electrical equipment; engines or horses; cars and other rolling stock; buildings, fixtures, tools and miscellaneous equipment; and cost of tractive power. 1882 log-linearly interpolated as missing. Adjusted to calendar year where necessary.

*Reliability grade:* B.

**Series 28: Canals, docks, etc.**

*Coverage*: 1866-1918

*Details*: Expenditure on new works and improvements, repairs and maintenance on harbours and canals from *Returns of local taxation in Ireland* (various years), deflated by the industrial price index. 1899 and 1901 log-linearly interpolated as missing. Adjusted to calendar year where necessary.

*Reliability grade:* B.

**Series 29: Leather**

*Coverage*: 1849-1913

*Details*: Hides, calculated as the number of cattle disappearances net of exports to Britain (excluding milche cows), calculated from Turner (1996, pp. 232-3, 238-9), which may be taken as that "which was slaughtered and consumed in Ireland" (Turner, 1996, p. 273). 1866 log-linearly interpolated as missing.

*Reliability grade:* D.

**Series 30: Excluded residual**

*Coverage*: 1801-1913

*Details*: Tobacco consumption, in lbs, calculated from Bielenberg and Johnson (1998) and Mitchell (1988, pp. 11-3). According to Bielenberg and Geary (2006), who also use tobacco consumption as a proxy for production, "almost all Irish tobacco was processed in Ireland." Excluded residual includes industries that were not itemized in the census, of which Tobacco was the only manufacture of importance (Bielenberg, 2008). 1871-5 log-linearly interpolated as missing.

*Reliability grade:* B.

## APPENDIX II. CONSTRUCTING AN INDUSTRIAL PRICE INDEX

This appendix documents the sources and transformations applied to the underlying price series of the aggregate industrial price index. While the series, coverage, sources and transformations are documented below, here we outline the approach common to all of the series to avoid repetition. The data for the underlying prices were collected from a wide array of primary sources, such as newspapers and contemporary material, and secondary sources, which we augmented if we uncovered new data to fill in the gaps or to extend the coverage.

The vast majority of prices were collected from contemporary newspapers. In order to avoid issues relating to the seasonality of industrial prices, we collected prices from the latest available publication in each calendar year. In almost all cases, a low and high price was reported for the given trading day in pounds (£), shillings (s.) and pence (d.). As a result, we use the average of the low and high price. In some cases, a single price was recorded, typically meaning that only one price was offered, which we use instead of the average. In a few instances, there were gaps in the series, which we bridge with log-linear interpolation. However, where there are missing observations for more than five years, we discard the series. The units in which prices were reported for a period spanning more than a century varied considerably. Therefore, we converted prices for the same product but recorded in different units into a common measure. In addition, there was a change of currency as the Irish and British pounds were amalgamated in January 1826. As a result, all prices before 1826, which were reported in Irish pounds, are converted into British pounds at the

prevailing exchange rate of IR£1.083/£1. The conversion factors that we use are shown in Table AII.1.

Table AII.1. *Conversion factors*

| | | |
|---|---|---|
| *Weight (based upon the pound avoirdupois)* | | |
| 1 pound (lb.) | 16 ounces | 0.4536 kilograms |
| 1 stone | 14 lbs | 6.3504 kilograms |
| 1 quarter (qtr) | 2 stone | 12.7008 kilograms |
| 1 hundredweight (cwt) | 4 qtrs | 50.8032 kilograms |
| 1 ton | 20 cwts | 1.016 tonne |
| *Liquid volume* | | |
| 1 gallon | 8 pints | 4.536 litres |
| 1 barrel | 36 gallons | 166.4 litres |
| 1 hogshead | 54 gallons | 249.6 litres |
| *Money* | | |
| 1 penny (d.) | | |
| 1 shilling (s.) | 12d. | |
| 1 pound (£) | 20s. | 240d. |
| 1 pound (£) | | IR£ 1.083 (12/13) |

*Source:* Broadberry et al. (2015, p. xxix).

**Series 1: Coal and ironstone**

*Coverage*: 1805-1914

*Sources*: *Belfast Commercial Chronicle*, *Belfast Newsletter*, *Dublin Weekly Nation*, *Londonderry Journal*, *Londonderry Sentinel,* and *Northern Whig*

*Details*: Price of English coal, per ton, spliced back using the price of Scotch coal. 1814, 1818-9, 1823, and 1893 log-linearly interpolated as missing.

**Series 2: Slate quarries**

*Coverage*: 1855-1918

*Sources*: *Belfast Mercantile Register and Weekly Advertiser*, *Londonderry Journal*, *Londonderry Sentinel*, *Londonderry Standard,* and *Northern Whig*

*Details*: Price of Bangor slate, per ton, spliced back using the price of queen slate. 1886, 1890, and 1901 log-linearly interpolated as missing.

**Series 3: Woollen and worsted**

*Coverage*: 1840-1921

*Sources*: Barrington (1927) and Turner (1996, pp. 265-7)

*Details*: Price of wool. 1841-4 log-linearly interpolated as missing.

**Series 4: Rope, twine, net**

*Coverage*: 1904-18

*Source*: Riordan (1920, p. 135)

*Details*: Price of rope, cordage and twine exports, per cwt, calculated from quantities and values.

**Series 5: Cotton trade**

*Coverage*: 1904-18

*Source*: Riordan (1920, p. 117)

*Details*: Price of cotton yarn imports, per lb., calculated from quantities and values.

**Series 6: Flax scutching**

*Coverage*: 1825-1921

*Sources*: Barrington (1927), *Belfast Commercial Chronicle*, *Belfast Mercantile Register and Weekly Advertiser*, *Belfast Morning News*, *Belfast Newsletter*, *Londonderry Journal*, *Northern Whig,* and Turner (1996, pp. 264-5)

*Details*: Price of hand-scutched flax, per stone, spliced back using the price of prime and undressed flax and forward using the price of flax. 1837, 1842, and 1886 log-linearly interpolated as missing.

**Series 7: Hosiery**

*Coverage*: 1904-18

*Source*: Riordan (1920, p. 137)

*Details*: Price of hosiery exports, per cwt, calculated from quantities and values.

**Series 8: Glass/stone/roof felt/etc.**

*Coverage*: 1867-1918

*Sources*: *Belfast Mercantile Register and Weekly Advertiser*, *Londonderry Journal*, *Londonderry Standard*, *Newry Reporter,* and *Newry Telegraph*

*Details*: Price of 300 foot coarse glass, per case, spliced back using the price of window crown glass. 1886-90 and 1910-3 log-linearly interpolated as missing.

**Series 9: Iron and steel**

*Coverage*: 1808-1918

*Sources*: *Belfast Commercial Chronicle*, *Belfast Newsletter*, *Londonderry Journal,* and *Londonderry Sentinel*

*Details*: Average price of Swedish and Scottish iron, per cwt. 1818-9, 1823, and 1886-90 log-linearly interpolated as missing.

**Series 10: Newspapers/periodicals**

*Coverage*: 1801-1921

*Sources*: *Belfast Newsletter*, *Freeman's Journal,* and *Saunders's Newsletter*

*Details*: Average price of the *Belfast Newsletter* and *Freeman's Journal*, per copy, spliced back using the price of *Saunders's Newsletter*.

**Series 11: Fertilizer/disinfectants**

*Coverage*: 1880-1921

*Sources*: *Ballymena Observer*, *Belfast Newsletter*, *Belfast Morning News*, *Freeman's Journal*, *Kildare Observer*, *Londonderry Journal*, *Newry Reporter*, *Northern Whig*, *Waterford Standard,* and *Wicklow People*

*Details*: Price of superphosphate (30-5 per cent), per ton, listed in advertisements from the following manure manufacturers: Cleary's Seed, Drummond's Manures, Kelly & Co., John Kirk, and Rainey's Manures. Where more than one company advertised within the same year, the prices were identical in every case. 1897-1900, 1911, 1914, 1916, and 1918-20 log-linearly interpolated as missing.

**Series 12: Soap/candles**

*Coverage*: 1805-1918

*Sources*: *Belfast Commercial Chronicle*, *Belfast Newsletter*, *Londonderry Journal*, *Londonderry Sentinel,* and *Ulster Gazette*

*Details*: Average price of candles, per dozen, spliced back using the price of Russian tallow, and brown soap, per cwt. Candle prices for 1814, 1818-9, 1823, and 1910 log-linearly interpolated as missing.

**Series 13: Timber trades**

*Coverage*: 1829-1918

*Sources*: *Belfast Newsletter*, *Freeman's Journal*, *Londonderry Journal*, *Londonderry Sentinel*, *Londonderry Standard,* and *Northern Whig*

*Details*: Price of machine sawn laths/planks, per meter, spliced back using the price of Memel timber. 1857, 1860, 1872, and 1887-91 log-linearly interpolated as missing.

**Series 14: Brewing**

*Coverage*: 1904-18

*Source*: Riordan (1920, p. 157)

*Details*: Average price of ale, beer and porter exports, in barrels.

**Series 15: Bread and biscuits**

*Coverage*: 1800-1921

*Sources*: Mitchell (1988, p. 771)

*Details*: Price of bread, per 4 lbs.

**Series 16: Grain milling**

*Coverage*: 1800-1921

*Sources*: *Belfast Newsletter,* Kennedy and Solar (2007, pp. 135-7), and *Londonderry Sentinel*

*Details*: Price of flour at retail market, per stone, spliced back using the average north and south price of flour. 1873, 1876, and 1888 log-linearly interpolated as missing.

**Series 17: Spirits**

*Coverage*: 1812-1918

*Sources*: *Belfast Commercial Chronicle*, *Belfast Newsletter*, *Cork Examiner*, *Londonderry Journal,* and *Londonderry Sentinel*

*Details*: Average prices of Watt's, Islay, and Grain O.P. whiskey, per gallon, spliced back using the price of Irish whiskey (old duty paid). 1814, 1819, 1823, and 1886-90 log-linearly interpolated as missing.

**Series 18: Butter, cheese, marg. etc.**

*Coverage*: 1800-1921

*Sources*: Kennedy and Solar (2007, pp. 164-7) and *Londonderry Sentinel*

*Details*: Price of butter, per lb., spliced back using the average north and south price of butter. 1873, 1876 and 1888 log-linearly interpolated as missing.

**Series 19: Aerated waters, etc.**

*Coverage*: 1904-18

*Source*: Riordan (1920, p. 165)

*Details*: Price of aerated and mineral water exports, per cwt, calculated from quantities and values.

**Series 20: Bacon curing**

*Coverage*: 1850-1918

*Sources*: *Belfast Newsletter*, *Londonderry Journal,* and *Londonderry Sentinel*

*Details*: Price of bacon, per cwt. 1886 log-linearly interpolated as missing.

**Series 21: Bottling**

*Coverage*: 1904-18

*Source*: Riordan (1920, p. 167)

*Details*: Price of glass bottle imports, per cwt, calculated from quantities and values.

**Series 22: Fish curing**

*Coverage*: 1852-1918

*Sources*: *Belfast Newsletter*, *Cork Examiner*, *Dublin Daily Nation*, *Dublin Weekly Nation*, *Freeman's Journal*, *Irish Times*, *Londonderry Journal*, Riordan (1920, pp. 294-5), and *Weekly Irish Times*

*Details*: Average price of cured herring and cured mackerel exports, per cwt, calculated from quantities and values, spliced back using the price of herring (cured, red, and salted). 1863 and 1887-8 log-linearly interpolated as missing.

**Series 23: Sugar and glucose**

*Coverage*: 1812-1918

*Sources*: *Belfast Commercial Chronicle, Belfast Newsletter, Dublin Weekly Nation, Londonderry Journal, Londonderry Sentinel,* and *Northern Whig*

*Details*: Price of white sugar, per lb., spliced back using the price of brown sugar and sugar (scale). 1813-4, 1818-9, 1823, 1855, and 1886 log-linearly interpolated as missing.

**Series 24: Leather**

*Coverage*: 1805-1918

*Sources*: *Belfast Commercial Chronicle*, *Cork Constitution*, *Londonderry Journal*, *Londonderry Sentinel*, *Northern Whig,* and *Waterford News*

*Details*: Price of native leather, per lb., spliced back using the price of cow hides. 1813-4, 1818-9, 1823, and 1836-7 log-linearly interpolated as missing.

**Series 25: Excluded residual**

*Coverage*: 1812-1918

*Sources*: *Belfast Commercial Chronicle, Dublin Weekly Nation, Londonderry Journal, Londonderry Sentinel,* and Riordan (1920, p. 182)

*Details*: Price of manufactured tobacco exports, per lb., calculated from quantities and values, spliced back using the price of pigtail and leaf tobacco. 1814, 1819, 1823, and 1839 log-linearly interpolated as missing.

**APPENDIX III. ADDITIONAL MATERIAL**

**Table AIII.1. Industrial labour productivity in Ireland and the United Kingdom (1861 = 1)**

| | Ireland | United Kingdom |
|---|---|---|
| 1861 | 1.00 | 1.00 |
| 1871 | 1.48 | 1.28 |
| 1881 | 1.91 | 1.47 |
| 1891 | 2.31 | 1.56 |
| 1901 | 2.59 | 1.65 |
| 1911 | 3.29 | 1.68 |

*Sources:* Industrial production: see text and Feinstein (1972) and Broadberry et al. (2015).

Industrial employees: Geary and Stark (2002).

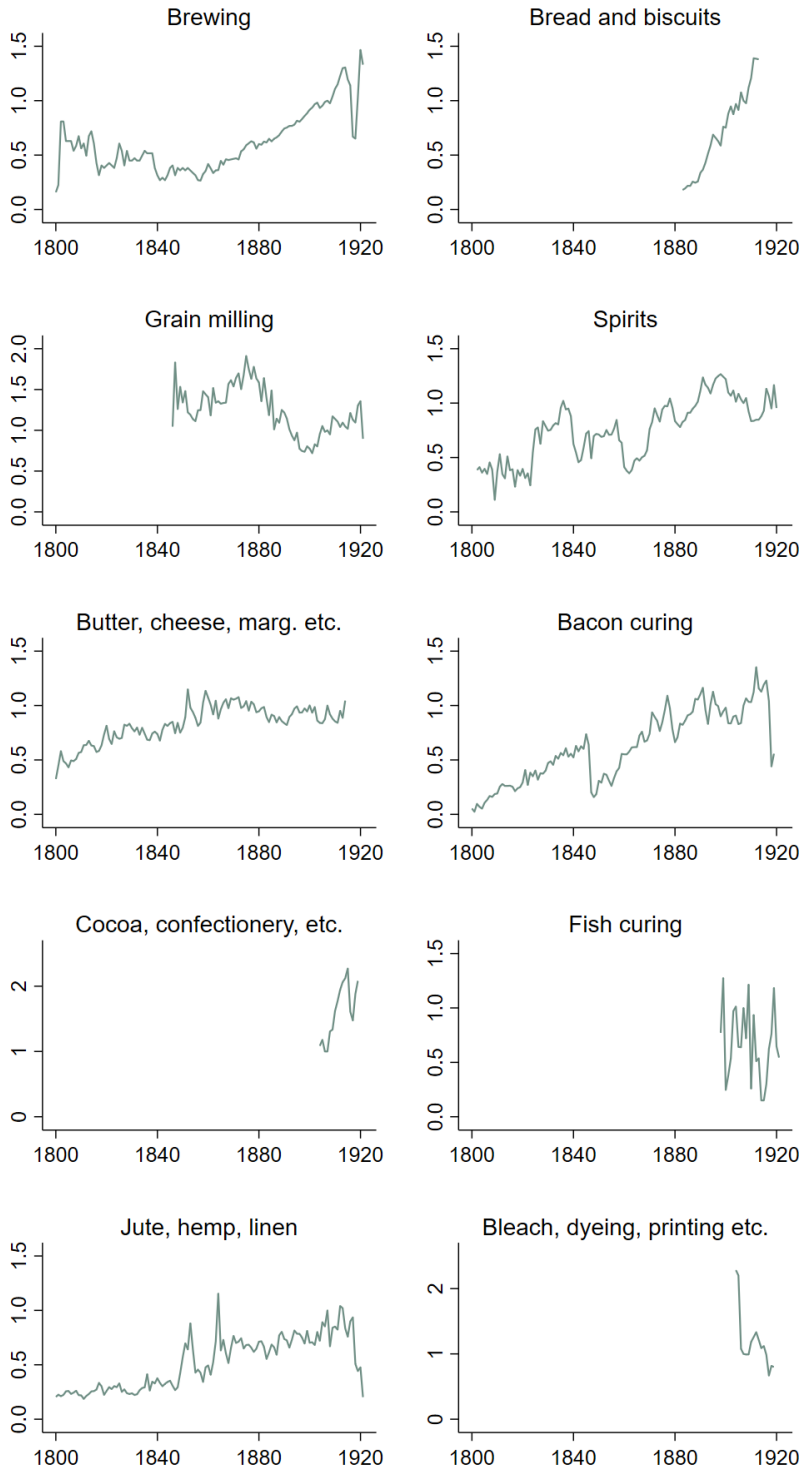


**Figure AIII.1. Production by industry, 1800-1921 (1907 = 1)**

*Notes:* The series are available at https://nyuad.nyu.edu/en/research/faculty-labs-and-projects/social-science-history-lab/data.html.
*Source:* See text.

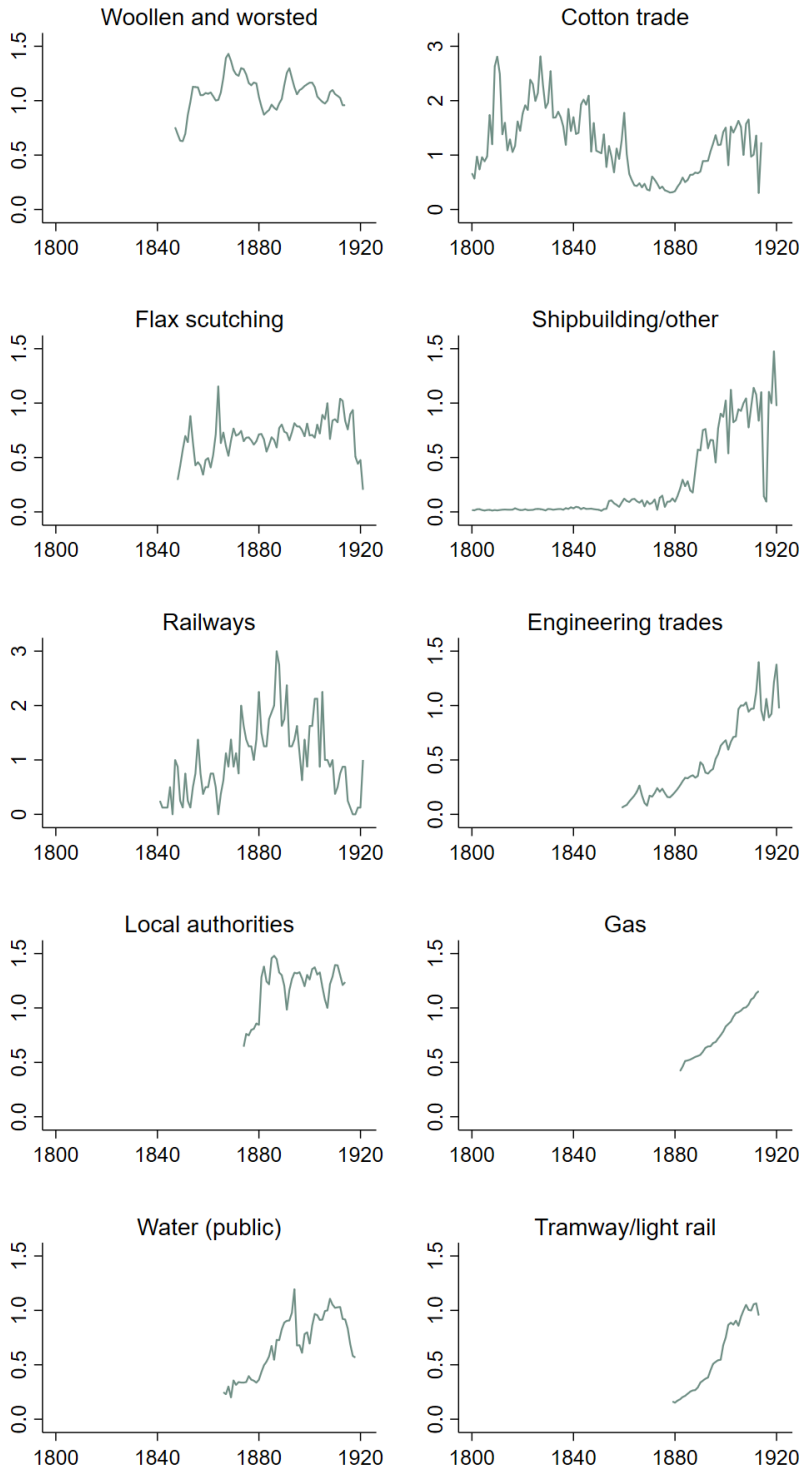


**Figure AIII.1. Production by industry, 1800-1921 (1907 = 1) (Continued)**

*Notes:* The series are available at https://nyuad.nyu.edu/en/research/faculty-labs-and-projects/social-science-history-lab/data.html.
*Source:* See text.

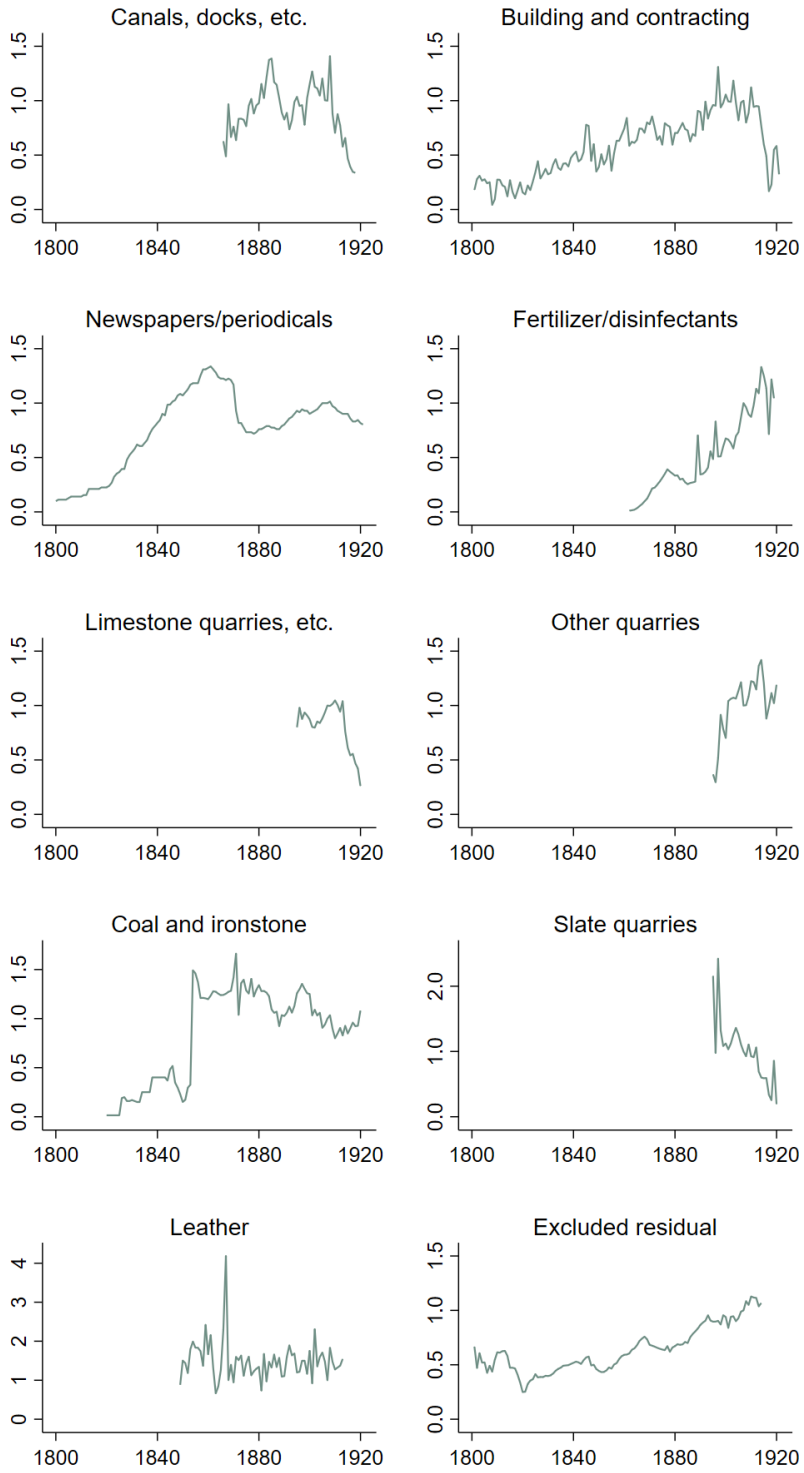


**Figure AIII.1. Production by industry, 1800-1921 (1907 = 1) (Continued)**

*Notes:* The series are available at https://nyuad.nyu.edu/en/research/faculty-labs-and-projects/social-science-history-lab/data.html.
*Source:* See text.

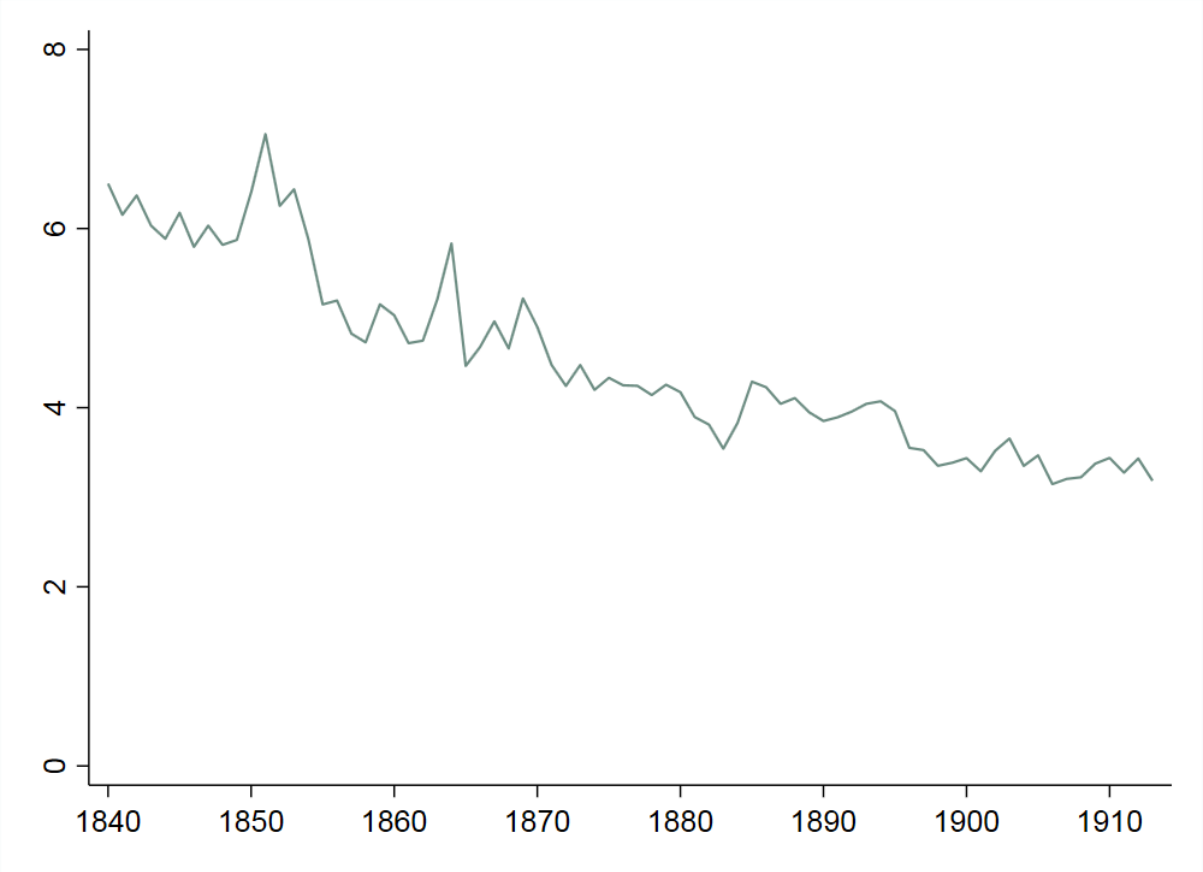


**Figure AIII.2. Ireland's share of industrial production in the United Kingdom, 1840-1913 (%)**

*Notes:* The indices of industrial production are indexed to 1907 = 1 and multiplied by the value added in 1907 reported in Bielenberg (2008).

*Sources:* See text and Feinstein (1972), Broadberry et al. (2015) and Bielenberg (2008).

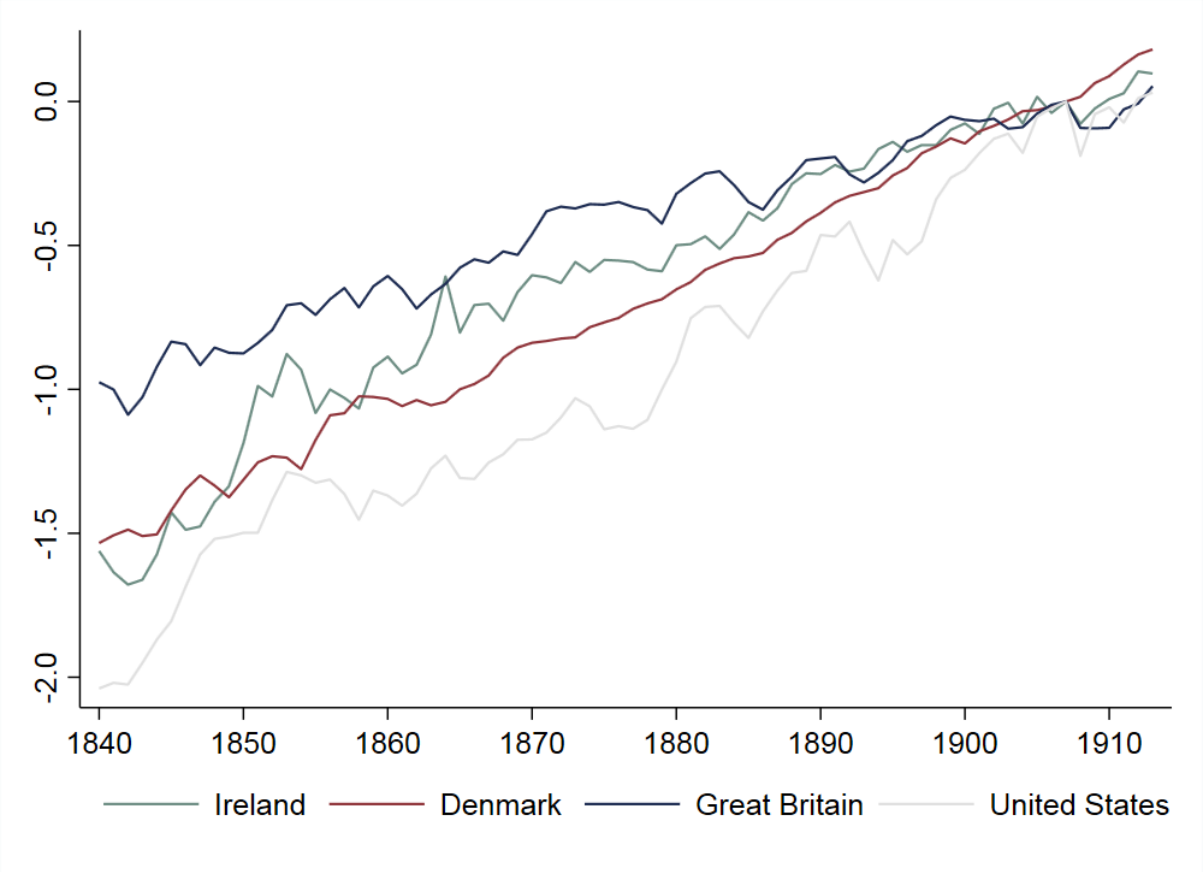


**Figure AIII.3. Industrial production per capita in four economies, 1840-1913 (log scale)**

*Sources:* See text and Mitchell (1988), Hansen (1974), Feinstein (1972), Broadberry et al. (2015), Davis (2004), and Historical Statistics of the United States (1975).