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**Seán Kenny, Jason Lennard and Kevin
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An annual index of Irish industrial production, 1800-1921

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

We construct an annual index of Irish industrial output for 1800-1921, the period during which the entire island was in a political Union with Great Britain. We also construct a new industrial price index. Irish industrial output grew by an average of 1.4 per cent per annum over the period as a whole, and by 1.8 per cent per annum between 1800 and the outbreak of World War I. Industrial growth was more rapid than previously thought before the Famine, and slower afterwards. While Ireland did not experience deindustrialization either before the Famine or afterwards, its industrial growth was disappointing when considered in a comparative perspective.

Keywords: Ireland, Industrial production, Famine, Historical national accounts

JEL: E01, N13, N14

* Kenny: Department of Economic History, Lund University. Lennard: Department of Economic History, London School of Economics; Department of Economic History, Lund University; and Economic Statistics Centre of Excellence. O'Rourke: NYU Abu Dhabi. For help and comments, we are grateful to John Fitzgerald, Paul Sharp, Peter Solar, and participants at the Irish Quantitative History Group Annual Conference at Trinity College Dublin.

1. Introduction

This paper presents the first-ever annual index of Irish industrial production from 1800 to 1921, the period during which the whole island was part of the United Kingdom. There are two main reasons to construct such an index: it helps us measure the overall development of the Irish economy during the Union with Britain, and it helps us to better understand that development.

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 been 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 is 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 our period (Bielenberg, 2009), and he and Geary have used these to calculate industrial growth rates during the first two quarters of the 19th century (Bielenberg and Geary, 2006). We make use of many of the series collected by Bielenberg and others, as well as series collected by ourselves, to create an annual industrial output index spanning the entire period 1800-1921. This is a necessary preliminary step on the way to eventually building GDP estimates using output data.

A reliable index of industrial output is also essential in adjudicating long-standing debates about Irish economic performance under the Union, 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 above all with 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 performance is also important in assessing its 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, 1998; 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 20th 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 begin by outlining the methodology used to construct our index, before presenting the main results in Section 3. A brief discussion of how robust are our results is followed by a concluding section in which we place Ireland's 19th century industrial performance in a comparative perspective and ask what our results mean for the debate about Irish performance, or under-performance, during the Union with Britain.

2. Data and methodology

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, for example Guinness which was the largest brewery in Ireland for most of the period (Davis, 2004; Bielenberg, 2009, p. 77).

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 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).

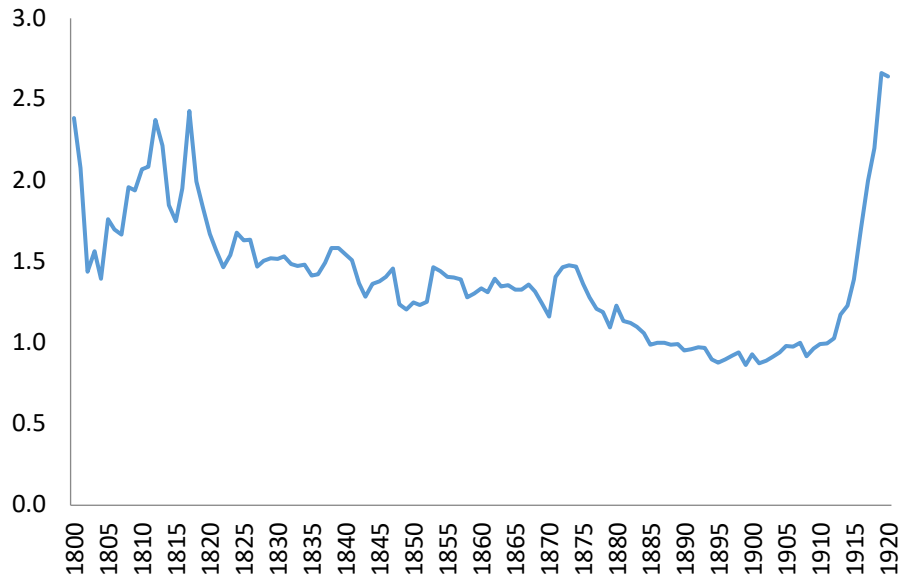


Figure 1. New annual index of Irish industrial prices, 1800-1921 (1907 = 1)

Source: See text and Appendix II.

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.

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).

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 cross-industry 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% 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).

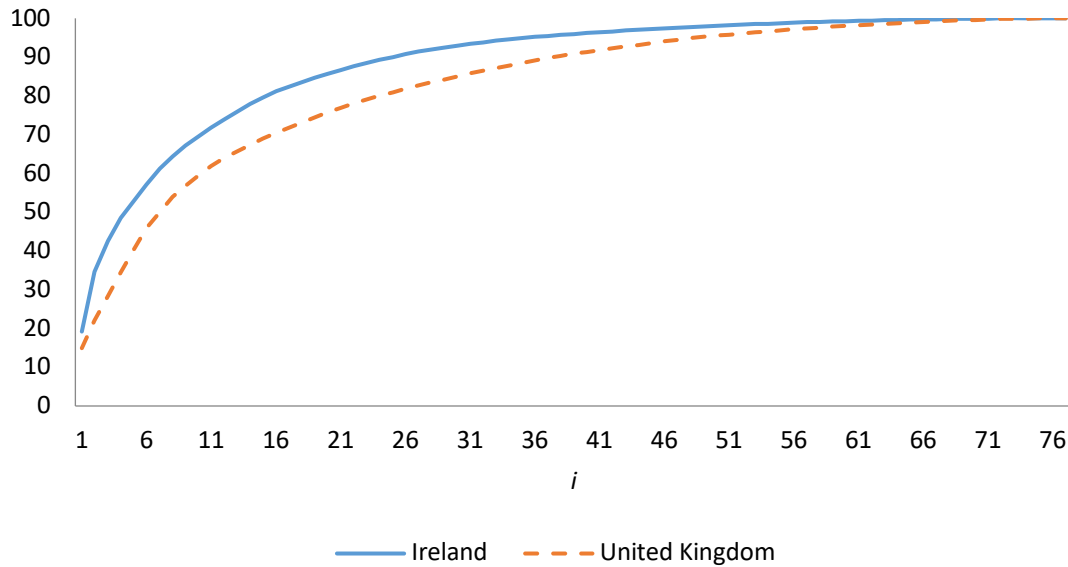


Figure 2. Cumulative share of value added in Irish and UK industries (%)

Note and source: Calculated from Bielenberg (2008).

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

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

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).

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. In order to address this challenge, we 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.

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 missing observations. For a small number of observations, we log-linearly interpolate to fill the gaps that are listed in Appendix I. A final 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 (from 1800 to 1855 and 1910 to 1921), from our index.

3. Results

The new annual index of industrial production in Ireland during the Union with Great Britain is presented in Figure 3. Between 1800 and 1921, industrial production grew by 1.4 per cent on average.¹ On this basis, output doubled roughly every 50 years, implying a five-fold increase over slightly more than a century. As can be seen from the figure there was a dramatic collapse in output following the outbreak of World War I, and so the average growth rate from 1800 to 1914 was higher, at 1.8 per cent per annum. The overall pace of industrial expansion in the 19th and early 20th centuries should be of little surprise. The findings of Bielenberg (1994) and Bielenberg and Geary (2006), presented in Table 2, give the same impression of modest but sustained growth. However, there are some discrepancies between our results and theirs when it comes to individual sub-periods that are potentially important for the chronology of Irish industrialization.

¹ The average growth rates reported in the text are compounded.

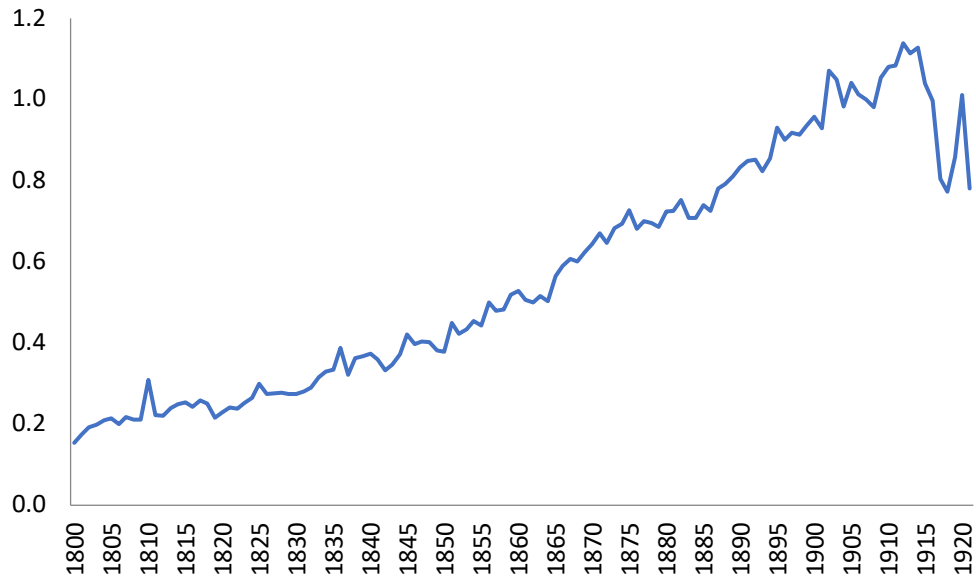


Figure 3. New annual index of Irish industrial production, 1800-1921 (1907 = 1)

Source: See text.

For the two sub-periods 1802-1825 and 1825-1845, Bielenberg and Geary (2006) estimate growth rates of 1.4 and 1.4 to 1.5 per cent respectively, whereas we calculate higher figures of 1.9 per cent and 1.7 per cent for the same periods. For the entire period from the Union to the Famine (1800-1845) we find that Irish industry grew by 2.3 per cent per annum (there was rapid growth between 1800 and 1802). In absolute terms there was certainly no deindustrialization in pre-Famine Ireland: far from it.

On the other hand, population grew by 1.1 per cent between 1801, when the population series starts, and 1845 (Mitchell, 1988). Since industrial growth averaged 2 percent between 1801 and 1845, per capita growth was therefore 0.9 per cent over the period. While lower,

the figure is still positive: there was no aggregate de-industrialization in pre-Famine Ireland however you measure it, and our new index only strengthens this conclusion.²

For the period between 1845 and 1907, Bielenberg (1994, p. 254) reports average growth of 1.5 to 1.7 per cent, but we find a lower rate of 1.4 per cent. Industrial growth between the Famine and World War I (1851-1913) averaged 1.5 per cent per annum. This was lower than the pre-Famine average, but it was growth just the same. And since population was falling during the period, this absolute growth rate translated into a significantly faster per capita growth rate of 2.1 per cent per annum. Therefore, while our overall conclusion that growth averaged about 1.5 per cent during the Union is consistent with other quantitative studies, we find that the pace was somewhat quicker before the Famine, and a little slower afterwards, than have previous researchers. Performance was better, or not as bad, before the Famine as previous researchers have found, consistent with suggestions that the Union may not have mattered as much as was once thought; but it was not as good after the Famine as was once thought either.

Table 2. Comparison of average industrial production growth (%)

Period	Bielenberg and Geary	Bielenberg	New index
1802-25	1.4		1.9
1825-45	1.4-1.5		1.7
1845-1907		1.5-1.7	1.4

Sources: Bielenberg (1994, p. 254) and Bielenberg and Geary (2006).

² Aggregate growth does not rule out the possibility that certain sectors or regions declined (Geary, 1998; Bielenberg and Geary, 2006).

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 per capita (IP_t/N_t) into a term that measures industrial labour productivity (IP_t/L_t) and a term that captures industrial labour force participation (L_t/N_t) using the following identity:

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

where IP_t is industrial production, N_t is population and L_t is the number of industrial employees at time t . The results are reported in Table 3 for the census years between 1841 and 1911, indexing both industrial production per capita, and industrial labour productivity, to be equal to 1 in 1841. The growth in industrial production per capita, which increased by a factor of 5.6, was due to remarkable labour productivity growth, which rose by 3.1 per cent per year on average. The strong productivity growth in industry does not depend on the new data. If we relied on the growth rates from existing studies in Table 2, we would still find that productivity improved by 3 to 3.2 per cent a year in this period. Weighing against this though was 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 decline of almost a third.

Table 3. Growth accounting (1841 = 1)

	Industrial production per capita (IP_t/N_t)	Industrial labour productivity (IP_t/L_t)	Industrial labour force participation (L_t/N_t) (%)
1841	1.00	1.00	13.39
1851	1.58	1.73	12.23
1861	1.99	2.34	11.39
1871	2.83	3.54	10.72
1881	3.22	4.60	9.36
1891	4.14	5.45	10.17
1901	4.77	6.31	10.12
1911	5.64	8.25	9.15

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

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 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 industrialization

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

Finally, as noted above Irish industrial output collapsed after the onset of World War I: it fell by over 30 per cent during the war years, a dramatic decline by any standards. While there was a rapid post-war recovery, with output making up two-thirds of the ground it had lost by 1920, there was then a second collapse in 1921 that undid all of the previous gains. By the time that Ireland was partitioned into North and South, its industrial output was no higher than it had been in 1887.

4. Robustness

As noted above constructing historical industrial production indices is challenging for two main 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 70 per cent of value added and a maximum of 88 per cent.

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 $1.4 = 1/0.7$. 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 4 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 0.98 ($p < 0.01$). 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).

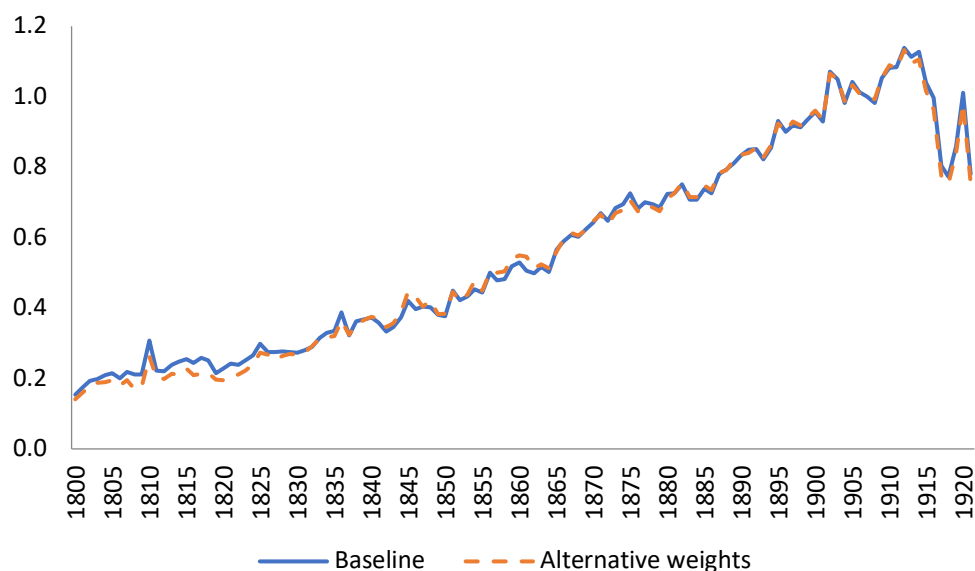


Figure 4. New annual index of Irish industrial production, 1800-1921: Sensitivity to alternative weights (1907 = 1)

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.

The value-added shares for these 13 groups are shown in Table 4. 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 $w_t = 0 \forall t \leq 1845$, $w_t = ((t - 1845)/(1907 - 1845)) \forall 1845 < t < 1907$ and $w_t = 1 \forall t \geq 1907$. x_t^{final} is then cumulated to produce an index where 1907 = 1.

Table 4. 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).

Figure 5 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 0.69 ($p < 0.01$). The average rate of growth is unchanged at 1.4 per cent 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.

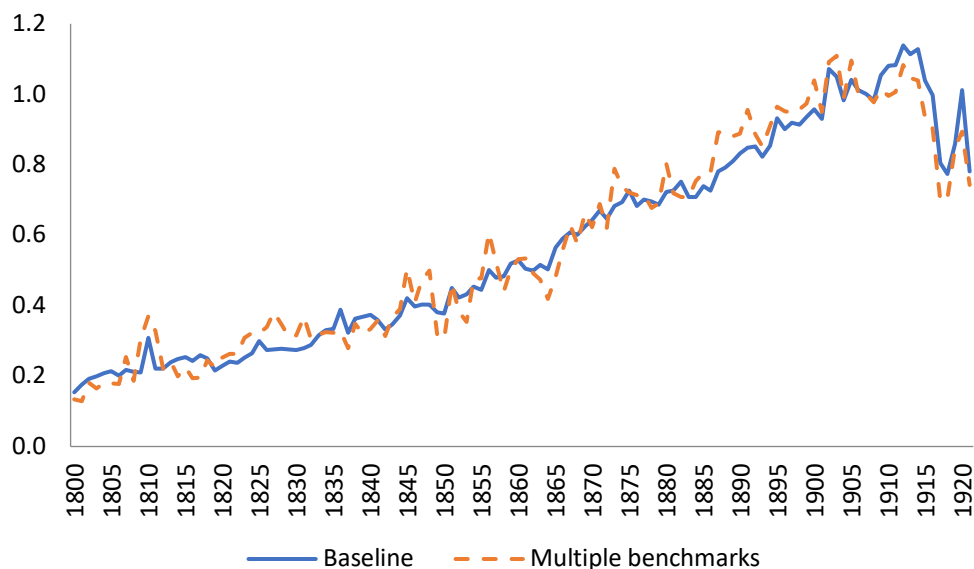


Figure 5. New annual index of Irish industrial production, 1800-1921: Sensitivity to multiple benchmarks (1907 = 1)

Source: See text.

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 in some periods.

Figure 6 shows that excluding brewing, of which Guinness was an important part, reduces the growth of industrial production to 0.9 per cent between 1800 and 1921. The beerless growth rate was 2.1 per cent between 1800 and 1845, down slightly from 2.3 per cent in the

baseline case. It was 1.2 per cent between 1851 and 1913, down from 1.5 per cent. The omission of brewing only really mattered after 1919: industrial output as a whole fell by 4.7 per cent per annum between 1919 and 1921, but without brewing the decline would have been as high as 17.8 per cent per annum. The two series are far more similar before World War I. Moreover, their fluctuations are similar with a correlation in first differences of 0.91 ($p < 0.01$). 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.

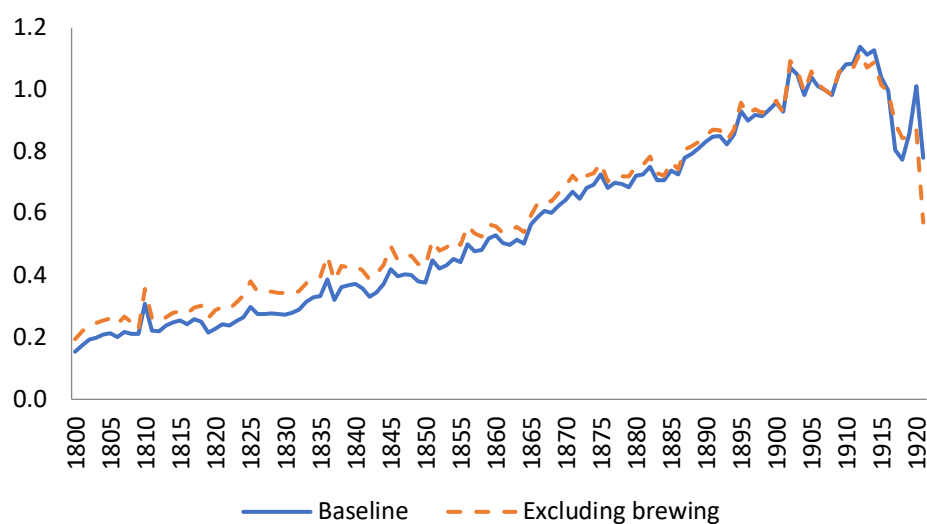


Figure 6. New annual index of Irish industrial production, 1800-1921: Sensitivity to excluding brewing (1907 = 1)

Source: See text.

In summary, we have gauged the robustness of our index in three ways: holding constant the value-added weights of Ireland's leading industries, using two benchmarks of value

added, and excluding brewing. Our index appears to be robust to reasonable methodological alternatives.

5. Conclusion: what do the new data tell us?

These new data shed light on some of the most enduring debates in Irish economic history.

First, there has been heated disagreement between the intellectual heirs of George O'Brien on the one hand, and Louis Cullen on the other, regarding whether or not the Act of Union, and in particular the customs union with Great Britain that it entailed, led to Irish deindustrialization. Our data confirm that the debate, while vigorous and fascinating, is largely misplaced, since pre-Famine Ireland did not in fact de-industrialize. It did not even deindustrialize after the customs union with Britain came into effect in the mid-1820s. It did not even de-industrialize in per capita terms, either before or after the mid-1820s. We thus find ourselves in agreement with authors such as Cullen (1972), Geary (1995), and Bielenberg and Geary (2006), rather than with Mokyr (1985). Of course, it remains theoretically possible that in the absence of the Union Irish industry would have grown even more rapidly than it in fact did, but to make such an argument convincingly would require explicit counterfactual modelling of a sort that has been absent from the Irish debate thus far.

Why then the widespread perception that pre-Famine Ireland deindustrialized? Even the textiles sector grew over the pre-Famine period as a whole, albeit at the modest rate of 0.9 per cent per annum. However, textiles production shrank from 1825 on, by 0.3 per cent per

annum, while in per capita terms textiles output was falling throughout the period (by 0.3 per cent per annum between 1801 and 1845, and by 1 per cent per annum after 1825). The textiles sector was one of the leading sectors of the Industrial Revolution, and the fact that it was shrinking in Ireland from the mid-1820s onwards was a symbol of Ireland's failure to keep pace with the industrial leaders of the time. A failure to distinguish between the fortunes of such an important sector, and of industry as a whole, is perhaps understandable.

Second, Irish industry continued to grow 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 7 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 1818 (the first year for which Danish data are available) and 1913, Irish industrial output grew at 1.6 per cent per annum, compared with 3.6 per cent in Denmark, 2.8 per cent in Britain, and 5.4 per cent in the US. It is hard to argue that slower industrial growth contributed to a faster 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, seems vindicated.³

³ Irish industrial output growth does not even stand out in per capita terms, although a clear acceleration is observable from 1845 on reflecting the collapse in the Irish population (Figure AIII.1). Irish per capita industrial growth averaged 2 per cent per annum between 1818 and 1913, less than the 2.5 per cent recorded in Denmark, or the 2.8 percent experienced in the United States. It was however higher than the British average (1.6 per cent per annum). Per capita industrial growth was also slower in Ireland than in Denmark and the US

Finally, the dramatic collapse in output from 1914 on seems to us to be a startling finding, worthy of further investigation in its own right. World wars, not to mention local independence struggles, are too often treated as caesurae in the chronologies of economic historians, but it is far from clear that an absence of war is the natural state of human affairs, and conflict has often had dramatic and long-lasting effects. As Ireland’s Decade of Centenaries nears its end, there is a need for economic history to reflect on the shorter and longer run impacts of these early 20th century conflicts on Ireland’s economic development.

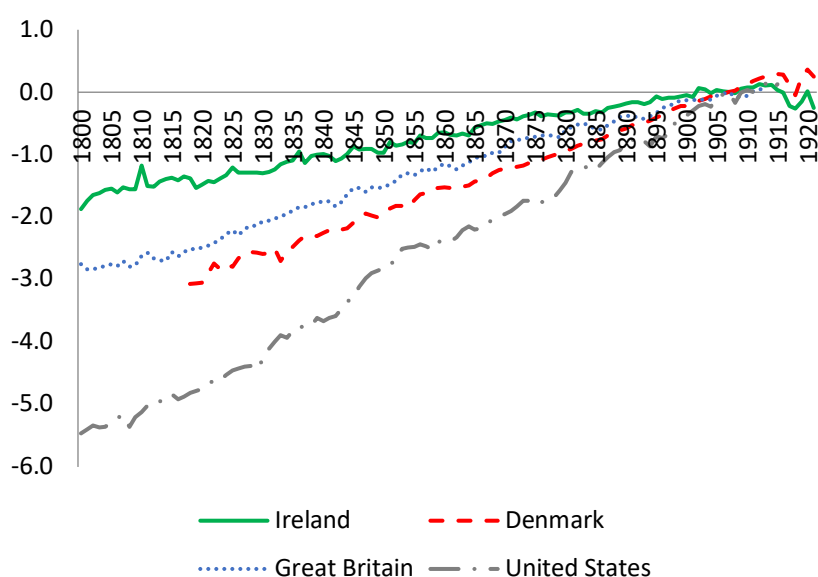


Figure 7. Industrial production in four economies, 1800-1921 (log scale)

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

after the Famine. Between 1851 and 1913 the average per capita growth rates are: Ireland 2.1 per cent; Denmark 2.3 per cent; United States 2.5 per cent; and Britain 1.4 per cent.

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APPENDIX I. CONSTRUCTING AN INDUSTRIAL PRODUCTION INDEX

This appendix documents the sources and transformations applied to the underlying output series of the aggregate industrial production index.

Series 1: Limestone quarries, etc.

Coverage: 1895-1920

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

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).

Series 3: Coal and ironstone

Coverage: 1820-1920

Details: Coal production, in tons, from Bielenberg (2009, pp. 185-6), linked backwards with Minerals Ireland (2017).

Series 4: Slate quarries

Coverage: 1895-1920

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

Series 5: Jute, hemp, linen

Coverage: 1800-1919

Details: Linen goods exports, in cwts, from *Report on the trade and imports and exports at Irish ports* (various years), spliced backwards with Solar (1990b, 2005) and official trade figures (P.P., 1826). To account for the fact that the share of exports in output increased over time, we divide exports by the ratio of exports to output. This was 53 per cent in 1820 and 91 per cent in 1907 (Gill, 1925, p. 277; P.P., 1912). The ratio is 0.53 between 1800 and 1820, 0.91 between 1907 and 1921 and log-linearly interpolated in between.

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).

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.

Series 8: Cotton trade

Coverage: 1800-1914

Details: Imports of raw cotton, in lbs, spliced forward using net imports of Belfast cotton wool and yarn, 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).

Series 9: Flax scutching

Coverage: 1848-1921

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

Series 10: Building and contracting

Coverage: 1801-1921

Details: Timber imports, in loads, from Bielenberg (2009, pp. 194-6), spliced backwards with foreign timber imports, then linked backwards with total timber imports. 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). Proxying building activity with timber imports is also the approach followed by Broadberry et al. (2015, p. 186) in the case of Great Britain.

Series 11: Shipbuilding/other

Coverage: 1800-1921

Details: Shipping launched, in tonnage, from Bielenberg (2009, pp. 189-92), spliced forwards using the total number of ships built (for the Admiralty and merchants) by Harland and

Wolff and Workman Clark from Lynch (2001). As the source only reports the cumulative sum of ships built during the First World War, the total was distributed equally to each year.

Series 12: Railways

Coverage: 1800-1921

Details: Steam locomotives built from Rowledge (1993).

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.

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).

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), spliced 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). 1873-76 and 1878-9 log-linearly interpolated as missing.

Series 16: Brewing

Coverage: 1800-1921

Details: Beer brewed, in gallons, from Bielenberg (2009, pp. 183-4), spliced forwards with sales of Guinness from Bielenberg (2009, p. 86) and spliced backwards from sales of Guinness from Lynch and Vaizey (1960, p. 260). 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 in both periods ($r = 0.93$). 1869-70 log-linearly interpolated as missing.

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).

Series 18: Grain milling

Coverage: 1846-1921

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

Series 19: Spirits

Coverage: 1802-1920

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

Series 20: Butter, cheese, marg. etc.

Coverage: 1800-1919

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

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), spliced backwards with Solar’s (1987, pp. 151, 155) series for bacon and ham exports and official trade figures on bacon exports (P.P., 1826). 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.”

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).

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).

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.

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.

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), spliced backwards from 1894 using revenue earned by

the Belfast City and District Water Commissioners (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.

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.

Series 28: Canals, docks, etc.

Coverage: 1866-1918

Details: Expenditure on new works and improvements, repairs and maintenance on harbors 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.

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.

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.

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 All.1.

Table All.1. *Conversion factors*

<i>Weight (based upon the pound avoirdupois)</i>		
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
<i>Liquid volume</i>		
1 gallon	8 pints	4.536 litres
1 barrel	36 gallons	166.4 litres
1 hogshead	54 gallons	249.6 litres
<i>Money</i>		
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 prices, 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. INDUSTRIAL PRODUCTION PER CAPITA IN FOUR ECONOMIES

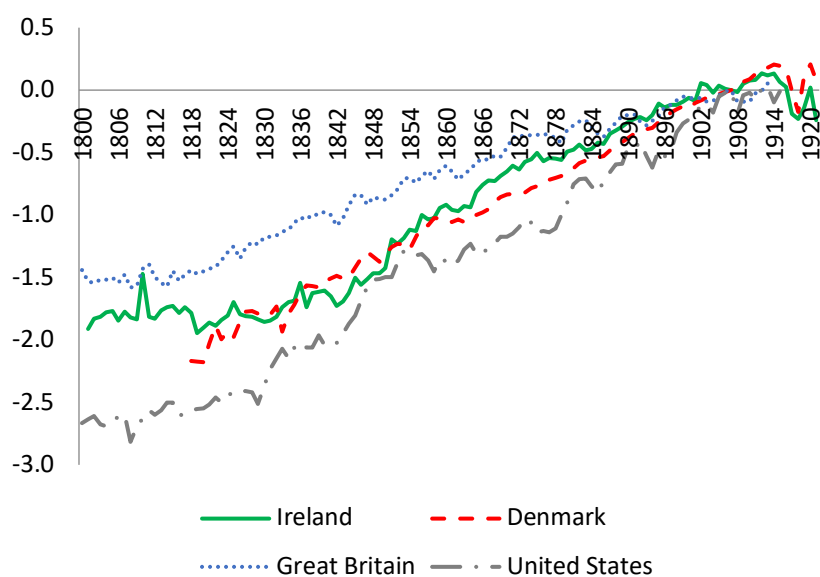


Figure AIII.1. Industrial production per capita in four economies, 1800-1921 (log scale)

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