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Large-scale Victorian Manufacturers: Reconstructing the lost 1881 UK employer census

Leslie Hannah, LSE, and
Robert Bennett, Cambridge

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Economic History Department, London School of Economics and Political Science,
Houghton Street, London, WC2A 2AE, London, UK. T: +44 (0) 20 7955 7084.

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Leslie Hannah and Robert Bennett

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Abstract

We present the first available - and near-complete - list of large UK manufacturers in 1881, by complementing the employer data from that year's population census (recovered by the British Business Census of Entrepreneurs project) with employment and capital estimates from other sources. The 438 largest firms with 1,000 or more employees accounted for around one-sixth of manufacturing output. Examples can be found in most industries. Exploiting powered machinery, intangible assets, new technologies and venture capital, and generally operating in competitive markets, their exports about equalled domestic sales. The more capital-intensive accessed stock markets, more - and in larger firms - than in follower economies. Some alleged later causes of UK decline relative to the US or Germany cannot be observed in 1881. Indeed, contemporary overseas observers - capitalist and socialist - correctly recognized the distinctive features of UK manufacturing as its exceptional development of quoted corporations, professional managers and "modern," scalable, factory production.

"The more I become acquainted with the astonishing resources of English manufacturers, their perseverance, their enterprise and their wealth, the more I am impressed with the feeling that we have a long and hard race yet to run before we surpass them in commercial pursuits."

Albert D Shaw, US Consul, Manchester, report to State Department, 15 July 1882

Shortly after Shaw delivered this judgment, the Royal Commission on the Depression examined widespread business concerns about British performance.

• Thanks to James Foreman-Peck, David Edgerton, members of the BBCE team and participants in a Reading seminar for comments on earlier versions and to numerous industry experts who generously assisted with estimating data missing from census returns. The usual dispensation applies. Corresponding author: lesliehannah@hotmail.com

Saul judged these to be overblown reactions to a depression that was largely confined to prices and agricultural output and Feinstein Matthews and Odling-Smee confirmed there were sectoral labour productivity differences within overall GDP changes, with any GDP slowdown driven by manufacturing confined to the years after 1899.[1] However, others have recently insisted that the "climacteric" in economic growth relative to earlier performance is appropriately dated to the 1870s, with total factor productivity increases peaking in 1856-73 then falling back.[2] Their calculations relate to GDP as a whole, weighted to data from the income and expenditure sides, the output side (showing less slowdown) being considered less reliable.[3] For US/UK manufacturing comparisons, Broadberry's backward extrapolations of output and employment levels intriguingly suggested that US labour productivity was already well ahead in the first half of the nineteenth century, prompting thoughtful re-examination of some of the alleged causes.[4]

Long before these assessments, leading business historians confidently blamed late Victorian Britain's rooted technical and managerial conservatism for severely limiting manufacturing scale and scope, relative to the US and Germany.[5] Our purpose here is not further to re-hash national income aggregates, but to open fresh perspectives by providing data on the microeconomics of UK manufacturing in 1881: measuring what had already been achieved by large enterprises, to provide benchmarks against which to evaluate later alleged performance shortfalls. Historians of nineteenth century business routinely regret the absence of a UK Census of Production before 1907, as did Victorian statisticians, with sectoral employment analyses relying on individual (not employer) returns, which officials considered "the least satisfactory part of the Census."[6] Factory Inspectors' reports track progressively larger plants but

[1] Saul, *Myth; Feinstein et al, 'Timing.'*
[2] Crafts and Mills, 'Sooner;' Crafts, 'Understanding.'
[3] Solomou and Thomas, 'Feinstein.'
[4] Broadberry, *Productivity;* see also Field, 'Unimportance.'
[5] Aldcroft ('Entrepreneur') provided a clear but nuanced prosecution case, whose main criticisms on scale and ownership Chandler (*Scale*) influentially amplified.
[6] Registrar-General, *Census,* p. 25. Woollard 'Classification' and others are more positive.

have only partial (and changing) coverage of sectors and businesses. In contrast US decennial manufacturing censuses provide a more richly detailed quantitative record, recording hands employed, capital, motive power and output; breakdowns by establishment size were published from 1900 and for 1850-80 can be reconstructed from manuscript returns.[7] German, French and Belgian censuses published information on the size range of businesses (by employment) in more sectors and earlier. However, exceptionally, for the four decennial population censuses of 1851-81, UK enumerators promisingly gathered information on firm size by asking business owners how many they employed. Yet no adequate tabulations were published, and the question was abandoned in the 1891 census. Clapham made the best he could of the results published for 1851.[8]

Two new research tools facilitate the more ambitious approach developed here. First, the British Business Census of Entrepreneurs (BBCE) database, using Big Data techniques to process the millions of original records, identifies employers in the original census manuscript returns.[9] This is a counterpart to the US census of manufactures, but only for employee numbers. From this we have selected all manufacturers returning 1,000 or more employees in 1881. Previous research using the BBCE, focused on the number of entrepreneurs, required adjustment for non-responses to the employer question, transcriptions errors, and lost returns.[10] The unique firm size data exploited here were especially problematic because large firms, particularly those incorporated, were found to be least likely to respond;[11] and the largest corporate employers, railways, made no census returns.[12]

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[7] Atack and Bateman, 'Nineteenth century.' Jeremy Atack and Richard Hornbeck generously shared their unpublished databases of US 1880 manuscript returns.
[8] *Economic History*, p. 35. Even the published tabulations were somewhat imperfect, especially for larger firms (van Lieshout et al, 'British Business').
[9] Bennett et al, *British Business*; idem, *Age*. Data guide and publications using BBCE at www.bbce.uk.
[10] Bennett et al 'Population;' Bennett et al, 'Changes.'
[11] Bennett and Hannah, 'British employer.'
[12] Separately in 1884 (Board of Trade, "Railways') the largest railway reported 55,061 employees, mainly operating transport services. We include only 41,119 manufacturing employees in 13 large railway-owned workshops, anticipating later production census practice.

We resolved this issue using a second set of resources: newly searchable databases of contemporary newspapers and parliamentary papers, infilling for British non-responders and for the Irish census records (which were largely destroyed) to cover the whole UK.[13] Strikes, boiler explosions and factory fires (not infrequent occurrences) often resulted in press reports of numbers of employees affected. Numerous factory visits by engineering institutes, factory inspectors, royal commissions, parliamentary select committees, journalists and foreign dignitaries also elicited employment data, which we searched using terms like "largest factory" and "000 hands." Census returns relate to 4 April 1881 and other sources to various dates from which approximations for the spring of 1881 can be interpolated. Combining sources produced the list of 438 UK manufacturing employers with 1,000 or more employees reported here. Census returns identified half of these.[14] Additions backfilled from supplementary sources risk hindsight bias, but we compensated by tracking forward several hundred firms making large employment returns to the 1851/61/71 censuses and three Royal Commissions (1867 on Trade Unions, 1868 on River Pollution and 1871 on Truck), identifying firms failing to make an 1881 return but remaining large.

In this paper we focus on manufacturers (a sector prominent in the literature on productivity achievements/shortcomings) in the last year that the employment question featured in the population census: 1881. After the end of the mid-Victorian boom (conventionally dated 1856-73), 1881 provides a suitable benchmark of its achievements, albeit possibly already slightly tarnished by the early-onset climacteric sometimes alleged. It is also a clear generation before the 1907 production census, a widely used later benchmark of problematic comparative performance. The BBCE already indicates the manufacturing

[13] *British Library Newspapers* online are constantly expanding, searches made up to June 2021; *British Parliamentary Papers* were already fully searchable online, with the usual qualifications about OCR errors.

[14] 35% of the total from 1881 returns; others from earlier censuses identifying likely large employers failing to return.

sector's increasing concentration in larger firms (for the firms it covered),[15] and the great bulk of large BBCE returns were for manufacturers.[16]

These new data enhancing the BBCE offer a new framework for understanding the UK's largest firms and their performance. The following section charts their growing weight in the UK economy. Next, we assess their contribution by industry, by capital and by stock exchange finance, then survey more fragmentary evidence on their production techniques, management, intangible assets and productivity. The conclusion considers feasible elaborations of these research techniques. All 438 firms with 1,000 or more employees are identified in Appendix 1, with additional material on 1871-81 in Appendix 2 and two further methodological appendixes available on request from the corresponding author.

Large Manufacturing Employers of 1881

Census returns derive from the instruction "in trades, manufactures or other business masters must, in all cases, be so designated, inserting always the number of workpeople in their employ at the time of the Census." Returners (usually household heads) and census examiners were asked to report domestic and farm servants separately (excluded from our totals) and to include all employees, though partners and some directors were not technically employees, and other white-collar employees may in some cases be omitted. We have (a few egregious mistakes apart) respected the numbers in census returns, from knowledgeable contemporaries answering a standard question on a fixed day. Outworkers - common especially in clothing - were excluded by many returners from "workpeople in their employ" but are included for some firms and standardisation is impracticable. Overseas employees would logically be excluded from a national census and cases where they were not, have largely been adjusted to conform. Partners, instructed to make only one return,

[15] Bennett et al, *Age,* pp. 125-32.

[16] Mining constituted most large 1881 returns not analysed here (mines are included only if owned by manufacturing firms). Agriculture, distribution, construction, finance and professional services made few or no ≥1,000 employee returns.

sometimes duplicated returns, which are removed. Some widely cited contemporary sources resorted to puffery and have been discounted unless corroborated by other sources; others reporting fewer or more employees than the census have been ignored. Proprietors rarely specified firm names: these are identified from sources like the *Dictionary of Business Biography*, the *Directory of Directors* and contemporary newspapers. Only 13% of managers of incorporated enterprises employing ≥1,000 responded, so supplementary sources for corporations were essential,[17] whereas slightly over half of unincorporated enterprises made returns.

Measuring size by employee numbers biases toward labour-intensive firms, excluding some more efficient firms.[18] Its attraction - apart from being the *only* measure in census returns - is that a person is a person (in silk and steel, in Galway and Glasgow, in 1851 and 1881). Yet that egalitarian principle may sometimes mislead. Full-timers produced more than part-timers, and adults more than juniors (especially children under 13, working only half-time while attending school). Suggestions that Irish produced less than Scots or women less than men (though self-evident if wages reflected marginal productivities) raise more difficult issues. In much 19th century labour, the role of sweat and muscle was reflected in higher male wages, while firms deploying more mechanical aids often increased female recruitment, with women accounting for most textile employment. Aggregating males and females by the compensation-weighting convention (counting a woman as two-thirds a man[19]) would reduce the proportion of firms in textiles and clothing in this list.

Many returns were rounded to the nearest hundred and should be considered estimates; rankings of firms with modestly differing totals should not be over-

[17] We identified only four returns that related to large corporations with a major stock exchange listing and numerous holders, but others were readily identified from stock exchange directories.
[18] It includes several Irish shirt manufacturers employing thousands of out-working seamstresses, while several integrated factories in Oldham - whose highly paid machine operators produced cotton cloth with fewer workers than the national average per spindle and loom - fell slightly below the 1,000-employee cut-off.
[19] Levi, *Wages,* pp.19-21.

interpreted. Employers of 1,000 or more naturally encountered problems radically different from the small employer but did not resolve them uniformly. Indeed, their diverse capabilities - sometimes driving and sometimes inhibiting further growth – might be used in future analysis to support competing theories of the causes of rising factory employment at scale.[20] Some of the businessmen[21] making returns had multiple business interests. Where they had multiple shareholdings/partnerships, comparison with more granular sources suggests they normally reported the entity that they considered their main business (including employees in all UK plants and branches), but a few grouped related firms. Press reports sometimes relate to individual factories, as did a few census returns, but, where the firm owned more, we have estimated additions to mimic the enterprise level of the typical census return.

The figures are thus generally for firms, not plants. Firms accessed wider scale and scope economies: buying power, reputation, patents, advertising, designers, tacit knowledge, laboratories, specialist managers, shared distribution networks and so on. Similarly, in US censuses plants in the same city or county under common ownership in the same industry were defined as one "establishment." By that definition the single-establishment firms in this list would be about half the total and the number of manufacturing establishments per multi-plant firm was in low single figures.

The results are summarized in Table 1. There were 438 manufacturing firms employing 1,000 or more, averaging 2,143 employees each, with a median of 1,500. The distribution is skewed: 33 "giant" firms (employing 5,000 or more) accounted for over a quarter of all large firm employees. Most people worked in enterprises well below our threshold size; overall mean employment per firm was fewer than 8, much as today. There were more firms employing ≥1,000 in

[20] Among those proposed in the literature are technological non-separability, labour discipline, transaction costs, asset-specificity, network dysfunction, market size, expertise-sharing and inertia.

[21] All large returners in 1881 were men. Earlier some young widows who had helped run their husband's firm and opted to continue were large employers.

manufacturing in 1881 than today, but today's on average employ 61% more people; their share in manufacturing employment has risen from 16% in 1881 to 27%.[22] This was accompanied by growth in plants per firm; by the later 20th century the *average* top 100 UK manufacturer operated 72 plants.[23] There was no Unilever in 1881 (the founding Lever brothers still helped manage their father's Bolton wholesale grocery employing 22). Our firms were chiefly concerned with managing their core business, not juggling portfolios of diverse subsidiaries as in such later conglomerate behemoths. Otherwise, the manufacturing firm size distribution was already much the same as today.[24]

Table 1. UK Manufacturing: Firms and their Employees, 1881.

Size (employees)	Number of Firms	Number of Employees		Mean employees per firm	
		All Employees	Manufacturing only	All Employees	Manufacturing only
"Giant" (≥5,000)	33	237,746	155,075	7,204	4,699
1,000-4,999	405	701,037	627,066	1,731	1,548
≤1,000	438	938,7783	782,137	2,143	1,786
0-999	649,562	n/a	4,077,863	n/a	<7
UK Manufacturing	650,000	n/a	4,860,000	n/a	<8

Source: worksheets of the present study. We have estimated the total number of manufacturing firms from the partial coverage of BBCE plus an allowance for Ireland. Firms with zero employees are self-employed manufacturers with no employees, accounting for about 70% of manufacturing firms but less than 9% of the manufacturing workforce. For total manufacturing employment we have deducted slightly more than 1% from Feinstein's (*National Income*, p. T131) 4.92m to allow for occupational returns by people who were unemployed at the census date and added 22,000 for gas employees (whom Feinstein excludes from manufacturing). The resulting 4.86m total manufacturing employment figure is also the figure in Lewis (*Growth,* p. 265) which we have used for manufacturing employment at other dates. Earlier estimates (including Booth, 'Occupations') were lower, clustering around 4.5m.

[22] In 2019 there were slightly more than 2.5m manufacturing employees, fewer than in 1881, see https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/adhocs/12035manufacturingenterprisesandlocalunitsbyemploymentsize. UK manufacturing employment and the numbers and share of ≥1,000 firms peaked at higher levels in the 1960s and 1970s (Zeitlin, 'Why,' pp. 103-5).

[23] Prais, *Evolution,* pp. 85-6. Even after multi-firm merger waves had created 8 firms with ≥20 plants, Shaw ('Large,' p. 48) estimates the mean number of plants among top 100 manufacturing employers at six and the median at three.

[24] For example, 199,000 (7.8%) of the 2,555,000 UK manufacturing employees of 2020 were self-employed compared with 7.1% (plus Irish self-employed) in 1881 and the sub-1000 size ranges were much the same as in Bennett and Hannah, 'British employer.'

The adjustments in the third column attempt to remove non-manufacturing employees from the reported employee numbers where sources allow. Although this is imperfect, the contrasts highlight that the largest firms of 1881 were more vertically integrated than smaller firms: backwards to raw material supplies (dominated by iron and steel giants owning coal, iron ore and limestone mines) and forwards to wholesale warehouses and distribution (mainly textile and clothing manufacturers).

The largest firms' share in employment may - as more recently - understate these employers' share in output and, a fortiori, the share of large firms ordered by output size. Apart from economies of scale, larger firms potentially accessed more learning-by-doing and divisions of labour (including more specialised management), cheaper transport (through private rail sidings and river or ocean access) and better internal and external financing, all possibly improving productivity. It will be noted later that large employers were also more capital-intensive and had developed significant intangible assets such as patents, designs and brands; many also paid higher wages than the national average and sometimes a little above the going rates for their locality and favoured apprenticeships and other on-the-job training.[25] We lack output data, but for all these reasons their overall share in value-added was probably somewhat higher than their share in employment: they perhaps accounted for a sixth of manufacturing output by value or more.[26]

Calculating aggregate concentration ratios for time series comparisons is not straightforward, given uncertainties in defining both numerator and denominator. Census returns of 1851-81 (albeit only a subset of totals) suggest a steadily rising share of large employers, as firms grew both by merger and by reinvesting profits, increasing divisions of labour, use of machine technology and learning-by-doing. Several dozen large companies of 1881 – notably in gas, rail

[25] More, *Skill*.
[26] The 1907 production census noted higher labour productivity in industries dominated by large firms, or selling proprietary or patented articles (Census, *Final Report*, pp. 13-14).

engineering, and iron/steel - also had a record of acquisitions. This early merger wave has been somewhat overshadowed by the multi-firm merger waves of 1888-90 and 1896-1900, in sectors relatively untouched by the earlier wave but often led by firms which were already large in 1881, such as Bazley White in Associated Portland Cement or Houldsworth in Fine Cotton Spinners. Focusing on the conventional top 100 firms for measuring aggregate concentration, their share of all manufacturing employees rose from 6.3% in 1871 to 7.3% in 1881, while comparison with Shaw's data for 1907 suggests a further rise to around 11% in the next generation.[27]

Industrial Distribution and Concentration Levels

In Table 2 we have classified these businesses by sector. They were overwhelmingly in the classic mechanized industries using the general-purpose technology of steam power. More large firms (58%) were in consumer goods (textiles, clothing, shoes, food, drink, consumer durables) than capital goods (building materials, machinery, ships, railway equipment and metal inputs to such goods).[28] However, capital goods firms accounted for just over half of all large-firm employees, much more than the one-fifth for UK manufacturing employees overall. 22 of the top 25 employers were producing capital goods. Having in 1843 abandoned largely fruitless attempts to restrict exports of leading-edge machines, UK businesses were now driving globalisation by building the transport networks and workshops of the world, accounting for 63% of world exports of capital goods.[29] The range of machinery – not only widely-used looms, locomotives, ships, printing presses and steam engines, but specialist items like tunnel borers, rubber mixers, horseless carriages, wire extruders and biscuit cutters – was extraordinary.[30] Chandler's suggestion that

[27] Shaw, 'Large.' In each case using occupational census data as the denominator (Lewis, *Growth,* p. 265) with interpolation for 1907. For the 1871 top 100 compiled on a similar basis to 1881, and a list of 1860s and 1870s mergers of large firms see Appendix 2.
[28] This division is necessarily approximate and products like sewing machines and road vehicles were both consumer and investment goods.
[29] Saul, 'Export,' p. 16.
[30] Hunt, *Ure's Dictionary*.

"In machinery the British did not even try"[31] from the 1880s to 1913 - not seriously sustainable in 1913 - is plainly absurd in 1881.

Table 2. Large UK Manufacturing Firms and Concentration by Industry 1881.

	Firms employing ≥1,000				Concentration	
	1 No of Firms	2 Employees	3 Mean (col2/col1)	4 Industry Employment	5 ≥1000	6 top 3
Iron and Steel[a]	84	143,012	1,704	450,000	32%	3%
Shipbuilding/Marine Engineering	31	77,610	2,504	107,000	73%	25%
Railway Engineering	28	63,965	2,284	100,000	64%	21%
Textile Machinery	13	25,300	1,946	50,000	51%	23%
Other Engineering[b]	17	31,372	1,845	100,000	31%	13%
Cotton	84	140,818	1,676	540,000	26%	3%
Wool/Worsted	27	37,268	1,380	265,000	14%	3%
Linen, flax, jute	37	69,758	1,885	140,000	50%	10%
Silk, lace, carpets, oilcloth	17	27,007	1,589	138,000	20%	7%
Textile finishing/dyeworks*	12	17,546	1,462	103,000	17%	6%
Gas/coke/chemical byproducts*	6	10,858	1,810	22,000	49%	37%
Other chemicals	16	24,494	1,531	82,000	30%	10%
Bricks, pottery, glass, cement	9	15,902	1,766	138,000	12%	6%
Paper, printing, books	12	18,007	1,501	193,000	9%	4%
Clothing	23	48,235	2,097	925,000	5%	2%
Footwear	5	7,889	1,577	275,000	3%	2%
Food/drink/tobacco	17	23,006	1.353	611,000	4%	1%
Industries with no large firms[c]	0	0	0	621,000	0%	n/a
Total manufacturing	438	775,334	1,774	4,860,000	16%	1%

Sources. Cols 1-3, present study. Col 2 is based on col 3 of Table 1 (it excludes employees of manufacturing firms in mining and services).
Col 4. authors' estimates, see Appendix 3 (available from corresponding author).
Col 5. calculated from cols 2 and 4; col 6 from present study's worksheets and col 4.
*These three sectors shared some features, including extensive employment of chemists. Textile finishers manufactured some of the dyes they used, and gas was then manufactured from coal, alongside extensive coke, oil and chemical by-products. We have treated gas undertakings as manufacturers, deferring to nineteenth century practice (Booth, 'Occupations'), not as utilities. Our "other chemicals" sector also includes three copper refiners who produced chemical by-products.
[a] including some simple final products (e.g. cutlery, files, saws, chains, wire, screws and other fixings) whose manufacture was sometimes integrated with iron/steel production.
[b] including agricultural engineering, machine tools, non-transport steam engines, telegraph cables, Bessemer converters etc.
[c] principally leather, timber, furniture, road carriages and some nonferrous and miscellaneous manufactures.

[31] Chandler, 'Managerial Enterprise,' p. 22; compare Saul, 'Market,' Foreman-Peck, 'Balance.'

We have tried to align estimates of employment in all manufacturing firms in column 4 of Table 2 with our data for large firms in the first three columns, but they are necessarily approximations. Nonetheless the broad results of this exercise are plausible.[32] There are only five industries in which large employers may - within the margins of error of the data - account for most of a sector's employment: shipbuilding, railway engineering, textile machinery, coal gasification and linen (col 5). The two industries with most large firms – iron/steel and cotton - were also massive employers, so less than a third of their employees were in large firms.

There were 24 large employers in clothing, but this sector had many thousands of firms with approaching a million employees, so concentration was low. Mechanical band-knives from the 1860s cut multiple identical cloth or leather pieces in standard sizes for uniforms, gloves, shoes, corsets, men's suits or shirts. They were finished not only by steam-driven sewing machines in factories but by homeworkers operating treadle machines, giving outworkers a new lease of life,[33] and for some fine work on lace or linen embroidery hand needlework survived. Much the same was true in hosiery where circular machines knitted "tubes," but hand finishers still closed and "fully fashioned" some stockings. Moreover, 649,527 dressmakers, milliners and tailors made individual occupational census returns (70% of clothing employees) and few of them worked in factories: many were self-employed, selling bespoke rather than standard lines, or working by hand or treadle machine in small shops. Similarly, food manufacturing was mainly populated by small businesses (grain millers, slaughterhouses) and self-employed maker-dealers (bakers, butchers). Large employers mass producing biscuits in continuous baking ovens (Huntley & Palmer, Peek Frean) or selling branded preserves in cans and bottles (Crosse & Blackwell, Colman Mustard) were exceptions.

[32] For example, the exceptionally comprehensive Factory Inspectors' returns for 1870 show shipbuilding with the highest average factory size, while their 1878 and 1885 textile returns show woollen mills smaller than others.

[33] Machines enabled one woman to do the work previously done by twelve (Mulhall, *Dictionary*, p. 296).

At the other end of the scale, the highest 3-firm concentration ratio (37%) was in local regulated monopolies supplying piped gas, yet they competed with many other suppliers of lighting and by-products (coke and chemicals). The mean 3-firm concentration ratio in col 6 is under 10%, though concentration, of course, increases with the fineness of classification. Platts accounted for 12% of textile machinery employment but in the following decades it supplied 87% of cotton spindles installed in Japan[34] and its share in Oldham was not much smaller. Other more narrowly-defined industries - warships, window glass, screws/nuts/bolts, envelopes or steel pens – were contestable oligopolies, though competition was weak where there were vertical restraints.[35] This was not an economy in equilibrium, but in a constant ferment of change: able to generate both the innovative variety and the selection forces that drove evolutionary success. Apparently entrenched incumbent firms could not easily prevent rivals' expansion: Fothergill & Hankey (which returned 8,000 employees in 1871) was bankrupt by 1875 but rival iron and steel firms with more successful financial, technical and labour strategies had replaced the output of its derelict South Wales blast furnaces.[36] Eleven others among the 326 firms that had employed 1,000 or more in 1871 no longer existed by 1881; many more had declined in size, but there was a net gain of 112 large firms and the 1881 firms were on average larger. With vigorous competitive assortment within a growing economy, a more integrated national market than Germany or the USA, and the UK's distinctive disavowal of protective tariffs, it is implausible to assert that any lacklustre manufacturing performance in 1881 derived from "lack of competition in product markets and the relative absence of creative destruction as disciplinary mechanisms to promote the efficiency of firms"[37] as more reasonably suspected of 1950.[38] Indeed, late Victorian Britain was arguably the most competitive economy the world had ever seen, a poster child (like the US in the late

[34] Saxonhouse. 'Tale,' p. 162.
[35] Government restraints on printing and armaments competition had dissipated, but the largest railway engineering works were owned by railway companies, which - following an 1876 court decision - were barred selling to third parties; their parent railways allocated few orders to outsiders.
[36] Riden and Owen, *British*, pp. 1-2, 23.
[37] Nicholas, 'Technology,' p. 182.
[38] Broadberry, *Productivity*, p. 157; Lazonick, *Business Organization*.

twentieth century) for the competition policy now recommended by neo-Schumpeterians for economies at the technological frontier.[39]

British industrial dominance was, of course, long-established and these firms - like rivals overseas - were mainly turning out old products, albeit with modern improvements and sometimes profound transformative effects. The Butterley Company (ranked 11th by employment) - the leading maker of iron girders spanning rivers and roofing modern buildings - was a partnership organised in 1807; its Derbyshire ironworks had first manufactured iron rails in 1792 (1,000 miles of horse-drawn railways pre-dating the first steam locomotive). Platt (ranked 15th) - the world's leading textile machinery maker - started manufacturing in Oldham in 1821. The LNWR's railway works (ranked 9th) opened in 1843, thirteen years after a constituent firm offered the world's first steam passenger rail service. Acids, chlorine, and (Leblanc) soda were produced by Tennants (of Glasgow and Tyneside, founded 1788 and ranked 98th by 1881) and these and superphosphate fertiliser, gunpowder and rubber by other mature chemical firms. Few producers of "modern" chemicals – Solvay soda or artificial dyestuffs – employed 1,000+ in 1881 and they were respectively French or German: Britain was catching up with France's Dombasle (and outstripping Deutsche Solvay) in soda but falling further behind in dyestuffs; the US was then *hors de combat*, importing most such modern chemicals from Europe.[40]

However, large UK firms were no slouches in other "new" industries that had more substantially developed in the previous two decades and were acknowledged by contemporaries as transformational and "modern."[41] Electricity

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[39] Aghion, *Power,* p. 61.

[40] BASF, a leading German dyeworks, already employed 1,140 (including 17 chemists) in 1876 (Abelshauser et al, *German Industry*, pp. 102-3). Brunner Mond (the British Solvay licensee) returned only 594 employees in 1881, but soon employed over 1,000, as its output caught up with Solvay in France, the other large "modern" chemical producer (Bertrams et al, *Solvay,* p. 53). Dynamite – another "modern" chemical – achieved giant scale after Alfred Nobel and his Scots collaborators engineered the merger of British and German producers into a UK-headquartered trust in 1886.

[41] Our definition of 'new' is one of several possible. Bairoch ("International,' p. 288) estimated that ca 1880 64-72% of UK manufacturing output - compared with only 30-38% in other developed countries - was in 'new technology' industries (by which he meant the main drivers of

was used in lighting, electroplating and telegraphy, mainly in 1881 the latter. The largest firms manufactured submarine telegraph cables, extending the overhead wires of national land networks to build the first worldwide web. Three Thames-based companies, each employing around 2,000, manufacturing cables and operating seagoing cable-layers, were larger than any overseas rival: India Rubber, Gutta Percha & Telegraph Works, Telegraph Construction & Maintenance (which had in 1876 acquired local competitor Henley), both incorporated in 1864, and Siemens Brothers, in 1880.[42] The big money in electricals - after the 1870s boom in construction - was in operating telegraphs. Most of the 100,000 miles of submarine cables linking national telegraphs worldwide (transforming global trading, finance and headquarters control over shipping lines) were British-made and in the hands of large British telegraph companies. By 1881, the basic worldwide web was complete, but new orders for competitive routes remained strong and this section of the British electrical industry continued to prosper.

Petroleum was another "new" industry: oil lamps challenged traditional lighting by candles, competing with producers in Asia (Russian Baku from 1846), Europe (Ottoman Romania from 1857) and the US (major Pennsylvania discoveries in 1869), sourced from oil wells (which the UK lacked). Domestic oil was mainly distilled from cannel coal (shale). The pioneer (and still largest) UK firm, Young's Paraffin Light & Mineral Oil Co, was incorporated in 1866 to take over partnerships exploiting the processing patent of the eponymous chemist, James Young, who had operated the world's first commercial refinery in 1851. By 1881 the company had invested £1m in three refineries in central Scotland, also making lubricating oil, paraffin wax, and oil lamps. With 2,500 employees, it ranked 90th= in the UK list and, though still smaller than gas lighting companies with some similar inputs and by-products, it had overtaken the 2,000 employees

industrial growth, notably cotton, iron, steel and chemicals, rather than traditional textiles, clothing, foodstuffs, timber and furniture).

[42] In 1881 Siemens employed 1,418 in England and 675 in Germany and the largest (43.5%) share of Siemens Brothers was owned by Sir William Siemens, a naturalised Briton (Von Weiher, *Siemens-Werke*, pp. 95, 111 n 4; Feldenkirchen, *Siemens*, p. 162).

at Price's Patent Candle, another lighting product that shared some raw material inputs. New shale rivals entered as Young's patents expired, though the largest, Broxburn Oil, still only employed 869. Shale production more than tripled after 1881, but domestic processors had increasing difficulty meeting the prices of Standard, Burmah and Shell, importing petroleum extracted and refined in America and Asia.

Other large firms in "new" industries mainly developed from established firms. In steel, an old product transformed by cheaper decarburising processes opening up new uses, some new companies were formed by inventors. The key Bessemer, Siemens and Gilchrist-Thomas steelmaking processes were all British inventions, and in the major early use the UK converted from iron to steel rails faster than Germany or the US.[43] Landore Siemens Steel was incorporated in 1870 and by 1881 operated 24 Siemens furnaces, employing 2,800 in South Wales. In contrast, the Henry Bessemer & Co partnership was, from its formation in 1858 to the patent expiry in 1877, mainly a (highly profitable) licensing firm and in 1881 still employed fewer than 1,000 at its six Bessemer converters in Sheffield and Glasgow. Both Siemens and Bessemer operated non-exclusively, licensing their technology widely, so existing ironworks with furnaces to feed the new steel converters could readily enter. The Dowlais Iron Co's sixth generation of managers had by 1881 (with 8,750 employees) changed the balance from iron to steel and become Britain's largest operator both of Bessemer converters and Siemens furnaces.[44] The third new steelmaking process, Gilchrist-Thomas dephosphorisation, was initially developed by Percy Gilchrist (at the Blaenavon Co from 1876) then (when Blaenavon failed) used development facilities offered by Bolckow Vaughan (the largest employer in coal, iron and steel).

Shipbuilding was a similarly vibrant new industry supplanting an old one, wooden sailing ships. The key innovations - widely applied only from the 1860s -

[43] Mulhall, *Dictionary*, p. 382.
[44] Meade, *Coal and Iron.*

were more fuel-efficient compound steam engines, high-pressure boilers, and screw propellers, almost exclusively developed by British marine engineers and naval architects. The first triple-expansion engine was installed by its inventor, Dr Alexander Kirk (of Napier shipyard on the Clyde) in 1874: he became senior partner in 1877 and employed around 2,000. At the same time new machines for cutting, bending and riveting iron facilitated the building of larger ships; steel ships did even better, carrying 20% more cargo than iron ships of equal size. Iron superseded wood in most UK ship construction by 1862, steel by 1886.[45] In 1881 UK shipyards built almost all the world's steel steamships and launched perhaps 90% of oceangoing steam merchant tonnage and warships (if sailing ships and paddle steamers in which other countries still specialized are included, around two-thirds). The mainly oceanic - and thus necessarily open – markets for modern ships offered few barriers to trade or investment (limiting foreign protectionism to navy purchases, subsidies and cabotage) and transport costs for delivering ships were essentially zero, so the UK dominated world supply, as in submarine cables with a similarly open oceanic market.

Most foreign multinationals with British manufacturing plants in the nineteenth century failed or made poor profits.[46] Only two qualified among our large firms in 1881,[47] both US sewing machine manufacturers. Singer Manufacturing had in the 1860s established its foreign headquarters in London, applying US production techniques in a Glasgow factory, where it was in 1881 rebuilding to match the scale of Elizabethport, New Jersey. With around 4,250 UK employees, Singer already ranked 36th by employment, though most were in distribution, not manufacturing. Its retail shops inspired consumer confidence in this new, complex, consumer durable and its marketing leadership constituted the company's distinctive competitive advantage, after its patents expired in 1877, halving prices. Singer's share (around three-quarters of the global market) was

[45] Pollard and Robertson, *Shipbuilding*.
[46] Godley, 'Pioneering.'
[47] Among other US multinationals, the London factories of Robert Hoe (printing presses) and Westinghouse Brake (railway equipment) employed fewer than 1,000 in 1881 and Wheeler & Wilson (sewing machines) had withdrawn from the UK in 1879. On the nationality of Holden and Siemens ca 1881, see Appendix 2 and n. 42 above.

secured by its canvasser-collector financing system, key to promoting sales while disciplining overenthusiastic salesmen. Invented by the London branch, it was adopted later by the US parent: Singer was a genuine transnational with a two-way flow of ideas and personnel.[48] The Howe Machine Co (employing perhaps 1,500 in its UK subsidiary, also with a Glasgow sewing machine factory) by contrast had a mindlessly boosterish approach and was soon bankrupt in both countries, while British-owned competitors still employed fewer than 1,000.

Singer's Scotland/US complementarity was matched in cotton sewing thread. Two Paisley firms, Coats and Clarks (in 1881 together employing 7,020 in Scotland and several thousand more in their US subsidiaries in New Jersey and Rhode Island), had global reach: sewing machinists valued quality thread brands for break-free operation. Applying Paisley manufacturing techniques in their US factories, the Scots dominated the American as well as European branded thread market and learned from US colleagues. These thread firms were to combine in 1896, becoming Europe's largest industrial, with double Singer's market capitalisation, as the latter approached saturation (at least in English-speaking markets), two decades before thread. More generally, UK-headquartered firms led multinational development in 1881[49] and in terms of aggregate capital invested remained ahead of US, German and French multinationals (combined) as late as 1938.[50]

The textile industries, accounting for 39% of large firm employees, were a classic outcome of the international division of labour promoted by free trade as industrialisation spread. In such basic industries (food and clothing accounted for most household expenditure worldwide), demand was inevitably growing faster in new overseas industrializers than in the rich UK with more discretionary expenditure. UK textile employment growth was slowing, although linen (in Ireland) and cotton (in Lancashire) were resilient. In 1881 cotton still

[48] Godley, 'Selling.'
[49] More than a dozen of our firms already manufactured overseas in 1881, see Appendix 2.
[50] Dunning and Lundon, *Multinational Enterprises,* p.174.

accounted for about half of nationwide textile employment. Export sales accounted for nine-tenths of the 5.35b yards of cotton cloth manufactured, most going to Asian countries just beginning to install British machinery in local factories.[51] This was substantially an American product: raw cotton, most from US plantations, absorbed around two-fifths of UK cotton revenues. With modern textile technologies spreading to countries with lower wages (continental Europe) or longer working hours (the US), this globally exposed, unprotected industry could hardly have survived if it had failed to neutralize the high wages of Lancashire by exceptionally high productivity. 70 of the 84 large firms integrated spinning with weaving and, occasionally, dyeing and printing too[52], but they controlled only about a quarter of UK capacity and new mills employing fewer than 1,000 remained competitive. Survivor analysis suggests scale around 1,000 employees was a modest advantage (as, with some branding and exceptionally skilled managers, was even larger scale) but vertical integration less so: smaller firms specializing in one process readily accessed Marshallian external economies in the Lancashire industrial district.[53]

Most large firms served national and export markets, even in sectors like brewing or clothing where producers generally served local markets. Indeed, in aggregate our large firms probably sold half their production abroad,[54] many having sales offices in Paris, New York, Bombay, Sydney and other trading hubs. Others outsourced distribution to commission agents and wholesalers at home and overseas.

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[51] Mulhall, *Dictionary*, p. 114.
[52] Suggesting more integration than indicated by the 1885 Factory Inspectors' returns, which treated some integrated firms as spinning- or weaving-only plants (our figures are for firms not plants).
[53] Leunig, 'British Industrial Success;' Broadberry and Marrison, 'External Economies.'
[54] Lewis (*Growth,* p. 119) estimated 52% of UK manufacturing production was exported in 1873. Weighting industry-wide export percentages ca 1881 (Mulhall, *Dictionary*; Bartlett, *Carpeting,* p. 66; Saul, 'Export,' p. 13; Anon, 'Commercial') by our large firm employees suggests they exported 43% of their output, but large firms generally exported more than small.

Capital Intensity and Firm Finance

Census returns reported only employee numbers, but data on invested capital exist for 284 of these large firms. Almost all public companies by 1881 published their paid-up capital (equities and fixed interest) in externally audited accounts. Less comprehensively - from archives and private company registrations - we have enterprise capital figures for closely held firms in, or near, 1881. These usually include working capital (stocks and works in progress and net trade credit to/from customers/suppliers) as well as factories and machinery, and land and natural resources as well as reproducible assets, but are not otherwise standardized. Firms lacking capital data differ from those with known capital: they were younger, smaller, unevenly distributed among industries and more likely to be partnerships, perhaps restricting their access to capital. We have adjusted for such biases in estimating the capital of missing cases.[55]

Accounting conventions left considerable leeway on matters like depreciation or capitalizing re-invested profits; partners with unlimited liability and shareholders with only partly paid shares risked more capital than reported; some capital expenditure was unobserved bank or peer-to-peer loans and private share issues; and some included non-enterprise expenditures (like worker housing). Reported capital measures are thus unavoidably noisy and should be interpreted with care. Ranks by employment and capital differ but, as in later periods,[56] they are correlated, with the largest deviations in capital-intensive industries. The Gas Light & Coke Co, Bass (beer) and Distillers (Scotch) - were ranked 18th, 75th and 359$^{th=}$ by employment but 2nd, 5th and 44th by capital. Many of our firms would not appear as large manufacturers by capital, being displaced by others with under 1,000 employees.

[55] We experimented with specifications using log employment, incorporation date, and dummies for industry, region, non-manufacturing employees, organisational forms and LSE-listing; our preferred estimate (see Appendix 4, available from corresponding author) achieved R-squared of 0.6866. The capital of the 35% of large firms with estimated capitals accounted for 25% of employees and 17% of the capital in Table 3.

[56] Bates, 'Alternative Measures.'

Table 3 shows industries in declining order of capital-intensiveness, with greater disaggregation than Table 2, separating three exceptions to industry norms. The large capital of Royal Dockyards[57] reflected the cost of supplying/repairing the Royal Navy, not the modest requirements of a typical shipyard, while sewing thread and alcoholic drinks were more capital-intensive than the cotton and food industries more generally. These and the chemical industry (including coal gasification which produced chemical by-products) were above the normal range of £121-£252 capital per employee. Other firms occasionally diverged from industry averages: a cement manufacturer (Bazley White) had nearly five times that of the average building materials firm; and an armour plate specialist (Vickers) over twice that of the average iron/steel manufacturer. The least capital-intensive firms were in linen and clothing, with many outworkers as well as factories.[58] Feinstein's estimate of the capital stock for all manufacturing was well under half our mean of £208 per employee: only £83 per employee, and much less for the residual five times our number of employees after deducting our large firms from both denominator and numerator.[59] We cannot firmly deduce from that alone that our firms were more capital-intensive than smaller employers, because national income and business accounts differed, but definitional differences can hardly account for such a large gap.[60] Large factories employed more capital per employee than smaller firms for obvious reasons: steam engines, lathes, steel converters and mule frames were more expensive than the shoemaker's last, tailor's scissors or dressmaker's needle used by small workshops and the self-employed.

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[57] Central government was the nation's largest employer, in manufacturing and more generally. We have treated its three large manufacturing operations (shipbuilding, armaments and army clothing) as three separate firms.

[58] Variations in capital-intensiveness broadly resemble 1880 US manufacturing and - using horsepower as a proxy for capital - the UK in 1870 and 1907 (Varian, 'Manufacturing,' p. 492).

[59] Pollard and Feinstein's (*Studies*, pp. 304, 452-3, 470-1) net reproducible fixed capital stock (factories, machinery and vehicles) of £402.6m at 1881 prices, divided by the 4.86m workforce (Table 1).

[60] Corporate accounts include non-reproducible capital such as land and Table 3 includes some non-manufacturing and overseas capital. Feinstein aggregated stocks and work in progress economy-wide not separating manufactures. However, we did not find any large firm accounts with the low reproducible fixed manufacturing capital implied by Feinstein's figures.

Table 3. Capital of Large UK Manufacturing Employers ca 1881

Industry	No of Firms	Paid up Capital (£m) Total	Mean	Capital per Employee (£)[a]
Gas, coke & by-products	6	16.475	2.746	1217
Royal Dockyards	1	17.437	17.437	1113
Alcoholic drinks/bottlers	8	10.040	1.255	810
Sewing thread	5	5.394	1.079	582
Chemicals	16	7.921	0.495	281
Other textiles[b]	17	6.991	0.412	252
Railway Engineering[c]	28	15.519	0.554	240
Other Engineering[d]	17	6.417	0.377	205
Wool[e]	27	7.160	0.265	192
Coal, iron and steel	84	49.221	0.586	186
Bricks, pottery, glass, cement	9	3.412	0.379	175
Paper & printing	12	2.863	0.239	159
Textile machinery	13	4.312	0.332	149
Textile finishing	12	2.298	0.191	149
Footwear	5	1.173	0.235	141
Food/tobacco	9	1.854	0.206	139
Cotton[f]	79	16.623	0.210	123
Shipbuilding/marine engineering	30	7.453	0.248	121
Clothing	23	5.993	0.261	109
Linen	37	6.826	0.184	94
All Large Manufacturers	438	195.389	0.446	208

Source: this study's worksheets

[a] because the capital includes non-manufacturing establishments of vertically integrated manufacturers, we have included all UK employees in the denominator. As we lack value-added data, the alternative measure of capital-intensity (the capital-output ratio) cannot be calculated.

[b] 11 of the 17 cases are estimated capitals and the figures in this row cannot be interpreted as representative of any of this miscellany of silk, lace, carpets, oilcloth etc. The two largest employers (Lister's silk mill and Crossley's carpet mill) used patented and untypically capital-intensive processes, and their known capital values have disproportionate influence on the predicted values.

[c] including 13 railway workshops which we assume accounted for 1% of the parent railway's capital (giving capital per employee slightly higher than independent railway manufacturers).

[d] Within this miscellaneous category two gunmakers (BSA and Royal Ordnance) had £147 capital per employee and three electrical engineers twice that at £296. Six agricultural machinery manufacturers averaged £204 per employee with a range of £127-£279.

[e] The largest wool employer, Titus Salt, had unusually high capital per employee because his partnership capital included the new town of Saltaire (worker housing, schools, etc). This is not an error (he and the tax authorities believed these were legitimate business expenses), though a national income accountant would re-allocate such capital. Such cases amplified the values predicted from an untypically low 44% of wool firms with known values, so this row probably overstates the capital of wool factories.

[f] Cotton is normally thought of as more capital-intensive than wool (Varian, 'Manufacturing,' p. 492), but appears less so here. Estimation bias is probably less serious than wool (57% of cotton capitals are known), though in cotton 5 firms in the most capital-intensive sector (sewing thread) have been separated and some remaining cotton firms were vertically integrated to warehousing (which used only limited machinery for packing). It was also common for subscribed but unpaid cotton capital to be used to guarantee deposits, mortgages and loans, only some of which were reported in the sources available (joint stock companies were not required to register debentures publicly until 1900), so cotton capital employed is likely understated.

The sources of capital varied. Some of our large employers were sole proprietors or private companies, but most were partnerships, which offered considerable flexibility for financing expansion or building managerial teams. Some partnerships had already lasted for several generations and, through trust arrangements, offered transferable shares; they required formal incorporation only if partners exceeded twenty. Outside ("sleeping") investors could lend to partnerships, sharing in profits but retaining the limited liability of fixed interest lenders, more securely after the 1865 Partnership Act than before. Widows or other heirs could thus limit risks when financing existing managers or professional recruits from outside as new partners, sometimes by phased and leveraged earn-in arrangements, comparable to modern management buy-ins. While technically most partnerships automatically dissolved on the death of a partner (unless otherwise agreed), the accumulation of intangible capabilities in firms of this size - and of sunk tangible assets with limited second-hand markets - meant that selling off the assets piecemeal destroyed value, so heirs, continuing partners or trustees usually tried to avoid that outcome. The managerial class from which new partners might be drawn – engineers, chemists, salesmen, accountants, lawyers, bankers, merchants and "counting house" clerks - rapidly expanded between the 1851 and 1881 censuses, inducing a "revolution in the method and management of industry."[61] Professional and local networks aided principals searching for equity partners or managers; there were also head-hunters and advertising media serving principals conducting searches.[62]

The names of some partnerships of this scale thus reflected past family owners and the reputational value of continuing name recognition: current partners were not required legally to feature in the business name. Existing owners sometimes sought new partners to ease their partial exit from business: many were notables such as members of parliament or mayors. Others opted for full retirement from active management and succession by their sons and/or

[61] Booth, 'Occupations,' p. 336.
[62] see the situations vacant and partnership advertisement columns of the *Times* or the *Engineer* and brokerages listed in local directories for facilitating ownership transitions.

professional managers. Private incorporation gave active participants and continuing passive investors limited liability without requiring much financial disclosure or loss of control. Plutocrats with ample wealth could also attract professional managers by high salaries and/or profit-related bonuses. In 1875 Edward Guinness chose to become sole proprietor of his family's Dublin brewery at the age of 29 by buying out his relatives' partnership shares, but he drove its remarkable expansion using a dozen experienced and loyal senior executives with annual salaries of ≥£1,000.[63] Enterprises of this scale usually had not one heroic leader but, among their owners and managers, a team with complementary skills, sharing strategic decision-making and administrative functions.[64]

A larger step was to incorporate as a public company,[65] attracting more investors and perhaps listing on a stock exchange and recruiting part-time outside directors. Public company directors typically had lower ownership shares than partners, though almost all were required - by investors, stock exchanges or their charters - to have at least a modest shareholding. Only 110 of our 438 firms were public companies, but they and six others (government undertakings with access to bond investors) shown in Table 4 together accounted for half the capital and 35% of employees in all our large firms. Firms with this wider financial access were, then, both larger employers and more capital-intensive than those with narrower ownership. It is plausible that this ability to raise outside capital contributed both to their achieving larger scale and/or managing issues of succession for owners and managers. 70% of them had incorporated over 1861-81 under the general incorporation acts, though others were of longer standing, many formed by royal charter or statutory incorporation.

[63] Dennison and MacDonagh, *Guinness*, p. 6-7.
[64] Payne, 'Industrial entrepreneurship.'
[65] The division of public from private companies - not legally defined in 1881 - was widely understood. We borrow the 1907 definition - 50 or more shareholders and/or issuing shares to the public – to distinguish them.

Table 4. Large Manufacturers: Stock Exchange Listings and Trading Venues 1881.

Trading venue	No. of Firms	Capital (£m)	
		Total	Mean per firm
London "A"	18	32.000	1.778
London "B"	24	27.090	1.129
Informal markets	25	12.230	0.493
Manchester	11	6.469	0.588
Sheffield	8	4.470	0.559
Birmingham	8	3.551	0.444
Belfast[a]	6	1.713	0.285
Newcastle	6	5.067	0.845
Glasgow	3	2.001	0.667
Halifax	2	0.541	0.270
Edinburgh	1	0.416	0.416
Oldham[b]	2	0.272	0.136
Leeds	1	1.188	1.188
Liverpool	1	0.948	0.948
Total	116	98.406	0.845
(Private firms[c]	322	97.344	0.302)

Source: this study's worksheets, with allocation to the senior market on which they were traded, based on *Burdett's Official Intelligence*, *Skinner's Stock Exchange Yearbook*, *Investors' Monthly Manual* and regional share lists in local newspapers.
[a] no exchange, but multiple brokers traded local industrials.
[b] no exchange, but its brokers' association organised an active market.
[c] sole proprietorships, partnerships and private companies (<50 shareholders, with no known trading venue or public issue).

Their trading venues are shown in Table 4. The London Stock Exchange (LSE) was already the dominant market for government bonds and railway securities. We have separated its official listings in these sectors ("A") from more conventional manufacturers ("B"), among which other venues' combined market share of 59% (by the capital in col 2) exceeded London's, though the latter remained the single leading "B" venue with 41%. However, many (including all "A"s) were listed on multiple exchanges and we have assigned them to the senior exchange (usually the LSE), although many were first listed and still mainly traded in the provinces. The important role of northern exchanges, particularly Manchester (whose immediate hinterland accounted for a third of large manufacturers), reflects well known regional specialisms, with few large manufacturers in southern English counties.[66]

[66] There were also concentrations of large manufacturers in Scotland, Northern Ireland, South Wales and the East and West Midlands.

"Informal" trading was a large category including many variations: from restricted markets such as Platts (whose internal market, with prices fixed by its accountants, from 1868 enabled managers, and later other employees, to share in profits and capital gains) to firms traded by brokers, auctioneers, accountants, solicitors and/or the firms themselves matching bargains under less stringent rules than official exchange listing. Some featured in share directories, but without a place of listing or prices: their investors relied on local networks, as also did many listed on the smaller regional exchanges. These stock exchanges played a larger role than today in new financing and some of these firms had been funded as start-ups, but also, as primarily today, listing an IPO was a convenient exit route for founding entrepreneurs and venture investors.

Production Techniques and Intangible Assets

The firms we have described were large, numerous and on some dimensions modern, but this was not mass production, at least not in the Fordist 1928 River Rouge sense: combining single-purpose machines producing interchangeable parts with largely unskilled labour to produce standard goods in vertically integrated plants. Yet some were unmistakably on a journey towards it: Palmers' Tyneside shipyard (employing 8,000) was noticed in similar terms. At one end, raw materials (coal, limestone, iron ore, timber, cloth) entered, while, at the other, after carefully sequenced processing by blast furnaces and some of the world's largest purpose-built machine tools, warships and ocean liners majestically slipped into the waves, for final fitting out. Palmer's - like the Rouge - was an outlier, but systematized workflows through factories were not exceptional. Precursors of the modern assembly line, like the "Long Shop" flows of agricultural machinery assembly at Garrett's of Suffolk, were medium-sized (employing only 500 in 1881), yet visiting engineers also admired larger factories that carefully sequenced flows and assembly processes.[67] Until the 1890s, most factories were multi-storey, which optimised distribution of power from central steam engines, often adopting the cascade principal of beginning

[67] As at Dowlais (*Engineer*, 27 May 1881, p. 396).

manufacture on the top floor and working down. They necessarily sequenced production in a different way to River Rouge (driven by electricity).

The "American system" of interchangeable manufacture was spread by sales of US gun-making machines to the Royal Ordnance factories and the Birmingham Small Arms Co, both also installing British-made copies, though civilian and police demand for guns was low in Britain. Singer also installed mainly American-designed machinery, though Hounshell's cautions about casual claims of mass production in New Jersey also apply to its Scottish factory.[68] Some British machinery firms exemplified the "American" system earlier and more comprehensively than the US. A journalist visiting Platt's Oldham factories (returning 7,000+ employees, many times US equivalents) noted the extensive use of unskilled labour on self-acting machine tools and its system of interchangeable parts, most machined in-house to ensure standardisation.[69] Platt's maintained records so replacement parts could be machined and supplied to its customers worldwide for fitting and, like Singer, manufactured many of its own machine tools. On the other hand, locomotives or tramp steamships were at best made in batches of six to twelve, but this could lead to hundreds of standard design locomotives, carriages, wagons, and steam engines being manufactured over a decade, though not the thousands annually of small arms or sewing machines. Universal small parts (screws, nuts, bolts) were produced by the billion, adopting the Whitworth standard (pre-dating its American equivalent) and railways standardized other components (boiler tubes, cranks, gearing), limiting duplications of spares.[70]

Firms often exploited the patents of their principals or employees (with suitable agreements on rights allocation) and there was an active market - both business-to-business and via patent agents - with third-party and overseas inventors. Firms with scientific skills cast round for new applications, while those lacking

[68] *American System*, pp. 109-21.
[69] Anon, 'Fortunes.'
[70] Musson, 'Whitworth,' for a balanced assessment of British and American origins of mass production and engineering standardisation.

them took steps to co-opt expertise. Henry Pochin, a partner in a Manchester manufacturing chemist with many patents, became a director of 22 companies, the largest Bolckow Vaughan, with 12,800 employees. Samuel Lister made his first fortune assembling patents for and licensing his woolcombing machines at home and abroad and had more than a hundred patents to his name. That for recovering usable silk from waste - spinning the fibres as if they were cotton rather than traditional silk-throwing – allegedly involved £250,000 in development expenditure, matching early twentieth century R & D expenditures at American Tobacco, General Electric and Du Pont,[71] enabling his Manningham Mills, near Bradford, to become the world's largest silk manufacturer, with 3,217 employees in 1881. Manningham was also something of an innovation nursery: one of its top managers, Henry Tetley, later drove the development of *artificial* silk (rayon, the first man-made fibre), pioneering the new chemistry-based textile industry.[72]

Warren de la Rue, onetime president of the Royal Astronomical Society, Royal Institution and Chemical Society and vice-president of the Royal Society, published dozens of scientific papers and patented inventions. He also played a key role in his family's printing firm in central London employing dozens of engineers (designing specialized machinery) and chemists (testing inks, varnishes and colours and conducting original chemical investigations) to maintain the company's leading-edge reputation as security printer of many of the world's postage stamps. Many others among our large employers - dyeworks, textile printers, breweries, steelworks and chemical manufacturers - maintained laboratories to test materials, optimize manufacturing processes, maintain product quality and/or comply with alkali emission controls. The value of UK patents around this time (scaled by capital formation) was already half the level achieved by more formalized twentieth century R & D and patent protection.[73]

[71] Iredale and Trickett, "Lister," p. 806; compare Hannah, "Whig Fable," p. 53, n. 36.
[72] Coleman *Courtaulds*, pp. 24-31.
[73] Sullivan, 'Estimates.'

Many of the firms in our population possessed other intangible assets, which - judging by the higher expenditure on marketing than technical research (in all countries) - were worth more. The 1875 Trade Marks Registration Act strengthened common law protections, though many then registered were already long established.[74] Large textile and pottery firms employed artists and designers to differentiate products and appeal to the fashionable, often protecting designs by copyright,[75] suing rivals passing off products not made by them. For some products – sewing thread, mustard, biscuits, beer, whisky, shoes, linen - extensive advertising was already creating the complex emotional consumer adherence of modern branding. Many of the large capital goods producers also advertised extensively in the trade press and directories.[76] Some top brands registered overseas but suffered counterfeiting in the US, continental Europe and Japan.[77] Manet's *Folies Bergère* barmaid offering a bottle of Bass beer (the first brand registered under the 1875 Act) in his 1882 painting may be a pioneering case of product placement by one of our firms or Manet's accidental testimony to successful global branding. Among Bass's hundreds of infringement actions, fortified by incriminating sampling by their laboratory, one quarter in the 1880s were abroad.[78]

New ideas in technology and marketing flowed as easily across international borders as the machines and publications that embodied them. The 1881 UK economy was unusually open, so favourably placed to monitor, assess and implement overseas innovations, as suggested by its high ranking on a complexity index of countries' presence at the 1878 Paris world exposition.[79] Dozens of our firms' managers had looked east for their technical education to Germany, France or Switzerland, knowing that British elite universities were

[74] Higgins, 'Forgotten Heroes.'
[75] As attested by design historians (e.g. Sykas, 'Secret Life') and the appearance of many of these firms' products in the Victoria & Albert Museum..
[76] see the large selection of their advertisements reproduced in https://gracesguide.co.uk.
[77] Lopes and Casson, 'Brand Protection.'
[78] Higgins and Verma, 'Business.'
[79] Domini, 'Patterns.'

better at classics, law and theology than science.[80] British entrepreneurs also looked west, but to factories not colleges. Inventive Americans were preoccupied with their domestic market during its rapid late industrialisation and failing to expand internationally;[81] instead they licensed others to develop British Empire and European markets. From 1847 Erastus Bigelow patented 40 carpet-making inventions, expanding his mills in Clinton Massachusetts, but sold his overseas patent rights to John Crossley of Halifax for £20,000 in 1852. Crossleys developed their own designs, sub-licensing others to use their improved machinery, and became considerably larger than Bigelow and European price-leader in carpet manufacturing. Corliss's high-pressure steam engines were the main US contributor to improved thermal efficiency and smooth delivery in the key power technology of the day but had low capital costs and high fuel consumption, making them less attractive at UK factor prices.[82] Hick Hargreaves & Co of Bolton, the main UK licensee, nonetheless made some improvements for UK users and matched the scale of the US company. Similarly, from Germany, the most promising alternatives to steam power were the internal combustion gas engines of Gasmotoren Fabrik Deutz under Otto and Daimler, who licensed their leading model (the "Otto" patented in 1876) to Crossleys of Manchester: by 1881 they had installed in the UK more than twice the gas horsepower of Germany.[83]

Americans, Germans and others were thus understandably keen that their firms - or inventions generating licensing income - should succeed in the challenging UK market, as Asians and Europeans aspire to succeed in California today. London had not only the world's largest concentration of rich urban consumers, but also informed venture capitalists, merchants, accountants, stockbrokers and engineers with global experience and ambitions. London's Old Broad Street was thus very much the Sand Hill Road of its day, with not only technical and

[80] though Cambridge mathematics was already world class, and its impressive Cavendish laboratory was financed by the Duke of Devonshire, owner of three of our large firms.
[81] In 1881 US manufactured exports were less than one-tenth of the UK's and smaller than Belgium's.
[82] Atack, 'Fact.'
[83] Dowson, 'Gas Power.'

marketing leadership but the advantage of risk diversification in its advanced venture capital market, facilitating the management of the radical uncertainty typifying new technologies.[84] There were many thousands of Americans and Germans in Britain at the time of the 1881 census, mainly in London, some attracted by history, culture or religion, some seeking commercial education or negotiating business deals in the world's largest city. The American machinery inventor-salesman, Francis Watkins, partnered with the Birmingham businessman Arthur Keen in 1856, eight years later launching the Patent Nut & Bolt Co with £200,000 capital, and already by 1881 the firm employed 3,400. Thomas Edison opened his first central electric station at London's Holborn Viaduct in January 1882, *before* New York's Pearl Street.

Directions for Future Research

The new data presented here offer a benchmark of large-scale manufacturers at the end of the mid-Victorian period in the world's largest concentration of manufacturing employees.[85] We describe employees and managers in 438 exceptionally large firms, not the whole population. Observations that smaller firms produced most output and that many used fewer machines and less power have contributed to (justified) assaults on the view that nineteenth century business could be definitively characterised as mechanized, large scale and steam-driven,[86] as earlier economic historians appeared to emphasize. Yet Marx - and other historians consciously or unconsciously influenced by him - concentrated on firms of this kind, believing that they heralded the future: powered factories with large and quasi-continuous though-puts and great efficiency at scale already had real achievements by 1881. That view of these leading firms was shared by many contemporary Americans, who - though they had ambitions to build bigger and better and soon would - recognized that on

[84] Michie, 'Options.'
[85] At census dates there were 4.860m manufacturing workers (UK 1881), 4.716m (Germany 1882) and 3.290m (US 1880). The qualifier 'modern' would increase the UK lead (n. 41 above).
[86] Samuel, 'Workshop,' Greenberg, 'Reassessing,' Sabel and Zeitlin, 'Historical Alternatives.'

many dimensions they had yet to do so.[87] US manufacturing labour productivity was already higher than the UK's, but the size of the gap remains moot, as does the extent to which it applied to these firms.[88] The American engineer Alexander Holley - like Marx - viewed Britain as on some dimensions a portent of the world's and America's future and - as Bessemer's master licensee in the US - knew what he was talking about. He noted that Cammell's Dronfield plant "probably turns out more rails with less men than any other rail making plant in the world"[89] and urged American industrialists to use steel in the wider range of applications and machines already familiar in the UK. In the two most capital-intensive manufactures (coal gasification and breweries) leading UK firms - Gas Light & Coke and Guinness - were not only larger than American equivalents but achieved higher outputs per employee.[90]

It is desirable to compare our population more comprehensively with other industrial countries, in terms of scale and productivity, though that is not as straightforward as might be supposed, even for firms where supplementary sources can compensate for the largest lacunae in our data (the absence of value added and physical output measures). The manuscript returns to the US 1880 census and the published returns for the French and German censuses of 1881/2, are for establishments or plants not firms, though in all four countries at that time there was a substantial overlap between these categories. The lower employment of continental European plants is palpable, though a few French and German *firms* had more employees than any UK equivalents. However, French and German wages were low, encouraging labour-intensive processes,

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[87] see introductory quotation.
[88] Broadberry (*Productivity*, p. 48) estimated an overall US labour productivity lead in 1879 approaching 88%. A contemporary analysis sponsored by the US Bureau of Statistics, based on visits to larger British establishments, though ignoring much resource-based manufacturing in which US production and productivity exceeded the UK's (such as sawmills, grist mills, curriers and wooden shipyards), suggested a narrower US labour productivity lead around 6-8% (Young, *Labor*, pp. 368-9).
[89] Warren, *Steel,* p. 69, see also McHugh, *Holley*.
[90] US 1880 census manuscript returns and the present study, see also Byatt, *British*, pp. 23-4; Dennison and MacDonagh, *Guinness*, p. 3.

while the UK and US resembled each other in being more capital-intensive.[91] Yet the distribution of firm sizes in the US perhaps matched the UK's of 1881 only toward 1900. Two decades earlier there were barely half as many US manufacturers with ≥£1m capital as the 35 in the UK[92] and the New York Stock Exchange was bereft of manufacturers compared with London or Manchester. It was not the case, as Chandler asserted, that Britain's mid-Victorian "industrialists had become attuned to a slower, smaller-scale process of industrial production and distribution."[93] On the contrary the "visible hand" of UK 1881 businesses was a model for US industrialists and financiers to catch-up with in the next two decades, though (as with many successful followers) tailoring the model for local conditions.

Our new data supplementing the BBCE potentially enable avoidance of some business historians' casually Whiggish attribution of success factors and underestimation of the creative destruction of failures.[94] Space constraints necessarily limit this article to a static benchmark for 1881, but applying the techniques exemplified here could facilitate comparable estimates back to 1851 and forward to the decade before 1914, improving our understanding of the dynamics of change. Our provisional findings suggest that some criticisms in the literature of the modernity, scale, mechanisation, and professionalism of Victorian business require revision. Understanding any shortcomings in relative performance in the following decades can now be more fully developed using the quantitative template for large firms assembled here as a potential benchmark for studies of future years.

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[91] Varian, 'Manufacturing.'
[92] United States, *1900 Census* and 1880 US census manuscript returns. 'Giant' UK firms by the capital criterion are listed in Appendix 1: those in iron/steel, textiles, breweries and cement account for the 1880/81 US lag.
[93] Chandler, 'Emergence,' p. 497. Given his imagined *explicandum,* his - and Aldcroft's earlier - explanations (which suggested retarded development of professional managers divorced from owners) are (unsurprisingly) also suspect (Foreman-Peck and Hannah, "Extreme Divorce;' Acheson et al, 'Corporate Ownership;' Hawkins, 'American boomers,' p. 803).
[94] Lamoureaux et al, 'Against Whig History;' Fridenson, 'Business Failure;' Aghion et al, *Power*.

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Appendix 1. The Largest Manufacturing Employers of 1881

This is a list of all 438 manufacturing firms identified as having 1,000 or more employees in 1881, with their business name and main business sector, arranged in declining order of 1881 employment (including non-manufacturing employees, as given in the standard census return). An asterisk indicates that the source is a census return, usually in the version of BBCE deposited in the Essex Data Archive. A few returns were identified as related to only one plant of a partnership and have been increased to standardise all returns at the firm level of the normal return. Several more returns were found on the subscription genealogy service ancestry.co.uk while conducting this research and will be added later to BBCE. More details on these firms and their proprietors/directors/partners can be found in standard sources such as the *Dictionary of Business Biography* or the online *Grace's Guide* (https://gracesguide.co.uk). We were not able to identify the firm of John Gilby, a Yorkshire capitalist who made a return as "part owner of a cotton mill employing 1025." The last column shows the paid-up capital of these firms, when reported on or around 1881; but those with the suffix "e" were estimated econometrically. Care is needed in interpreting the capital and employment figures for individual firms for the reasons stated in the article text and table footnotes. The authors would be grateful if future researchers on these firms would communicate any suggested corrections to the corresponding author.

Firm Name		Industry	employees	capital £
Royal Dockyards		shipbuilding	15672	17437464
Bolckow Vaughan Ltd		coal iron steel	12800	3389120
Rylands & Sons Ltd		integrated cotton	12250	1500000
Wigan Coal & Iron Co Ltd		coal coke iron	11000	2010774
Wm Baird & Co		coal iron	10000	3264000
Dowlais Iron Company		coal iron steel	8750	900000
London & NW Railway workshops		railway workshops	8269	1834000
Palmer's Shipbuilding & Iron Co Ltd		coal iron steel shipbuilding	8000	900880
Barrow Haematite Steel Co Ltd		coal iron steel	8000	2466105
Butterley Company		coal iron	8000	500000
Dent Allcroft & Co	*	gloves	8000	650000
Great Western Railway Workshops		railway workshops	7500	1502000
Earl of Dudley Estate Office		coal iron	7082	1050000
Platt Bros & Co Ltd	*	textile machines	7000	1240000
Ebbw Vale Steel Iron & Coal Co Ltd		iron steel coal	7000	2128362
Royal Ordnance Factories		guns gunpowder	6873	961129
Pease & Partners	*	coal iron wool	6500	1200000
Gas Light & Coke Company		gas coke chemicals	6300	9326500
Bell Brothers Ltd		coal iron steel engineering	6250	900000
William Dixon Ltd	*	coal iron	6000	372000
Tredegar Iron & Coal Co Ltd		coal coke iron	5500	1134144

North Eastern Railway Workshops		railway workshops	5500	1125000	
Consett Iron Co Ltd		coal iron	5500	697325	
Staveley Coal & Iron Co Ltd		coal iron	5000	813350	
John Elder & Co	*	shipbuilding marine engineering	5000	406965	
Robert Heath & Son		coal iron	5000	500000	
Pearson & Knowles Coal & Iron Co Ltd	*	coal. Iron, engineering	5000	830000	
Charles Cammell & Co Ltd	*	coal, iron, shipbuilding	5000	1150000	
Merry & Cunninghame		coal iron	5000	825000	
I & R Morley		hosiery	5000	1108205	
Cox Brothers	*	jute	5000	462000	
William Ewart & Son		linen	5000	400000	
Robert & Henry Parnall		wholesale clothier	5000	150000	
Patent Shaft & Axletree Co Ltd		coal iron steel axles	4750	626962	
Blaenavon Company Ltd		coal iron steel	4750	220000	
Bessbrook Spinning Co Ltd		integrated linen	4600	281896	
Midland Railway workshops		railway workshops	4500	1360000	
Lilleshall Co Ltd		coal iron steel machines bricks	4500	719000	
Stanier & Co	*	coal iron	4500	617046	e
Fownes Brothers & Co	*	gloves	4335	352219	
Weardale Iron & Coal Co Ltd		iron coal steel	4250	900000	
Singer Sewing Machine Manufacturing Co		sewing machines	4250	1000000	
Rhymney Iron Co Ltd		coal iron steel	4250	1140407	
Baxter Bros & Co		linen jute	4200	640000	
Sir W G Armstrong & Co		iron steel engineering	4000	988000	
Pilkington Brothers	*	glass	4000	448448	
John Crossley & Sons Ltd	*	carpets	4000	1187970	
York Street Flax Spinning Co Ltd		linen	4000	360000	
Llynvi & Tondu Ltd		coal iron	4000	449589	
Stanton Ironworks Co Ltd		coal iron	4000	420600	
Low Moor Ironworks Company		coal iron	3800	905449	
Bryant & May		matches	3750	400000	
Ulster Spinning Co Ltd		linen	3750	402590	
Crawshay Brothers	*	coal and iron	3500	600000	
J & G Thomson	*	iron, shipbuilding	3500	370742	e
Newton Chambers & Co		coal iron coke	3500	448963	
T & W Sidebottom	*	integrated cotton	3500	329078	e
William Barbour & Sons		linen thread	3500	250000	
Patent Nut & Bolt Co Ltd		iron steel fixings	3400	280000	
Huntley & Palmer	*	biscuits	3300	350000	
Coltness Ironworks	*	iron coal	3297	382950	
Bass Ratcliff & Gretton Ltd		beer	3250	3200000	
Samuel Lister		silk	3217	1576108	
Barrow Shipbuilding Co Ltd		shipbuilding	3200	430710	
John Brown & Co Ltd	*	iron steel coal	3146	1041537	

Vivian & Sons	*	nonferrous metals chemicals coal	3120	1200000	
West Cumberland Iron & Steel Co Ltd		coal iron steel	3100	630000	
J & J Clark		sewing cotton	3050	1789669	e
Shelton Bar Iron Co		iron	3000	150000	
Waterlow & Sons Ltd	*	printing, publishing	3000	382015	
Earle's Shipbuilding & Engineering Co Ltd		shipbuilding marine engineering	3000	310000	
Sheepbridge Coal & Iron Co Ltd		coal iron	3000	630739	
Frizinghall Works/Hodgsons	*	textile machines, worsted spinning	3000	411461	e
Thames Ironworks & Shipbuilding Co Ltd		shipbuilding	3000	237500	
McIntyre Hogg & Co		shirts	3000	203931	e
Tillie & Henderson		shirts	3000	203931	e
Robert Lindsay & Co Ltd		integrated flax	3000	80000	
Whittaker & Co/Hurst Mills Co Ltd		integrated cotton	3000	250000	
Steel Co of Scotland Ltd		iron steel	2950	646480	
Laird Brothers	*	shipbuilding marine engineering	2850	248095	e
Harland & Wolff		shipbuilding	2800	235065	
Landore Siemens Steel Co Ltd		coal steel	2800	747000	
Samuel Courtauld & Co		silk	2800	441574	
John Musgrave & Sons Ltd		cotton ironworks	2800	545800	
Sir Titus Salt (Bart) Sons & Co	*	integrated worsted	2800	1250000	
John Wood & Brothers Ltd		integrated cotton	2764	250000	
Richard Haworth & Co	*	integrated cotton	2700	271407	e
Andrew Leslie & Co	*	shipbuilding	2700	275800	
Alexander Pirie & Sons		paper stationery	2700	300000	
Stead Simpson & Nephews	*	footwear	2600	246387	e
Tootal Broadhurst Lee	*	integrated cotton	2600	341125	
Horrockses Miller	*	integrated cotton	2571	610872	
M Oldroyd & Sons Ltd		integrated wool	2500	450000	
Young's Paraffin Light & Mineral Oil Co Ltd		petroleum refining	2500	586625	
Lancashire & Yorkshire Railway workshops		railway workshops	2500	708000	
Bowling Iron Co Ltd		coal iron steel	2500	226700	
Charles Tennant & Co	*	chemicals	2500	363800	
Clay Cross Iron & Coal Co		coal iron bricks	2500	295913	e
Doulton & Co		table/sanitary pottery	2500	290192	
Henry Matier & Co		handkerchiefs linen	2500	62900	
Ashton Brothers		integrated cotton	2461	192400	
J H Gartside & Co Ltd	*	integrated cotton	2450	118410	
J & P Coats	*	sewing thread	2400	1697500	
Thomas Rhodes & Son	*	cotton weaving	2400	140000	
Chance Brothers		glass chemicals	2400	208000	
London & Manchester Plate Glass Co Ltd		glass	2400	555000	
Great Northern Railway Workshops		railway workshops	2400	635000	
Richards & Co		linen	2400	195000	

Shotts Iron Company		coal iron	2400	416168	
William Cubitt & Co	*	building and materials	2367	299459	e
Scott & Co	*	shipbuilding marine engineering	2331	258160	e
Arthur Guinness & Sons		beer	2300	2250000	
Dobson & Barlow	*	textile machinery	2300	206710	e
William Bracewell & Sons		integrated cotton	2300	351700	e
South Metropolitan Gas Company		gas coke chemicals	2250	1981490	
Great Eastern Railway Workshops		railway workshops	2250	377000	
William Gray & Co		shipbuilding	2200	253268	e
Charles Mitchell & Co		shipbuilding	2200	247520	
Nettlefolds Ltd		wood screws	2200	1030000	
Peek Frean & Co		biscuits	2200	199895	e
John Holdsworth & Co		worsted	2200	358623	e
William Calvert & Son	*	integrated cotton	2200	226165	e
John Orr Ewing & Co	*	textile dyeworks	2188	298448	e
John Dugdale & Sons	*	cotton spinning/iron foundry	2174	223784	e
Brookfield Linen Co Ltd		linen	2100	200000	
Glasgow Iron Company		coal iron	2100	327662	e
Daniel Gurteen & Sons	*	clothing	2100	150000	
Archibald Orr-Ewing & Co		textile dyeworks	2100	287737	e
John Foster & Son	*	integrated worsted	2100	360000	
Carron Company		coal iron hardware	2100	613811	e
John Heathcoat & Co		lace	2100	620622	e
Army & Navy Cooperative Society Ltd		clothing printing retail	2100	251495	
Neilson & Co		locomotives	2050	414283	e
Noah Hingley & Co		iron chains anchors	2050	291483	e
Welch Margetson & Co		shirts	2000	160754	e
Reddish Cotton Spinning Co Ltd/Houldsworth & Co		integrated cotton	2000	153100	
James Akroyd & Son Ltd		worsted	2000	448370	
Derham Brothers	*	footwear	2000	80000	
Barrow Flax & Jute Co Ltd	*	flax/jute	2000	300000	
R Napier & Sons		shipbuilding	2000	270000	
Hawks Crawshay & Co		iron engineering	2000	286511	e
Robert Sinclair & Co		shirts	2000	142131	e
Price's Patent Candle Company		candles kerosene soap	2000	835460	
Royal Army Clothing Depot		uniforms	2000	47375	
J & A D Grimond		linen	2000	220898	e
John Bradley & Co		iron coal	2000	350000	
Summerlee Iron Company		iron coal	2000	225000	
India Rubber Gutta Pecha and Telegraph Works Co		submarine cables	2000	412000	
Telegraph Construction & Maintenance Co Ltd		submarine cables	2000	691575	
Francis Sumner	*	integrated cotton	2000	108000	
Ormrod Hardcastle & Co		integrated cotton	2000	164600	

G & R Dewhurst		integrated cotton	2000	207763	e
Arthur & Co Ltd		wholesale clothing	2000	880000	
John Robertson & Co Ltd		integrated cotton	1950	160000	
Newcastle Chemical Works Co Ltd		chemicals	1950	584042	
William Stirling & Sons	*	textile dyeworks	1916	265176	e
John Barran & Sons		clothing	1900	258258	e
Thomas Taylor & Brother		integrated cotton	1900	300000	
Blair & Co Ltd	*	marine engineering	1880	225000	
McCorquodale & Co Ltd		stationery printing	1873	150000	
Thomas Fletcher & Sons	*	coal/cotton spinning	1863	220599	e
Sir Elkanah Armitage & Sons Ltd		integrated cotton	1850	223680	
Alexander Stephen & Sons	*	shipbuilding marine engineering	1847	209841	e
Smith & McLean	*	iron steel galvanising	1810	253795	e
Grout & Co		silk	1800	260941	e
Ashbury Railway Carriage & Iron Co Ltd		rolling stock iron	1800	334356	
Caledonian Railway workshops		railway workshops	1800	674000	
Coalbrookdale Co	*	iron	1800	212000	
J & T Brocklehurst & Sons		silk	1800	344765	e
Minton's	*	china porcelain tiles pipes	1800	207000	
Melland & Coward	*	integrated cotton	1800	134949	
John Tatham & Sons	*	textile machinery	1800	102000	
Samuel Allsopp & Co		beer	1800	1850000	
Nottingham Manufacturing Co Ltd		hosiery	1750	197392	
Eliza Tinsley & Co		nails chains	1750	223848	e
Asa Lees & Co Ltd		textile machines	1750	110100	
John Mayall	*	cotton spinning	1700	300000	
Curtis Sons & Co		textile machines	1700	157931	e
Cochrane & Co		iron engineering	1700	280394	e
Finlayson Bousfield & Co		linen thread	1700	191137	e
Edmund Potter & Co		calico printing	1700	130000	
William Brown & Nephews	*	integrated cotton	1652	175245	e
James Finlay & Co		cotton food	1650	688843	
Hick Hargreaves	*	steam engines machine tools	1650	245444	
Dubs & Co		locomotives	1650	324859	e
Beyer Peacock		locomotives	1650	423301	
J & J Craven	*	integrated worsted	1626	260653	e
Barlow & Jones Ltd		integrated cotton	1600	374986	
B Samuelson & Co		iron engineering	1600	304750	
Jonas Brook & Brothers	*	sewing thread	1600	950394	e
J & J W Worrall		cotton dyeworks printing	1600	200090	
Monkland Iron & Coal Co Ltd		coal iron	1600	400000	
Gilroy Sons & Co	*	integrated jute	1600	292895	
Thomas Marshall	*	cotton spinning	1600	179036	e
Cope Brothers	*	tobacco	1600	350000	
Brymbo Iron Company	*	iron	1600	79476	

London Lead Company		lead coal peat	1600	520891	e
R & W H Symington		corsets	1600	142681	e
J Pullar & Sons	*	dyeworks/dry cleaning	1588	224350	e
Marshall, Sons & Co Ltd	*	agricultural machinery	1574	200000	
William Garnett & Co	*	worsted spinning	1548	249489	e
W B Coddington & Sons		integrated cotton	1553	165863	e
Dunbar McMaster		linen	1550	125000	
William Collins, Sons & Company Ltd		printing publishing	1550	176000	
Swainson Birley & Co		integrated cotton	1550	165577	e
John Hawkins & Sons		integrated cotton	1550	165577	e
T C Brown-Westhead, Moore & Co		china sanitary pottery	1550	240801	e
Joseph Whitworth & Co		steel engineering	1500	450000	
Muspratt & Co		chemicals	1500	222000	
Turner Bros Hyde & Co	*	footwear	1500	150977	e
Mossend Ironworks	*	iron coal	1500	175000	
I & W Beardmore		iron steel	1500	214702	e
Nantyglo & Blaina Ironworks Ltd		coal iron	1500	538950	
Black & Wingate		integrated cotton	1500	200138	e
Todd & Higginbotham		integrated cotton	1500	121300	
Joshua Hoyle & Sons Ltd	*	cotton spinning	1500	200000	
Fielden Brothers		cotton spinning	1500	624000	
John Abbot & Co Ltd		iron	1500	210000	
William Rumney & Co	*	integrated cotton	1500	169038	e
Tunstill Brothers	*	integrated cotton	1500	160813	e
John Baynes	*	integrated cotton	1500	160813	e
Mitchell Brothers	*	integrated wool	1500	242589	e
Eley Brothers Ltd		ammunition	1500	230000	
Kershaw Leese & Co	*	cotton spinning	1500	160813	e
Howe Machine Co Ltd		sewing machines	1500	400000	
Farnley Iron Company Ltd		iron bricks	1500	198000	
Ackers Whitley & Co Ltd./J H Johnson	*	coal iron	1500	170000	
Walter Macfarlane & Co		architectural ironfounder/pipes	1500	214702	e
Chillington Iron Co Ltd		iron coal	1500	315000	
Birmingham Corporation Gasworks		gas coke chemicals	1500	2282131	
Black Hawthorn & Co/St Bede Chemical Works	*	engineering/chemicals	1477	304032	e
William Denny & Brothers	*	shipbuilding	1461	250000	
Raylton Dixon (Cleveland Dockyard)	*	shipbuilding	1450	183665	e
London & Glasgow Engineering & Iron Shipbuilding Ltd.		shipbuilding	1450	192575	
Dorman Long & Co	*	iron steel	1450	285000	
John Dickinson & Co		paper stationery	1434	296000	
Thomas Richardson & Co		marine engineering	1425	175000	
Barclay Curle		shipbuilding	1422	75000	
Siemens Brothers Ltd		submarine cables	1418	500000	

Belfast Flax Spinning & Weaving Co Ltd		integrated flax	1400	200000	
Combe Barbour & Combe		textile machinery	1400	112000	
Jarrow Chemical Company		chemicals	1400	250000	
Crosses & Winkworth Ltd		integrated cotton	1400	300000	
London & SW Railway Workshops		railway workshops	1400	508000	
North British Railway Workshops		railway workshops	1400	680000	
Tangye Brothers	*	engineering	1400	329958	
Anderston Foundry Company		ironfounders	1400	279000	
George Grant & Sons	*	cotton spinning	1400	188213	e
George Cheetham & Sons		integrated cotton	1400	151231	e
John Leech & Sons	*	cotton weaving merchant	1400	151231	e
William & Henry Foster	*	integrated worsted	1400	200000	
Abraham Brierley & Sons		integrated cotton	1400	151231	e
Robert McClure & Sons		integrated cotton	1400	78100	
Robert McBride & Co		linen	1400	101534	e
Clarke, Sons & Co		clothing	1400	305113	e
George Andrew & Sons		integrated cotton coal	1372	176590	e
J Radcliffe & Co	*	integrated cotton	1361	147474	e
Wigham Richardson	*	shipbuilding marine engineering	1350	163958	e
R R Jackson & Co Ltd		integrated cotton	1345	80000	
Joseph Rodgers & Sons Ltd	*	cutlery	1342	130000	
James Williamson & Son	*	oilcloth/cotton	1336	277912	e
Robert Hopwood & Sons	*	cotton/wool (flannel)	1335	152377	e
Vickers Sons & Co Ltd		iron steel	1300	830100	
Samuel Lawson & Sons		flax machinery	1300	185903	e
John Bazley White & Brothers	*	cement/bricks	1300	1000000	
John Hind & Son		linen	1300	68000	
John Birchenough & Sons	*	silk	1300	258037	e
Richard Smethurst & Co		integrated cotton	1300	141574	e
Great Western Cotton Company Ltd		integrated cotton	1300	134000	
Armitage & Rigby		integrated cotton	1300	142229	
Shaw Jardine & Co	*	cotton spinning	1300	125000	
Moss Bay Hematite Iron & Steel Co Ltd		coal iron steel	1300	242719	
John Fish Ltd		integrated cotton	1300	200000	
Johnston Allen & Co		linen	1300	95050	e
Metropolitan Railway Carriage & Wagon Co Ltd		rolling stock	1300	425835	
Cartwright & Warner	*	hosiery	1300	118596	e
Dunlop & Co		iron coal	1296	149930	
Clayton & Shuttleworth	*	agricultural machines	1295	221900	e
Ystalyfera Iron Company		coal iron tinplate	1281	100000	
Chatterley Iron Co Ltd		coal iron	1250	559653	
Thomas de la Rue & Co		security printing	1250	143111	e
Manchester Sheffield & Lincs Railway Workshops		railway workshops	1250	522000	
Robert Stephenson & Co		locomotives engineering	1250	186000	

John Bright & Brothers		integrated cotton carpets	1250	216400	
Thomas Robinson & Son Ltd		woodworking machinery	1250	88170	
Great Southern & Western Railway		railway workshops	1250	146000	
Wormalds & Walker		woolen blankets	1250	276875	
John Paton Son & Co		wool	1250	171719	e
J E & W Christy		hats	1250	295000	
Fenton O'Connor & Co		integrated linen	1250	103815	e
R & W Hawthorn	*	locomotives	1219	194080	
Crosse & Blackwell	*	canned/preserved food	1206	400000	
Liverpool United Gas Light Company		gas coke chemicals	1200	947930	
Henry Bannerman & Sons		integrated cotton	1200	149109	e
North British Rubber Co Ltd		rubber shoes, vulcanite	1200	300000	
Sharp Stewart & Co Ltd		locomotives	1200	252000	
Malcolm Ogilvie & Co	*	integrated jute	1200	114000	
Thomson Shepherd & Briggs		carpets jute	1200	100000	
Robert Shaw & Sons	*	integrated cotton	1200	55000	
Perry & Co Bow	*	building material contracting	1200	163549	e
Ransomes Sims & Head		agricultural machinery	1200	250500	
Marshall & Co		flax	1200	263822	
Oswald Mordaunt	*	shipbuilding	1200	250000	
John Smith & Sons	*	worsted spinning	1200	140167	
William Williams & Co	*	tinplate	1200	155218	e
F Steiner & Co		calico printing	1200	140469	e
Thomas W Booker & Co Ltd		tinplate coal	1200	873000	
W H Hornby & Co		integrated cotton	1200	131835	e
William Kirk & Partners		integrated linen	1200	100000	
Gloucester Wagon Co Ltd	*	railway wagons	1200	513469	
Tharsis Sulphur & Copper Co Ltd		copper, sulphur, metals	1200	1503160	
Walter Scott & Sons	*	wool tweed	1191	164483	e
A & A Galbraith	*	cotton	1186	162368	e
Thornliebank Calico Printworks	*	calico printing	1170	175000	
James Drummond & Sons	*	integrated worsted	1158	192665	e
A & J Inglis	*	shipbuilding marine engineering	1158	138468	e
Edmund N Haines	*	paper	1150	379445	e
Glasgow Corporation Gasworks		gas coke chemicals	1150	954609	
Thomas Sinton & Co		linen	1150	85220	e
William Fison & Co	*	worsted	1140	110000	
Manchester Corporation gasworks		gas coke chemicals	1135	982541	
John Chadwick & Co	*	silk	1134	228482	e
Sugden & Briggs	*	integrated worsted	1126	187917	e
Cooperative Wholesale Society Ltd		footwear clothing	1125	508406	
James Templeton & Co	*	carpets	1120	200000	
Clark & Co (John Clark Junior)	*	sewing thread	1115	706000	

Richard Hornsby & Sons Ltd	*	agricultural machinery	1112	310000	
Jubb & Co	*	wool	1109	185389	e
John Fowler & Sons	*	steam ploughs/locomotives	1100	279430	
James Shaw (Cwm Avon)	*	iron coal	1100	117400	
James Chadwick & Brother	*	sewing thread	1100	250000	
Glasgow & SW Railway workshops		railway workshops	1100	218000	
Langworthy Brothers & Co	*	integrated cotton	1100	110000	
George Mayall & Co		cotton spinning	1100	100000	
Eccles Shorrock Brother & Co	*	cotton weaving	1100	95000	
Joseph Smith	*	integrated cotton	1100	128246	e
Merrall & Son	*	worsted	1100	184049	e
John Haslam & Co		cotton spinning	1100	247120	
Gilmour & Co/Maryport Hematite Iron Co		iron coal	1100	281980	
Joseph Hargreaves		integrated worsted	1100	193462	e
Samuda Brothers		shipbuilding	1100	80000	
James Laing		shipbuilding brass fittings	1100	136627	e
Midland Railway Carriage & Wagon Co		rolling stock	1100	405554	
C & J Clark	*	footwear	1100	186785	e
F W Grafton & Co	*	calico printing	1079	127785	e
W & J Knox	*	linen thread/fishing nets	1079	127512	e
Perry & Co Ltd	*	steel pens	1060	272865	
D & W Henderson/Tod & McGregor	*	shipbuilding marine engineering	1060	225000	
Parkgate Iron Co Ltd		iron	1050	235000	
William Lund & Sons		integrated worsted	1050	185612	e
James Collinge & Sons	*	integrated cotton	1050	117056	e
John Sharp & Sons		jute flax	1050	265521	e
Thomas Barnes & Co Ltd		integrated cotton	1050	84000	
R & T Birkin	*	lace	1050	232214	e
Marcus Ward & Co		paper publishing	1050	153270	
Pim Brothers & Co		clothing	1050	90570	e
Crewdson Crosses & Co Ltd		integrated cotton	1050	200000	
Whiteabbey Flax Spinning Co Ltd		linen	1050	140000	
John Brinton & Co		carpets	1050	192700	
J Schweppe & Co		soda water/bottling	1050	288000	
John Gilby	*	cotton	1025	114571	e
Henry Bayley Son & Co		cotton spinning	1025	100000	
John Fergus & Co	*	flax/bleachworks	1019	121179	e
McConnel & Co Ltd		cotton spinning	1018	100000	
Erskine Beveridge & Co	*	linen	1010	120000	
Edward Ripley & Son		wool dyeing	1005	179292	e
Joseph Verdin & Sons	*	salt	1002	193480	e
Footman Pretty & Nicolson		corsets	1000	73843	e
Messrs Lea	*	worsted/carpets	1000	231067	e
Spottiswoode & Co	*	printing publishing	1000	70249	

Maple & Co	*	upholstery furniture	1000	197105	e
William Fraser & Co	*	clothing	1000	53016	
J & J Colman	*	mustard	1000	92381	e
Shropshire Iron Co Ltd	*	iron	1000	137659	e
N Corah Sons & Cooper	*	hosiery	1000	82000	
J Ruston Proctor & Co	*	agricultural machinery	1000	185290	e
Thomas Dugdale Brother & Co	*	integrated cotton	1000	117812	e
J & A Leigh	*	integrated cotton	1000	112079	e
William Rouse & Sons	*	worsted weaving	1000	169074	e
Robert Hyde Buckley & Sons	*	integrated cotton	1000	150000	
Martin Sons & Co	*	worsted weaving	1000	300000	
John Shaw & Sons	*	integrated wool	1000	250000	
Fairbairn Kennedy & Naylor	*	textile machinery/machine tools	1000	135000	
Acklam Iron Works	*	iron coal	1000	203265	e
New British Iron Co/Ruabon Ironworks	*	iron coal	1000	357955	
Gibson Robertson & Co	*	integrated jute	1000	119165	e
P & W McLellan	*	railway wagons/structural steel	1000	207990	e
William Hamilton & Co	*	shipbuilding coal	1000	137435	e
Birmingham Railway Carriage & Wagon Co Ltd		rolling stock	1000	474558	
Howard & Bullough		textile machinery	1000	103498	e
Birmingham Small Arms Metal Co Ltd		guns bicycles	1000	162500	
Clyde Spinning Company		cotton spinning	1000	75600	
Distillers Co Ltd		whisky	1000	852000	
Northern Spinning Co Ltd		linen	1000	110000	
Henry Tate & Sons		sugar	1000	116118	e
Christopher Waud & Co	*	integrated worsted	1000	169074	e
Daniel Illingworth & Sons		woolcombing worsted spinning	1000	169074	e
Thomas Adams & Co Ltd		lace	1000	277885	
William Jessop & Sons Ltd		steel	1000	370610	
W S Hodgkinson & Co		paper	1000	215813	e
Cape Copper Mining Co Ltd (Neath works)		copper	1000	140000	
Salis Schwabe & Co		calico printers dyeworks	1000	150000	
Swanston & Bones		shirts	1000	76673	e
Falkirk Iron Company		iron	1000	149637	e
Storey Brothers & Co		oilcloth table baize	1000	204279	e
Cassell Petter & Galpin		printing publishing	1000	466863	
Panteg Steelworks & Engineering Ltd		steel	1000	133412	e
William Doxford & Sons		shipbuilding marine engineering	1000	173000	
Saxby & Farmer		railway signals	1000	142572	e
Thomas Cross & Co		cotton bleachworks	1000	119420	e
Herdman & Co		linen	1000	75248	e

Middleton & Tonge Cotton Spinning Co Ltd		cotton spinning	1000	161764	
Devon Great Consols Co Ltd		arsenic copper	1000	491343	e
Fawcett Preston & Co		sugar machinery boilers	1000	141384	
Globe Cotton Spinning & Manufacturing Co Ltd		cotton	1000	179734	
Harvey & Co of Hayle		ships pumps engines rope	1000	295500	
Norton Brothers & Co Ltd		diverse wool products	1000	200000	
John Moir & Son Ltd		food preserves	1000	150000	
Rylands Brothers Ltd		wire	1000	80000	
Thomas Taylor & Co		cotton spinning	1000	155000	
Aerated Bread Co Ltd		bread	1000	92378	
Kynoch & Co Ltd		gun cartridges	1000	100000	
Sparrow & Co		coal iron	1000	153823	e
M B Foster & Sons		beer bottler	1000	300000	
Prince Smith & Son		textile machinery	1000	147173	e
William Ritchie & Sons		jute	1000	81966	e
Thomas Royden & Sons		shipbuilding	1000	97637	e
Robert Platt		cotton spinning	1000	117812	e
William Clowes & Sons Ltd	*	printers publishers	1000	130000	
Dunville & Co Ltd		whisky tea	1000	500000	
Benjamin Whitworth & Brothers		integrated cotton	1000	88080	e
Whitworth & Co Ltd		worsted	1000	90979	
J & T M Greeves		flax spinning	1000	75248	e
James Clendinning & Sons		linen handkerchiefs	1000	75248	e
James Glass & Co		linen handkerchiefs	1000	85108	e
Edward & John Burke		bottlers brewers distillers	1000	800000	
W J Shaw & Sons		bacon	1000	103212	e
Tees-side Iron & Engine Works Co Ltd		iron engineering	1000	208957	

Appendix 2. Additional Information on 1871 and 1881.

A. A list of largest 100 1871 manufacturing employers compiled on the same basis as the 1881 list.

Firm Name	employees 1871
Ebbw Vale Steel Iron & Coal Co Ltd	12500
Royal Dockyards	11276
Wigan Coal & Iron Co Ltd	11000
Bolckow Vaughan Ltd	9000
Wm Baird & Co	9000
Dowlais Iron Company	9000
Fothergill Hankey & Co	8000
Butterley Company	7500
Dent Allcroft & Co	7500
Pease & Partners	7500
Royal Ordnance Factories	7457
Earl of Dudley Estate Office	7000
Palmer's Shipbuilding & Iron Co Ltd	6750
Platt Bros & Co Ltd	6250
London & NW Railway workshops	6000
Great Western Railway Workshops	6000
Blaenavon Company Ltd	5700
Robert & Henry Parnall	5500
John Crossley & Sons Ltd	5100
Robert Heath & Son	5000
Tredegar Iron Works	4860
William Dixon & Co	4800
Richardson & Co	4600
Merry & Cunninghame	4535
Bell Brothers & Co	4500
Cox Brothers	4500
Lilleshall Coal & Iron Co	4500
Coltness Ironworks	4500
Rylands & Sons	4350
Patent Shaft & Axletree Co Ltd	4250
Consett Iron Co Ltd	4200
I & R Morley	4200
Rhymney Iron Co Ltd	4003
William Ewart & Son	4000
Stanier & Co	4000
Fownes Brothers & Co	4000
Baxter Bros & Co	4000
Crawshay Brothers	4000
Eliza Tinsley & Co	4000
North Eastern Railway Workshops	3988
Low Moor Ironworks Company	3800

Weardale Iron & Coal Co Ltd	3750
Thames Ironworks & Shipbuilding Co Ltd	3750
Horrockses Miller	3570
Staveley Coal & Iron Co Ltd	3500
York Street Flax Spinning Co Ltd	3500
Sir Titus Salt (Bart) Sons & Co	3500
Malcolmson Brothers (Portlaw)	3500
Llynvi & Tondu Ltd	3450
Ulster Spinning Co Ltd	3250
Charles Cammell & Co Ltd	3200
Barrow Haematite Steel Co Ltd	3000
Bryant & May	3000
Vivian & Sons	3000
Shelton Bar Iron Co	3000
Tillie & Henderson	3000
Robert Lindsay & Co	3000
Laird Brothers	3000
Bowling Iron Co Ltd	3000
John Holdsworth & Co	3000
Glasgow Iron Company	3000
R Napier & Sons	3000
John Bradley & Co	3000
J & C Bailey (Nantyglo)	3000
Ystalyfera Iron Company	3000
Ashton Brothers	2860
Thomas Taylor & Brother	2800
John Brown & Co Ltd	2750
McIntyre Hogg & Co	2750
Sir W G Armstrong & Co	2700
John Musgrave & Sons	2640
Midland Railway workshops	2600
Newton Chambers & Co	2500
William Barbour & Sons	2500
West Cumberland Iron & Steel Co Ltd	2500
John Wood & Brothers	2500
John Foster & Son	2500
James Akroyd & Son	2500
Blochairn Iron Works	2500
T Cooke & Co	2500
Marshall & Co	2475
Samuel Courtauld & Co	2402
Chance Brothers	2400
Richards & Co	2400
William Bracewell & Sons	2300
Newcastle Chemical Works Co Ltd	2300
Kershaw Leese & Co	2300
Shotts Iron Company	2260
Patent Nut & Bolt Co Ltd	2250

M Oldroyd & Sons	2250
Harland & Wolff	2200
J & T Brocklehurst & Sons	2200
Monkland Iron & Steel Co	2200
Daniel Gurteen & Sons	2150
Pilkington Brothers	2100
John Heathcoat & Co	2100
Cwm Avon Ironworks Co	2100
William Cubitt & Co	2088
Noah Hingley & Co	2050
Summerlee Iron Company	2050

For the calculation of the changing 100-firm concentration ratio their total employment is adjusted downwards for non-manufacturing employees by the same ratio as the top 100 in 1881, pending a fuller analysis of the 1871 data.y

B. British Manufacturing multinationals.

The "over a dozen" firms employing 1,000 or more in the UK in 1881 mentioned in note 49 which were also multinationals with factories abroad were (in addition to Coats and Clark mentioned in the text):

John Heathcoat & Co (silk)
Nottingham Manufacturing (hosiery)
Birkin (lace curtains)
Dent Allcroft (gloves)
Clayton & Shuttleworth (agricultural machinery)
Saxby & Farmer (railway signals)
Tharsis (pyrites processing)
Royal Dockyards (shipbuilding)
Dunbar McMaster (linen)
Barbour (linen)
Moir (preserved foods)
Cox Brothers (jute)
James Finlay (cotton and jute).
India Rubber Gutta Pecha & Telegraph Works (cables)

This excludes many with overseas subsidiaries engaged only in sales/distribution/mining. Others were too small domestically to enter our lists: Isaac Holden, the innovative woolcomber, is excluded because he employed only 700 in Bradford but 3,300 more in his French factories, where labour was cheaper.

C. Mergers before the 1881 census date.

This note was prepared in response to a referee who questioned whether the mergers before 1881 were significant compared with later ones. The following is not compiled on a comparable basis to Hannah's firm disappearance by merger index in Oxford Economic Papers 1974 for 1880-1914, so precise quantification is not possible. What it does show is that there was considerable pre-1881 merger activity. This suggests one of the reasons why the British merger wave of the 1890s was smaller than that in the US was perhaps that mergers had been occurring for a longer prior period (consistent with the evidence of stock markets developing earlier in the UK than US and the positive correlation of stock prices and merger activity).

We have tried to exclude obvious non-mergers like when a new joint stock company "acquires" all the assets of an existing partnership; or when a new partner is admitted to a partnership bringing modest assets; or when a bankrupt firm's land is bought by a rival (but if a working factory/machinery/workers are taken over from the receiver that is a merger). To be counted, mergers have to be significant: say three firms merging, several sequential acquisitions, or a few hundred employees added. We have excluded some doubtful cases, such as the merger of two works in Elswick under the Sir W G Armstrong partnership in 1862, or the London and Hull partnerships merged in 1878 into Reckitt & Sons Ltd. These appear to have had many common owners before, so are more in the nature of capital rearrangements.

As we are mainly concerned with manufacturing, we also exclude cases where manufacturers acquired coal/iron mines (eg John Brown & Co Ltd, Stanton Ironworks Co Ltd, Landore Siemens Steel Co Ltd) and many more cases of a small mine acquisitions which would greatly increase the number of mergers. Forward integrations to wholesaling by merger (e.g Nottingham Manufacturing's acquisition of a London wholesaling firm) are also not included. Similarly, we have ignored mergers which did not result in an enterprise above our threshold size of 1,000 employees, such as Alliance and Dublin Consumer's Gas (an 1845 merger), Truman Hanbury Buxton's 1874 acquisition of Phillip's Burton brewery or John Lysaght's merger of various ironworks in 1877-80. There were also demergers: for example, Waterlows, the printing partnership, divided in two in 1877.

The following firms are examples of significant mergers in 1871-81 contributing to increased scale in 1881:

Tharsis Sulphur & Copper (multiple acquisitions of UK copper refiners and by-product processors)
Pearson & Knowles Ltd (1874 incorporation merging coal and iron firms and wireworks)
Bolckow Vaughan & Co Ltd (modest acquisition of South Bank ironworks 1879)
Steel Co of Scotland Ltd (large acquisition of Blochairn Iron Works 1880)
Nettlefolds Ltd (1880 incorporation merging 5 screw firms)

Perry & Co Ltd (1876 merger of 4 steel pen makers)
Gas Light & Coke Co (large sequential acquisitions).
South Metropolitan Gas (large sequential acquisitions)
Birmingham Corporation Gas (1875 merger of 2 private companies)
Birmingham Small Arms & Metal Co Ltd (1873 acquisition of Adderley ammunition factory)
Telegraph Construction & Maintenance Co Ltd (1876 acquisition of W T Henley's telegraph works)
Rylands & Sons Ltd (multiple sequential acquisitions in Lancashire cotton)
Wormalds & Walker (blanket manufacturers, acquired Britannia Mills Dewsbury 1880)
B W E Alford's 1962 PhD on the London Letterpress Printing Industry 1850-1914 shows acquisitions by Clowes in 1880 (p. 88) and Spottiswoode in 1872 (p. 108)

Others before 1871 were:
Wigan Coal & Iron Co Ltd (1865 incorporation of merged firms)
Patent Nut & Bolt Co Ltd (1864 incorporation merging two firms)
Liverpool United Gas Light (1848 merger)
Glasgow Corporation Gas (1869 merger of 2 private companies)
Richardson Denton Dick & Co Ltd (a failed corporate merger of 1865 demerged into two separate large shipbuilding partnerships a few years later).
Thomas Richardson & Co (1866 acquired Pile Spence & Co iron/engineering)
Keen Robinson Belville & Co (1862 merger of 2 branded food companies)
Hopkins Gilkes & Co Ltd (1865 merger of railway engineering and iron works)
Rosedale & Ferry Hill Iron Co Ltd (large 1864 merger, bankrupt by 1879).
Fothergill Hankey & Co (large 1863 merger of Plymouth and Aberdare Ironworks, failed 1875)
Patent Shaft & Axletree Co Ltd (acquired Old Park Steelworks 1867)
Tootal Broadhurst Lee (1860s acquisition of Sunnyside and Newton Heath cotton mills)
Crewdson Crosses & Co Ltd (1864 Bolton cotton merger)
James Chadwick & Brother (1850 bobbin mill acquisition)
J & J Clark (sequential 1860s acquisitions in Paisley sewing thread)
Archibald Orr-Ewing & Co (2 acquisitions in 1850s and 1860s, dyeworks)
W & J Knox (linen thread, acquired Stoneyholme mill 1864)
Walter Scott & Sons (tweed manufacturer acquired Nithsdale and Kingholme Mills 1870)
Stephenson's Jarrow Chemical Company (merger of 1858)
Turner Bros (acquired Northampton shoe factory 1861)

Plus many railway company workshops were merged (mainly before 1871) as a result of mergers of their parent railways.