

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

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ABSTRACT

The 437 largest firms with 1,000 or more employees accounted for around one-sixth of UK manufacturing output in 1881. Exploiting powered machinery, intangible assets, new technologies and venture capital, their exports about equalled domestic sales. The more capital-intensive accessed stock markets, more - and in larger firms - than in follower economies. Everywhere self-employment, handicrafts, external economies and family ownership persisted into the late nineteenth century, but contemporary overseas observers - capitalist and socialist - correctly recognized the *distinctive* features of UK manufacturing. They were its exceptional development of quoted corporations, professional managers and “modern,” scalable, factory production.

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“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

Shaw had no doubt that UK manufacturers retained significant advantages of large and efficient manufacturing resources, while others see Victorian Britain’s technical and managerial conservatism severely limiting scale and scope. A resolution has been elusive partly because of a lack of hard data. Historians of nineteenth century business routinely regret the absence of a UK census of production before 1907, as did Victorian statisticians. Historical GDP estimates from the output side are thus somewhat unreliable, while sectoral employment analyses rely on individual (not employer) occupational returns, which officials considered “the least satisfactory part of the Census.”¹ Factory Inspectors’ reports track progressively larger plants but 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.² 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 1851.³

Two new research tools facilitate the more ambitious approach developed here. First, Big Data techniques used to process the millions of original manuscript census returns provide the

¹ Registrar-General, *Census*, p. 25. Woollard ‘Classification’ and others are more positive.

² Atack and Bateman, ‘Nineteenth century.’

³ *Economic History*, p. 35. Even the published tabulations were somewhat imperfect, especially for larger firms (van Lieshout et al, ‘British Business’).

British Business Census of Entrepreneurs (BBCE) database.⁴ 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. Newly searchable databases of contemporary newspapers and parliamentary papers provide a second resource that facilitates tracing census omissions UK-wide.⁵ This supplements BBCE records (for England, Wales and Scotland) for non-response gaps, and for the absence of Irish records, which were destroyed in 1922, to give the whole UK. Strikes, boiler explosions and factory fires (not infrequent occurrences) often resulted in press reports of the 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 437 UK manufacturing employers with 1,000 or more employees reported here.

The largest private sector employers - railways - made no census returns,⁶ and agriculture, distribution, finance and professional services had few or no $\geq 1,000$ employee returns.⁷ Our exclusive focus on manufacturers does not deny that changes in agriculture, services and mining were complements to the Industrial Revolution, but manufacturing generated key productivity improvements, scale economies and innovative clusters; the great bulk of large-firm returns were by manufacturers. Census returns identified half of the large manufacturers considered here.⁸ The remainder backfilled from supplementary sources risks hindsight bias, but we attempted to

⁴ Bennett et al, *Age of Entrepreneurship*.

⁵ *British Library Newspapers* online are constantly expanding, searches made up to December 2020; *British Parliamentary Papers* were already fully searchable online, with the usual qualifications about OCR errors.

⁶ Separately in 1884 (Board of Trade, “Railways”) the largest railway reported 55,061 employees but these mainly operated transport services. We include only manufacturing employees in 13 railways’ workshops, anticipating later UK production census practice.

⁷ Mining constituted most large returns not analysed here (mines are included only if owned by manufacturing firms); a few building contractors also returned thousands of employees.

⁸ 37% of the British total directly from 1881 returns; others from earlier censuses identifying likely large employers failing to return.

compensate 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. The “giant” manufacturers of 1881 – 33 employing 5,000 or more – are listed in Appendix 1, with 404 more firms with 1,000-4,999 employees identified in Appendix 2.

These new data offer a clearer framework for understanding the UK’s largest firms and their comparative performance. The following section charts their growing weight in the UK economy. Next, we present breakdowns by industry, by capital and stock exchange finance, and survey more fragmentary evidence on the production techniques, management, intangible assets and productivity of these firms. The conclusion considers feasible elaborations of these research techniques.

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 apparel - 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, 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 $\geq 1,000$ responded, so supplementary sources for corporations were essential,⁹ whereas slightly over half of unincorporated enterprises made returns.

Measuring size by employee numbers biases toward labour-intensive firms, excluding some more efficient firms.¹⁰ 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 man¹¹) 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-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.¹² Some of the businessmen¹³ making returns had

⁹ 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.

¹⁰ 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.

¹¹ Levi, *Wages*, pp.19-21.

¹² Among those proposed in the literature are technological non-separability, labour discipline, transaction costs, asset-specificity, network dysfunction, market size, expertise-sharing and inertia.

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 may relate to individual factories, 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 437 manufacturing firms employing 1,000 or more, averaging above 2,000 employees each, with a median of 1,500. The distribution is highly skewed: 33 “giant” firms (those 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 $\geq 1,000$ in 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%.¹⁴ This was accompanied by growth in plants per firm; in the later 20th century the *average* top 100 UK manufacturer operated

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

Size (employees)	Number of Firms	<u>Number of Employees</u> All Sectors Manufacturing	<u>Mean employees per Firm</u> All Sectors Manufacturing.
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¹³ 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.

¹⁴ 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/12035/manufacturingenterprisesandlocalunitsbyemploymentsize>. UK manufacturing employment and the numbers and share of $\geq 1,000$ firms peaked at higher levels in the 1960s and 1970s.

“Giant” (≥5,000)	33	237,746	157,075	7,204	4,760
1,000-4,999	404	690,531	618,259	1,709	1,530
≥1,000	437	928,277	775,334	2,124	1,774
0-999	649,563	na	4,084,666	na	<7
UK manufacturing	650,000	na	4,860,000	na	<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 (*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. Other estimates (including Booth, ‘Occupations’) are lower, clustering around 4.5m. There is considerable uncertainty about whether occupational categories like general labourers, maker-dealers, engineers and clerks should be allocated to manufacturing.

72 plants.¹⁵ In 1881 firms were chiefly concerned with managing their core business, not juggling portfolios of diverse subsidiaries as in some later conglomerate behemoths. Otherwise, the 1881 manufacturing firm size distribution was already much the same as today.¹⁶

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 division of labour (including more specialised management), cheaper transport (through private rail sidings

¹⁵ Prais, *Evolution*, pp. 85-6. Even after the 1896-1900 multi-firm merger wave 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.

¹⁶ 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 Smith and Hannah.

and river or ocean access) and better internal and external financing, all tending to improve 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; they 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.¹⁷ 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.¹⁸

Calculating 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 internally by reinvesting profits, increasing divisions of labour, use of machine technology and learning-by-doing. Mergers also played a role: several dozen large companies of 1881 had a record of acquisitions. Our preliminary study of 1871, on a similar basis to 1881, suggests the top 100 firms' share of manufacturing employment rose from 6.4% to 7.3% in that decade, while comparison with Shaw's data for the top 100 manufacturing employers of 1907 suggest a steeper rise to around 11% in the next generation.¹⁹ Concentration was accelerated by the multi-firm merger waves of 1888-90 and 1896-1900. The large firms of 1881 – Bazley White in Associated Portland Cement, Houldsworth in Fine Cotton Spinners, Gartside in Calico Printers, and many others - were prime movers in these mergers and anchored their post-merger management.

INDUSTRIAL DISTRIBUTION AND CONCENTRATION LEVELS

Sector differences can be examined in terms of concentration and its technological underpinnings, "new" industries, and international markets. In Table 2 we have classified these

¹⁷ More, *Skill*.

¹⁸ 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).

¹⁹ Shaw, 'Large.' In each case using occupational census data as the denominator (Lewis, *Growth*, p. 265) with interpolation for 1907.

businesses by industries roughly equivalent to today's "two-digit" level of aggregation. 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, tobacco, lighting oil, consumer durables) than capital goods (building materials, machinery, ships, railway equipment and metal inputs to such goods).²⁰ 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 building the transport networks and workshops of the world, accounting for 63% of world exports of capital goods.²¹ The range of machinery – not only widely-used looms, locomotives, ships, printing presses, band saws and steam engines, but specialist items like tunnel borers, rubber mixers, horseless carriages, primitive electric motors, wire extruders and biscuit cutters – was extraordinary.²² The suggestion that "In machinery the British did not even try"²³ 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.

	<u>Firms employing ≥1,000</u>					
	1. No of Firms	2. Employees	3. Mean (col2/col1)	4. Industry Employment	5. Concentration ≥1000	6. top 3
Iron and Steel ^a	83	138,018	1,663	450,000	31%	3%
Shipbuilding/Marine Engineering	31	77,910	2,513	106,000	74%	25%
Railway Engineering	29	64,965	2,240	100,000	65%	21%

²⁰ This division is necessarily approximate and some products (e.g. sewing machines, road vehicles) were both consumer and investment goods.

²¹ Saul, 'Export,' p. 16.

²² Hunt, *Ure's Dictionary*.

²³ Chandler, 'Managerial Enterprise,' p. 22; compare Saul, 'Market,' Foreman-Peck, 'Balance.'

Textile Machinery	13	25,100	1,931	50,000	50%	22%
Other Engineering ^b	17	31,372	1,845	100,000	31%	13%
Cotton	84	141,207	1,681	540,000	24%	3%
Wool/Worsted	25	34,718	1,391	265,000	13%	3%
Linen, flax, jute	37	71,858	1,942	140,000	51%	10%
Silk, lace, carpets	17	26,212	1,542	138,000	19%	7%
Textile finishing/dyeworks	12	16,630	1,386	103,000	16%	6%
Gas/coke/chemical by products	6	10,858	1,810	22,000	49%	39%
Other chemicals	17	24,809	1,459	82,000	30%	11%
Bricks, pottery, glass, cement	10	16,002	1,600	138,000	12%	6%
Paper, printing, books	12	17,457	1,455	193,000	9%	4%
Clothing	24	48,897	2,037	925,000	5%	2%
Footwear	4	6,789	1,697	275,000	2%	2%
Alcoholic drinks/bottling	7	9,586	2,195	71,000	14%	9%
Other drink/food/tobacco	9	12,706	1,412	540,000	2%	1%
Industries with no large firms ^c	0	0	0	662,000	0%	0%
Total manufacturing	437	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, guided by earlier attempts at aggregating 1881 occupational census returns (Jeans, *England's Supremacy*; Levi, *Wages*; Booth, 'Occupations'; Phelps-Brown and Handfield-Jones, 'Climacteric'; Mitchell, *Abstract*; Lee, *Regional employment*). Some industrial categories correspond to modern standard industrial classifications, but applying the modern SIC to 1881 produces one industry with negligible employment (electrical engineering, which in our classification is "other machinery") and three (metal manufacture, textiles and clothing/footwear) each employing more than a million (we have subdivided them). Two sectors shared some features with the chemicals sector, including extensive employment of chemists. Textile finishers also manufactured some of the dyes they used. Coal-gasification (later usually included in utilities) was grouped with chemicals by contemporary statisticians: it manufactured extensive coke and chemical by-products. Our "other chemicals" sector also includes two copper refiners who produced chemical by-products.

Col 5. calculated from cols 2 and 4; col 6 from present study's worksheets and col 4.

^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 products, textiles and miscellaneous manufactures.

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. However, we cannot distinguish steelworkers in a shipyard from its shipwrights, so some employees in column 2 do not appear in its column 4 but rather in the row above. More generally, some manufacturing occupational returns (blacksmith, engineer, clerk, general labourer or textile worker) might be in any of several industries and (as with multiple earlier attempts, by which we have to some extent been guided) our allocations among them are unavoidably uncertain. Nonetheless the broad results of this exercise are plausible.²⁴ There are only five industries in which large employers may - within the margins of error of the data - account for most employment: shipbuilding, railway engineering, textile machinery, coal gasification²⁵ and linen (see col 5). The two industries with most large companies – iron/steel and cotton - were also massive employers, so perhaps only a third of their employees were in large firms.

The unweighted average share of the top 3 firms in industry employment (col 6) was only 10% and in none of them did they account for more than 39%. The highest was in gas supply, whose firms were regional monopolies, but most of these industries can reasonably be considered competitive. There were some vertical restraints,²⁶ and in shipbuilding, the construction of leading-edge warships or ocean liners was nearer to oligopoly. Of course, concentration increases with the fineness of classification (some of the more concentrated industries of Table 2 might reasonably be considered nearer 3-digit than 2-digit) and narrower delineations of the market. Platts accounted for only 12% of textile machinery employment but in the following decades it supplied 87% of cotton spindles installed in Japan²⁷ and its share in its home market (Oldham, a town with more cotton

²⁴ 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.

²⁵ 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.

²⁶ The largest railway engineering works were owned by railway companies, which - following an 1876 court decision - were barred selling to third parties, and their parent railways allocated few orders to outsiders.

²⁷ Saxonhouse. 'Tale,' p. 162.

spinning than any other *country*) was not much smaller. Others among these firms had considerable market power or approached oligopoly in specialist niches.²⁸

At the other end of the scale, there were 24 large employers in clothing, but this industry accounted for 19% of total manufacturing employment, so concentration was nonetheless low. Mechanical bandsaws from the 1860s could quickly 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,²⁹ and for some fine work on lace or linen embroidery, hand needlework survived. Much the same was true in hosiery where new circular machines knitted "tubes," but hand finishers closed and "fully fashioned" socks and 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 (custom) rather than standard lines, or working by hand or treadle machine in small shops. Food manufacturing was also mainly populated by small businesses (grain millers, slaughterhouses) and the self-employed (bakers, butchers). Large employers mass producing biscuits in continuous baking ovens (Huntley & Palmers, Peek Frean) or preserving branded produce in cans and bottles (Crosse & Blackwell, Colman's Mustard) were exceptions.

Many long-established firms were turning out "old" (long-familiar) products. The Butterley Co (ranked 11th by employment) - the leading maker of iron girders - 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 machinery maker - started making textile machinery in Oldham in 1821. The LNWR's railway works

²⁸ In window glass, there were three dominant firms, though smaller producers and imports from the continent remained challengers. In Birmingham, generally a stronghold of modestly sized metalworking, Nettlefolds had a virtual monopoly of UK wood screw production and Perry a dominant position in steel pens.

²⁹ Machines enabled one woman to do the work previously done by twelve (Mulhall, *Dictionary*, p. 296).

(ranked 9th) opened in 1843, thirteen years after a constituent firm offered the world's first steam passenger rail service. Acids, chlorine, superphosphate fertiliser and soda ash were produced by Tennants of Glasgow (founded 1788) and other chemical firms; firms processing rubber had been added in the 1840s.

However, some industries were “new,” in the sense that they had substantially developed in the previous decade or two and were acknowledged by contemporaries as transformational and “modern.”³⁰ Electrical manufacturing was primarily submarine telegraph cables, extending the overhead wires of national land networks to build the first worldwide web. Three companies, each employing around 2,000, based in or near London, were larger than any overseas rival in manufacturing cables and operating seagoing cable-laying vessels: India Rubber, Gutta Percha & Telegraph Works, Telegraph Construction & Maintenance (which had in 1876 acquired local competitor Henleys), both incorporated in 1864, and, Siemens Brothers, in 1880.³¹ The big money in electricals - after the 1870s boom in construction - was in operating telegraphs. Most of the 100,000 miles of submarine cables to link national telegraphs worldwide (transforming global trading, finance and headquarters control over shipping lines) were British-made and in the hands of large British companies like Eastern Telegraph, connecting India, East Asia and Australia to Europe. 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

³⁰ Our definition of ‘new’ is one of several possible. Bairoch (“International Industrialisation,’ 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 industrial growth, notably cotton, iron, steel and chemicals, rather than traditional textiles, clothing, foodstuffs, timber and furniture).

³¹ In 1881 Siemens employed 1,418 in England and only 675 in Germany and the largest (43.5%) share of Siemens Brothers was held by Sir William Siemens (Von Weiher, *Siemens-Werke*, pp. 95, 111 n 4; Feldenkirchen, *Siemens*, p. 162).

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 1850 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, had overtaken the 2,000 employees at Price's Patent Candle, another lighting product that shared some raw material inputs. New shale rivals entered as Young's patents expired and the industry was still expanding in 1881, though probably only the second largest, Broxburn Oil, then employed around 1,000. 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. 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 blast 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.³² The third new 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 similar vibrant new industry supplanting an old one, in this case wooden sailing ships. The key innovations - widely applied only from the 1860s - 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's 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; soon 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. 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.

British manufacturers exercised surprisingly limited efforts to protect intellectual property and British laissez-faire liberals - some copiously copying foreign ideas themselves - argued that patents should be abolished everywhere. British inventions from the sandwich to the postage stamp were never patented and there was much "collective invention" in which ideas were shared (Allen 1983) and worries that patents would suppress rather than encourage new technologies. In contrast to today's aggressive US-led intellectual property policy, and its then policy of heavy protection of its small engineering industry and free rein to pirating of copyrights and denominations

³² Meade, *Coal and Iron*.

of origin,³³ the UK government did not use its imperial, trade or financial heft to bring infringers to heel. UK industrial dominance – from cotton through steel and telegraph cables to modern steamships – relied on intellectual property that was tacit - sometimes secret, sometimes shared - as well as patented.

Most foreign multinationals with British manufacturing plants in the nineteenth century failed or made poor profits.³⁴ Only two qualified among our large firms in 1881,³⁵ both US sewing machine manufacturers. Singer Manufacturing had in the 1860s established its foreign headquarters in London, applying US production techniques in its 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 had expired in 1877, halving prices. Singer's share (around three-quarters of the global market) was 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.³⁶ 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

³³ Mark Twain enjoyed copyright protection in the UK, while Charles Dickens was pirated by US publishers, until the US conceded reciprocity in 1891. Wisconsin farmers shamelessly produced 'Cheddar' cheese.

³⁴ Godley, 'Pioneering.'

³⁵ Among other early 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 Siemens, see n. 29 above.

³⁶ Godley, 'Selling.'

quality thread brands for break-free operation. Applying Paisley manufacturing techniques in their US factories, the Scots dominated the American as well as European thread market and learned from US colleagues. These thread firms were to combine in 1896, becoming Europe's largest industrial, with larger market capitalisation and manufacturing employment than Singer, as the latter approached saturation (at least in English-speaking markets), two decades before thread. More generally, UK-headquartered firms led multinational development in 1881³⁷ and in terms of aggregate capital invested remained ahead of US, German and French multinationals (combined) as late as 1938.³⁸

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 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. 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 (with a mean of

³⁷ Our firms already manufacturing in the US, continental Europe and/or the Empire in 1881 included Nottingham Manufacturing (hosiery), Birkin (lace curtains), Dent Allcroft (gloves), Clayton & Shuttleworth (agricultural machinery), Saxby & Farmer (railway signals), Royal Dockyards (shipbuilding), Barbour (linen), and James Finlay (cotton and jute). 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.

³⁸ Dunning and Lundon, *Multinational Enterprises*, p.174.

1,780 employees) integrated spinning with weaving and, occasionally, dyeing and printing too³⁹, 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 (typically about 300,000 spindles or 220 power looms) 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.⁴⁰

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,⁴¹ 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.

CAPITAL INTENSITY AND FIRM FINANCE

Census returns reported only employee numbers, but for 64% of these firms (accounting for 74% of their employees) data exist on their invested capital.⁴² 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

³⁹ 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).

⁴⁰ Leunig, 'British Industrial Success.'

⁴¹ Weighting each industry's export percentage (from Mulhall, *Dictionary*, and other sources) by large firm employees (col 2 table 3) suggests they exported 43% of their output, but this is a lower bound. Large firms generally exported more than small; many are known to have been more export-oriented than their industry.

⁴² We estimate only 1% of the large capitals in railways was in workshops. This results in capital per employee slightly higher than independent railway manufacturers.

otherwise standardized. Firms lacking capital data do not resemble 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 this by estimating the capital level for missing cases.⁴³

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). Capital measures of firm scale are thus noisy. Nevertheless, though ranks by employment and capital differ, as in later periods,⁴⁴ they are correlated. As expected, deviations are largest in capital-intensive industries.⁴⁵ For example, the Gas Light & Coke Co, Bass (beer) and Distillers (Scotch) - were ranked 18th, 75th and 359th 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.

Table 3. Capital of Large UK Manufacturing Employers ca 1881

Industry	No of Firms	Paid up Capital (\$m)		Capital per Employee (£) ^a
		Total	Mean Size	
Gas, coke & by-products	6	16.521	2.753	1221
Royal Dockyards	1	17.437	17.437	1113
Alcoholic drinks/bottlers	7	9.312	1.330	839
Railway Engineering	29	15.388	0.531	234
Wool	25	7.595	0.304	218
Chemicals & by-products	17	6.103	0.359	210

⁴³ We experimented with several specifications using log employment, industry, region and public company dummies to estimate capital with adjusted R-squares around 0.6. The capital of the 36% of large firms whose capital was estimated accounted for 26% of employees and 17% of the capital in Table 3.

⁴⁴ Bates, 'Alternative Measures.'

⁴⁵ defined as capital per employee. In the absence of value-added data, the alternative capital/output ratio cannot be calculated.

Other Engineering	17	6.716	0.395	210
Other Textiles	17	5.111	0.301	190
Coal Iron & Steel	83	48.214	0.581	186
Paper & Printing	12	2.949	0.246	169
Bricks, Pottery, Glass, Cement	10	3.521	0.352	162
Textile Machinery	13	4,565	0.351	158
Textile Finishing	12	2.531	0.211	152
Footwear	4	1.035	0.259	143
Cotton	84	20.445	0.243	142
Food/Tobacco	9	1.810	0.201	136
Shipbuilding/Marine Engineering	30	7.874	0.262	121
Clothing	24	6.387	0.266	115
Linen	37	6.687	0.178	95
Manufacturers employing $\geq 1,000$	437	188.868	0.432	205

Source: this study's worksheets

^a because the capital includes all that in vertically integrated firms, we have included all UK employees (not just those in manufacturing) in the denominator.

Table 3 shows industries in declining order of capital-intensiveness. Royal Dockyards⁴⁶ are shown separately from other shipbuilders: the capital reflected the cost of supplying/repairing the Royal Navy, not the modest requirements of a typical shipyard. Most industries were within the range of £121-£234 capital per employee, though firms diverged from these averages: a sewing thread firm (Coats) had five times the capital per employee of the average cotton firm; a cement manufacturer (Bazley White) nearly five times that of the average building materials firm; and an armour plate specialist (Vickers) over twice that of the average steel manufacturer. The distinctively capital-intensive industries were gas coke and its chemical by-products and alcoholic drinks

⁴⁶ 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.

(including their bottlers), while the least capital-intensive were linen and clothing firms.⁴⁷ Feinstein's estimate of the net reproducible fixed capital stock (factories, machinery and vehicles) for *all* manufacturers (including smaller firms employing five times those in our large firms) was only slightly more than twice our capital figure for large employers.⁴⁸ We cannot firmly deduce from that alone that our firms were more capital-intensive than smaller employers, because national income and corporate accounts differed, but definitional differences can hardly account for a gap of that size.⁴⁹ 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.

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 attracting additional managers. 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 earn-in arrangements, comparable to modern management buy-ins. While technically most partnerships automatically dissolved on the death of a partner, 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

⁴⁷ 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).

⁴⁸ £402.6m at 1881 prices (Pollard and Feinstein, *Studies*, pp. 304, 452-3, 470-1).

⁴⁹ Corporate accounts include non-reproducible capital such as land. Feinstein aggregated stocks and work in progress economy-wide not separating manufactures. Table 3 includes some non-manufacturing capital. However, we could not find any large firm accounts with as low a portion of reproducible fixed manufacturing capital as applying Feinstein to all firms would imply.

– engineers, chemists, sales managers, accountants, bankers, merchants or “counting house” clerks, - rapidly expanded between the 1851 and 1881 censuses, inducing a “revolution in the method and management of industry.”⁵⁰ Professional and local networks aided principals searching for equity partners or managers; there were also head-hunters and advertising media serving principals conducting searches.⁵¹

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 professional managers. Private incorporation gave active participants and continuing passive investors limited liability without (before 1900) requiring much financial disclosure or loss of control. Plutocrats with ample wealth could also attract professional managers by higher 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 \geq £1,000.⁵² Enterprises of this scale usually had not one heroic leader but, among or beyond their owners and managers, a team with complementary skills, sharing strategic decision-making and administrative functions (Payne 1978).

A larger step was to incorporate as a public company,⁵³ 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

⁵⁰ Booth, ‘Occupations,’ p. 336.

⁵¹ see the situations vacant and partnership advertisement columns of the *Times* or the *Engineer* and brokerages listed in local directories for facilitating ownership transitions.

⁵² Dennison and MacDonagh, *Guinness*, p. 6-7.

⁵³ The distinction between private and public companies was in 1881 not legally defined but widely understood. We use two aspects of the 1907 legal definition - having 50 or more shareholders and/or issuing shares to the public – to distinguish them in 1881.

investors, stock exchanges or their charters - to have at least a modest shareholding. Only 106 of our 437 firms were public companies, but they and six others (government undertakings with access to bond investors) shown in Table 4 together accounted for nearly half the capital and 34% 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 their 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.

Allocations of trading venues in Table 4 are based on stock exchange directories and regional share lists. 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 61% (by the capital in col 2) exceeded London’s, though the latter remained the single leading “B” venue with 39%. 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.⁵⁴

“Informal” trading was also a large category including many variations: from restricted

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

Trading Venue	Number of Firms	Capital (£m)	
		Total	Mean per Firm.
London “A”	18	32.000	1.778
London “B”	23	25.106	1.092
Informal markets	23	11.210	0.487

⁵⁴ There were also concentrations of large manufacturers in Scotland, Northern Ireland, South Wales and the East and West Midlands.

Manchester	11	6.469	0.588
Sheffield	8	4.180	0.522
Birmingham	8	3.236	0.404
Belfast ^a	6	1.717	0.286
Newcastle	5	4.858	0.972
Glasgow	4	2.134	0.534
Edinburgh	2	0.900	0.450
Oldham ^b	2	0.272	0.136
Leeds	1	1.188	1.188
Liverpool	1	0.948	0.948
Total	112	94.217	0.841
(Private firms ^c	325	94.651	0.291)

Source: this study's worksheets, with allocation to the senior market on which they were traded, using information from *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).

markets such as Platts (whose internal market, with prices fixed annually 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's in new financing and some of these firms had been funded as start-ups, but also, as primarily today, listing with 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 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 some of the world's largest machine tools, battleships 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 still quite small (employing only 500 in 1881), yet visiting engineers also admired larger factories that carefully sequenced flows and assembly processes.⁵⁵ Most factories were multi-storey until the 1890s, which optimised distribution of power from a central steam engine, often adopting the cascade principal of beginning 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 spread by purchases of US gun-making machines by the Royal Ordnance factories and the Birmingham Small Arms Co, which also installed British-made copies, though civilian demand for guns was low in the UK. Singer installed mainly American-designed machinery in its Scottish factory, where Hounshell's caution about casual claims of mass production surely also apply.⁵⁶ Some British textile machinery firms exemplified the "American" system more comprehensively: a journalist visiting Platt's two interconnected Oldham factories 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.⁵⁷ 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 built 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

⁵⁵ as at Dowlais (*Engineer*, 27 May 1881, p. 396).

⁵⁶ *American System*, pp. 109-21.

⁵⁷ Anon, 'Fortunes.'

like screws or bolts were produced by the billion, adopting the Whitworth standard (pre-dating its American equivalent) and railways standardized many other components (a locomotive had thousands of parts), limiting duplications of spares.

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 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. One for recovering usable silk from waste - spinning the fibres as if they were cotton rather than traditional silk-throwing - enabled his Manningham Mills, 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.⁵⁸

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

⁵⁸ Coleman *Courtaulds*, pp. 24-31.

around this time (scaled by capital formation) was already half the level achieved by more formalized twentieth century R & D and patent protection (Sullivan 1994).

Many of the firms in our population possessed other intangible assets, which - judging by the higher expenditure by business on marketing than technical research (in all countries) - were worth more. The 1875 Merchandise Marks Act formalized common law protections of trademarks, though many then registered were already long established.⁵⁹ Large textile and pottery firms employed artists and designers to differentiate products and appeal to the fashionable, often protecting designs by copyright,⁶⁰ suing rivals passing off products not made by them. For some products – sewing cotton, 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.⁶¹ Some top brands registered overseas but suffered counterfeiting in the US, continental Europe and Japan.⁶² 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.⁶³

The software of new ideas in technology and marketing flowed as easily across international borders as the hardware (machines and publications) that sometimes 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

⁵⁹ Higgins, 'Forgotten Heroes.'

⁶⁰ As attested by design historians (e.g. Sykas, 'Secret Life') and the appearance of many of these firms' products in the Victoria & Albert Museum.

⁶¹ see the large selection of their advertisements reproduced in <https://gracesguide.co.uk>.

⁶² Lopes and Casson, 'Brand Protection.'

⁶³ Higgins and Verma, 'Business.'

at the 1878 Paris world exposition.⁶⁴ Dozens of our firms' managers had looked east for their technical education to Germany, France or Switzerland, knowing that British (like American) elite universities were better at classics, law and theology than science.⁶⁵ 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;⁶⁶ 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.⁶⁷ 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, in 1881 the most promising alternatives to steam power were the internal combustion engines of Gasmotoren Fabrik Deutz under Nikolaus Otto and Gottlieb Daimler, who licensed the Otto gas engine (their most successful model) to Crossleys of Manchester; in the next decade over twice as many were installed in the UK as in Germany.⁶⁸

Americans, Germans and others were thus understandably keen that their firms - or inventions generating licensing income - should succeed in the challenging UK market, with not only the world's largest concentration of rich urban consumers, but also informed venture capitalists,

⁶⁴ Domini, G, 'Patterns of specialisation and economic complexity through the lens of universal exhibitions, 1855-1900,' Institute of Economics, Sant'Anna School of Advanced Studies, Pisa, working paper, 2019.

⁶⁵ though Cambridge mathematics was already world class and the impressive Cavendish laboratory was financed in 1881 by the Duke of Devonshire, owner of three of our large firms.

⁶⁶ In 1881 US manufactured exports were less than one-tenth of the UK's and smaller than Belgium's.

⁶⁷ Atack, 'Fact.'

⁶⁸ Dowson, 'Gas Power.'

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 marketing leadership but the advantage of risk diversification in its advanced venture capital market, facilitating the management of the radical uncertainty typifying new technologies.⁶⁹ 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 salesman, Francis Watson, partnered with the Birmingham businessman Arthur Keen, in 1864 launching the Patent Nut & Bolt Co with £200,000 capital, and already by 1881 they 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 give a snapshot of large-scale manufacturers at the end of the mid-Victorian period in the world's largest concentration of modern manufacturing employees.⁷⁰ We describe employees and managers in 437 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,⁷¹ as economic historians in earlier generations 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

⁶⁹ Michie, 'Options.'

⁷⁰ 4.860m manufacturing workers in the UK at the 1881 census, against 4.716m (Germany 1882) and 3.290m (US 1880). The qualifier 'modern' would increase the UK lead (n. 30 above).

⁷¹ Samuel, 'Workshop,' Greenberg, 'Reassessing,' Sabel and Zeitlin, 'Historical Alternatives.'

would - recognized that on many dimensions they had yet to do so.⁷² It may be that US manufacturing labour productivity was already higher than the UK's, but that was not generally the case for these firms.⁷³ 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"⁷⁴ and urged American industrialists to use steel in the wider range of applications and machines that the UK had already attained.

It is desirable to compare our population more comprehensively with other major industrial countries, though that is not as straightforward as might be supposed. 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, while the UK and US resembled each other in being more capital-intensive.⁷⁵ Yet the distribution of plant and firm sizes in the US perhaps resembled the UK's of 1881 only by 1900. Two decades earlier there were barely half as many US manufacturers with \geq £1m capital as the 33 in the UK⁷⁶ and the New York Stock Exchange was bereft of manufacturers compared with London or Manchester. It was not the case that Britain's mid-Victorian "industrialists had become attuned to a slower, smaller-scale process

⁷² see introductory quotation.

⁷³ Foreman-Peck and Hannah, forthcoming, which qualifies the findings of Broadberry, *Productivity*.

⁷⁴ Warren, *Steel*, p. 69, see also McHugh, *Holley*.

⁷⁵ Varian, 'Manufacturing.'

⁷⁶ United States, *1900 Census*. We are grateful to Jeremy Atack and Richard Hornbeck for sharing their unpublished work on the US 1880 manuscript returns. 'Giant' firms in iron/steel, textiles, breweries and cement account for the 1880/81 UK lead.

of industrial production and distribution.”⁷⁷ On the contrary the “visible hand” of UK 1881 businesses was a model for US catch-up (and in some cases overtaking) in the next two decades.

These rival economies were not frozen in time by entrenched oligopolists (rare) or ossified social conventions (dire as the latter were in Britain and Germany) but dynamic systems. Competition and creative destruction in the UK - from new products, processes, organisational innovations and (with arguably the most open borders the industrialized world has ever known) foreign and empire competitors – transformed these large firms, bankrupting some, enriching others and doubling living standards every half-century. The recent past provided some warnings. Richard Fothergill’s partnership reported the largest⁷⁸ number in any individual census return in 1871 (8,000 employees in collieries and ironworks) and began building Bessemer converters, but was bankrupt by 1875, bringing down with him his London bill-brokers and permanently closing all manufacturing. One needed not only the right strategy but chemical and metallurgical skills to perfect processes and sufficient capital to withstand recessions and strikes. Scalable techniques reduced costs but also intensified competition, hence the increased drive to merge. This database enables one to avoid the business historian’s casually misleading attribution of success factors and classic underestimation of the creative destruction of failures.⁷⁹ Applying the quantitative 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 findings already 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 needs more careful evaluation of mid-Victorian businesses with substantially more - and more diverse, international, and “modern” - experience of large-scale business methods than late industrialisers emulating the UK’s successful development model.

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⁷⁷ Chandler, ‘Emergence,’ p. 497. Given his implausible *explicandum*, it is unsurprising that his explanation – retarded development of professional managers divorced from owners - is also suspect (Foreman-Peck and Hannah, ‘Extreme Divorce;’ Acheson et al, ‘Corporate Ownership;’ Hawkins, ‘American boomers,’ p. 803).

⁷⁸ though at least four iron coal and steel firms with more employees failed to return in 1871.

⁷⁹ Fridenson, ‘Business Failure.’

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Appendix 1. Giant Manufacturing Firms of 1881.

This is a list of all the giant manufacturing firms of 1881, derived from census returns or other sources, as detailed in the text and appendix 2, and ordered by descending size of capital (appendix 2 provides an alternative ordering by employment). “Giant” is defined as employing at least 5,000 people and/or having £1m or more paid-up capital. 33 firms were identified by each criterion, of which 16 were giant by both, so there are 49 “giant” firms in all. Not all capital or employment was solely in manufacturing: vertical integration backward to mining and forward to wholesaling was common among these giant firms.

British multinationals engaged in manufacturing that also met these criteria are included here and in appendix 2 (with all their capital⁸⁰ but only UK employees) *if they employed 1,000 or more in the UK*. Among multinationals excluded by the latter criterion – with their capital, industry and main location of employment - are Rio Tinto (£5.803m, copper and chemical by-products, Spain), New Zealand & Australian Land (£3,498m, branded dairy and meat products, Australasia), Imperial Continental Gas (£2.8m, gas, coke and chemical by-products, continental Europe), Mason & Barry (£1.852m, copper and chemical by-products, Portugal), United States Rolling Stock, (£1m, railway engineering, US), Liebig’s Extract of Meat (£0.48m, beef bouillon, Uruguay) and Isaac Holden & Sons (partnership capital unrecorded, but employing 700 (UK) and 3,300 (France) in wool-combing). US Rolling Stock was a “free-standing” company (defined as having no more than a “brass plate” HQ, directors and a stock exchange listing in the UK) and qualified only by the capital criterion (it employed only 450 in

⁸⁰ Except in the few cases where we could exclude their overseas capital.

its US factory) but the others employed thousands worldwide and dozens or hundreds in management, finance, purchasing, distribution and/or manufacturing in the UK.

Capital 1881 (£)	Firm Name	Industry	employees 1881
17437464	Royal Dockyards	shipbuilding	15762
9326500	Gas Light & Coke Company	gas coke chemicals	6300
3389120	Bolckow Vaughan Ltd	coal iron steel	12800
3264000	Wm Baird & Co	coal iron	10000
2760000	Bass Ratcliff & Gretton	brewers	3000
2466105	Barrow Haematite Steel Co Ltd	coal iron steel	8000
2282131	Birmingham Corporation Gasworks	gas coke chemicals	1500
2250000	Arthur Guinness & Sons	brewers	2300
2128362	Ebbw Vale Steel Iron & Coal Co Ltd	iron steel coal	7000
2010774	Wigan Coal & Iron Co Ltd	coal coke iron	11000
1981490	South Metropolitan Gas Company	gas coke chemicals	2250
1850000	Samuel Allsopp & Co	brewery	1800
1834000	London & NW Railway Workshops	steel locomotives rolling stock	8269
1697500	J & P Coats	sewing thread	2400
1600000	Platt Bros & Co Ltd	textile machines	7000
1520000	Vivian & Sons	nonferrous metals chemicals	3120
1502000	Great Western Railway Workshops	steel locomotives rolling stock	7500
1500000	Rylands & Sons Ltd	integrated cotton	12250
1400000	I & R Morley	hosiery	5000
1360000	Midland Railway workshops	locomotives rolling stock	4500
1250000	Sir Titus Salt (Bart) Sons & Co	worsted spinning/weaving	2800
1200000	Pease & Partners	coal iron wool	6500
1187970	John Crossley & Sons Ltd	carpets	4000
1150000	Charles Cammell & Co Ltd	coal, iron, shipbuilding	5000
1140407	Rhymney Iron Co Ltd	coal iron steel	3500
1134144	Tredegar Iron & Coal Co Ltd	coal coke iron	5500
1125000	North Eastern Railway Workshops	locomotives rolling stock	5500
1050000	Earl of Dudley Estate Office	coal iron	7082
1041537	John Brown & Co Ltd	iron steel coal	3146
1030000	Nettlefolds Ltd	wood screws	2200
1000000	Glasgow Corporation Gasworks	gas coke chemicals	1150
1000000	John Bazley White & Brothers	cement/bricks	1300
1000000	Singer Sewing Machine Manufacturing Cor	sewing machines	4250
961129	Royal Ordnance Factories	guns gunpowder	6873
900880	Palmers Shipbuilding & Iron Co Ltd	coal iron steel shipbuilding	8000
900000	Dowlais Iron Company	coal iron steel	8750
900000	Bell Brothers Ltd	coal iron steel engineering	6250
830000	Pearson & Knowles Coal & Iron Co Ltd	coal. Iron, engineering	5000
825000	Merry & Cunninghame	coal iron	5000
813350	Staveley Coal & Iron Co Ltd	coal iron	5000
697325	Consett Iron Co Ltd	coal iron	5500
650000	Dent Allcroft & Co	leather gloves	8000
500000	Butterley Company	coal iron	8000
500000	Robert Heath & Son	coal iron	5000
462000	Cox Brothers	jute	5000
406965	John Elder & Co	shipbuilding marine engineering	5000
400000	William Ewart & Son	linen	5000
372000	William Dixon Ltd	coal and iron	6000
150000	Robert & Henry Parnall	wholesale clothier	37 5000
88137153	top 49 combined		281052
77868504	top 33 by column criterion		237746

Appendix 2. All 1881 manufacturers with 1,000 or more employees, ranked by employment size

Firm Name	capital (£)	employees
Royal Dockyards	17437464	15672
Bolckow Vaughan Ltd	3389120	12800
Rylands & Sons Ltd	1500000	12250
Wigan Coal & Iron Co Ltd	2010774	11000
Wm Baird & Co	3264000	10000
Dowlais Iron Company	900000	8750
London & NW Railway Workshops	1834000	8269
Barrow Haematite Steel Co Ltd	2466105	8000
Butterley Company	500000	8000
Palmers Shipbuilding & Iron Co Ltd	900880	8000
Dent Allcroft & Co	650000	8000
Great Western Railway Workshops	1502000	7500
Earl of Dudley Estate Office	1050000	7082
Ebbw Vale Steel Iron & Coal Co Ltd	2128362	7000
Platt Bros & Co Ltd	1240000	7000
Royal Ordnance Factories	961129	6873
Pease & Partners	1200000	6500
Gas Light & Coke Company	9326500	6300
Bell Brothers Ltd	900000	6250
William Dixon Ltd	372000	6000
Tredegar Iron & Coal Co Ltd	1134144	5500
Consett Iron Co Ltd	697325	5500
North Eastern Railway Workshops	1125000	5500
Staveley Coal & Iron Co Ltd	813350	5000
Robert Heath & Son	500000	5000
Pearson & Knowles Coal & Iron Co Ltd	830000	5000
Charles Cammell & Co Ltd	1150000	5000
Merry & Cunninghame	825000	5000
John Elder & Co	406965	5000
Cox Brothers	462000	5000
William Ewart & Son	400000	5000
I & R Morley	1400000	5000
Robert & Henry Parnall	150000	5000
Blaenavon Company Ltd	220000	4750
Patent Shaft & Axletree Co Ltd	311962	4750
Bessbrook Spinning Co Ltd	281896	4600
Lilleshall Co Ltd	719000	4500
Stanier & Co	556613	4500
Midland Railway workshops	1360000	4500
Fownes Brothers & Co	376818	4335
Weardale Iron & Coal Co Ltd	900000	4250
Singer Sewing Machine Manufacturing Company	1000000	4250

Baxter Bros & Co	640000	4200
Stanton Ironworks Co Ltd	420600	4000
York Street Flax Spinning Co Ltd	360000	4000
John Crossley & Sons Ltd	1187970	4000
Pilkington Brothers	448448	4000
Sir W G Armstrong & Co	988000	4000
Low Moor Ironworks Company	905449	3800
Ulster Spinning Co Ltd	387406	3750
Bryant & May	400000	3750
Crawshay Brothers	600000	3500
Rhymney Iron Co Ltd	1140407	3500
Newton Chambers & Co	448963	3500
J & G Thomson	468818	3500
T & W Sidebottom	411541	3500
William Barbour & Sons	250000	3500
Patent Nut & Bolt Co Ltd	280000	3400
Huntley & Palmer	350000	3300
Coltness Ironworks	382950	3297
Samuel Lister	660272	3217
Barrow Shipbuilding Co Ltd	330710	3200
John Brown & Co Ltd	1041537	3146
Vivian & Sons	1520000	3120
West Cumberland Iron & Steel Co Ltd	630000	3100
J & J Clark	700000	3050
Shelton Bar Iron Co	150000	3000
Sheepbridge Coal & Iron Co Ltd	630739	3000
Earle's Shipbuilding & Engineering Co Ltd	310000	3000
Thames Ironworks & Shipbuilding Co Ltd	237500	3000
Robert Lindsay & Co Ltd	80000	3000
Waterlow & Sons Ltd	380000	3000
Bass Ratcliff & Gretton	2760000	3000
McIntyre Hogg & Co	192810	3000
Tillie & Henderson	192810	3000
Frizinghall Works/Hodgsons	383523	3000
Steel Company of Scotland Ltd	646480	2950
Laird Brothers	268993	2850
Landore Siemens Steel Co Ltd	747000	2800
Harland & Wolff	235065	2800
John Musgrave & Sons Ltd	545800	2800
Sir Titus Salt (Bart) Sons & Co	1250000	2800
Samuel Courtauld & Co	441574	2800
John Wood & Brothers Ltd	250000	2764
Andrew Leslie & Co	275800	2700
Richard Haworth & Co	297562	2700
Alexander Pirie & Sons	300000	2700
Tootal Broadhurst Lee	341125	2600
Stead Simpson & Nephews	285389	2600
Horrockses Miller	610872	2571

Bowling Iron Co Ltd	240000	2500
Clay Cross Iron & Coal Co	294592	2500
W Gray & Co	263100	2500
Lancashire & Yorkshire Railway Workshops	708000	2500
M Oldroyd & Sons Ltd	450000	2500
Young's Paraffin Light & Mineral Oil Co Ltd	586625	2500
Charles Tennant & Co	363800	2500
Henry Matier & Co	62900	2500
Ashton Brothers	192400	2461
J H Gartside & Co Ltd	118410	2450
Great Northern Railway Workshops	635000	2400
J & P Coats	1697500	2400
Thomas Rhodes & Son	140000	2400
Richards & Co	261494	2400
Chance Brothers	208000	2400
London & Manchester Plate Glass Co Ltd	555000	2400
William Cubitt & Co	234711	2367
Scott & Co	311068	2331
William Bracewell & Sons	353444	2300
Arthur Guinness & Sons	2250000	2300
Dobson & Barlow	211037	2300
Great Eastern Railway Workshops	377000	2250
South Metropolitan Gas Company	1981490	2250
Nettlefolds Ltd	1030000	2200
Charles Mitchell & Co	247520	2200
William Calvert & Son	242841	2200
John Holdsworth & Co	407244	2200
Peek Frean & Co	212139	2200
John Orr Ewing & Co	372865	2188
John Dugdale & Sons	240026	2174
Glasgow Iron Company	330090	2100
Carron Company	459479	2100
John Foster & Son	389114	2100
Brookfield Linen Co Ltd	200000	2100
John Heathcoat & Co	238452	2100
Archibald Orr-Ewing & Co	358183	2100
Daniel Gurteen & Sons	136357	2100
Army & Navy Cooperative Society Ltd	251495	2100
Noah Hingley & Co	250451	2050
Hawks Crawshay & Co	248387	2000
John Bradley & Co	350000	2000
Shotts Iron Company	416168	2000
Summerlee Iron Company	225000	2000
R Napier & Sons	270000	2000
Beyer Peacock	347240	2000
Reddish Cotton Spinning Co Ltd/Houldsworth & Co	153100	2000
Francis Sumner & Co	108000	2000
Ormrod Hardcastle & Co	164600	2000

G & R Dewhurst	221263	2000
James Akroyd & Son Ltd	448370	2000
Barrow Flax & Jute Co Ltd	100000	2000
J & A D Grimond	218670	2000
Doulton & Co	290192	2000
Derham Brothers	80000	2000
Welch Margetson & Co	128914	2000
Robert Sinclair & Co	128914	2000
Royal Army Clothing Depot	47375	2000
Arthur & Co Ltd	880000	2000
India Rubber Gutta Percha & Telegraph Works Co Ltd	412000	2000
Telegraph Construction & Maintenance Co Ltd	691575	2000
Price's Patent Candle Company	835460	2000
John Robertson & Co Ltd	160000	1950
Newcastle Chemical Works Co Ltd	584042	1950
Thomas Taylor & Brother	300000	1900
John Barran & Sons	207907	1900
Hurst Mills Co Ltd	131000	1888
Blair & Co	198992	1880
McCorquodale & Co Ltd	150000	1873
Thomas Fletcher & Sons	206583	1863
Oldham Whittaker & Sons	205622	1854
Sir Elkanah Armitage & Sons Ltd	223680	1850
Alexander Stephen & Sons	247908	1847
Smith & McLean	285840	1810
Coalbrookdale Co	212000	1800
Ashbury Railway Carriage & Iron Co Ltd	334356	1800
Caledonian Railway Workshops	674000	1800
Melland & Coward	134949	1800
J & T Brocklehurst & Sons	266577	1800
Minton's	207000	1800
Samuel Allsopp & Co	1850000	1800
John Tatham & Sons	102000	1800
Eliza Tinsley & Co	214971	1750
Kitson & Co/Monkbridge Iron	410000	1750
Nottingham Manufacturing Co Ltd	197392	1750
Asa Lees & Co Ltd	110100	1750
John Mayall	300000	1700
Finlayson Bousfield & Co	187003	1700
William Stirling & Sons	292099	1700
William Brown & Nephews	184129	1652
James Finlay & Co	688843	1650
Hick Hargreaves	245444	1650
J & J Craven	304165	1626
Monkland Iron & Coal Co Ltd	317000	1600
Brymbo Ironworks	79476	1600
Barlow & Jones Ltd	374986	1600
Jonas Brook & Brothers	248854	1600

Thomas Marshall	178623	1600
Gilroy Sons & Co	292895	1600
J & J W Worrall	200090	1600
R & W H Symington	134487	1600
London Lead Company	95000	1600
Cope Brothers	350000	1600
J Pullar & Sons	273780	1588
William Marshall & Sons Ltd	200000	1574
William Garnett	292107	1558
W B Coddington & Sons	173656	1553
Swainson Birley & Co	173339	1550
John Hawkins & Sons	173339	1550
Dunbar McMaster	125000	1550
T C Brown-Westhead, Moore & Co	166180	1550
Mossend Ironworks	175000	1500
I & W Beardmore	239092	1500
Nantyglo & Blaina Ironworks Ltd	538950	1500
John Abbot & Co Ltd	210000	1500
Farnley Iron Company Ltd	198000	1500
Ackers Whitley & Co Ltd./J H Johnson	170000	1500
Walter Macfarlane & Co	239092	1500
Chillington Iron Co Ltd	315000	1500
Neilson & Co	351008	1500
Black & Wingate	237543	1500
Todd & Higginbotham	237543	1500
Joshua Hoyle & Sons Ltd	200000	1500
Fielden Brothers	130000	1500
William Rumney & Co	168065	1500
Tunstill Brothers	168065	1500
John Baynes	168065	1500
Kershaw Leese & Co	168065	1500
Mitchell Brothers	281845	1500
Birmingham Corporation Gasworks	2282131	1500
Turner Bros Hyde & Co	167396	1500
Footman Pretty & Nicolson	98767	1500
Curtis Sons & Co	139805	1500
Howe Machine Co Ltd	400000	1500
Joseph Whitworth & Co	700000	1500
Muspratt & Co	222000	1500
Eley Brothers Ltd	230000	1500
Black Hawthorn Eng/St Bede Chemical	272987	1477
William Denny & Brothers	250000	1461
Dorman Long & Co	285000	1450
Raylton Dixon (Cleveland Dockyard)	155450	1450
London & Glasgow Engineering & Iron Shipbuilding Ltd.	192575	1450
John Dickinson & Co	296000	1434
Thomas Richardson & Co	175000	1425

Barclay Curle	75000	1422
Siemens Brothers Ltd	500000	1418
Anderston Foundry Company	279000	1400
London & SW Railway Workshops	508000	1400
North British Railway Workshops	680000	1400
Crosses & Winkworth Ltd	300000	1400
George Grant & Sons	222673	1400
George Cheetham & Sons	157545	1400
John Leech & Sons	157545	1400
Abraham Brierley & Sons	157545	1400
Robert McClure & Sons	78100	1400
William & Henry Foster	200000	1400
Belfast Flax Spinning & Weaving Co Ltd	200000	1400
Robert McBride & Co	90549	1400
Combe Barbour & Combe	112000	1400
Tangye Brothers	329958	1400
Jarrow Chemical Company	250000	1400
Thomas Bayley & Co Ltd/Digby Collery Co	161996	1400
George Andrew & Sons	154605	1372
J Radcliffe & Co	153451	1361
Wigham Richardson	145422	1350
R R Jackson & Co Ltd	80000	1345
Joseph Rodgers & Sons Ltd	130000	1342
James Williamson & Son	201181	1336
Robert Hopwood & Sons	150726	1335
Vickers Sons & Co Ltd	580100	1300
Moss Bay Hematite Iron & Steel Co Ltd	242719	1300
Dubs & Co	307138	1300
Metropolitan Railway Carriage & Wagon Co Ltd	425835	1300
Richard Smethurst & Co	147060	1300
Great Western Cotton Company Ltd	134000	1300
Armitage & Rigby	142229	1300
Shaw Jardine & Co	125000	1300
John Fish Ltd	200000	1300
John Hind & Son	68000	1300
John Birchenough & Sons	196151	1300
John Bazley White & Brothers	1000000	1300
Cartwright & Warner	110722	1300
Samuel Lawson & Sons	170431	1300
Clayton & Shuttleworth	237418	1295
Ystalyfera Iron Company	100000	1281
Chatterley Iron Co Ltd	559653	1250
Manchester Sheffield & Lincs Railway Workshops	522000	1250
Robert Stephenson & Co	186000	1250
Great Southern & Western Railway	146000	1250
John Bright & Brothers	216400	1250
Fenton O'Connor & Co	81516	1250
Thomas de la Rue & Co	150324	1250

Thomas Robinson & Son Ltd	88170	1250
R & W Hawthorn	194080	1219
Crosse & Blackwell	400000	1206
William Williams & Co	199191	1200
Thomas W Booker & Co Ltd	873000	1200
Oswald Mordaunt	519473	1200
Sharp Stewart & Co Ltd	252000	1200
Henry Bannerman & Sons	136607	1200
Robert Shaw & Sons	55000	1200
W H Hornby & Co	136607	1200
John Smith & Sons	140167	1200
Malcolm Ogilvie & Co	114000	1200
Thomson Shepherd & Briggs	100000	1200
Marshall & Co	263822	1200
William Kirk & Partners	100000	1200
F Steiner & Co	149200	1200
Liverpool United Gas Light Company	947930	1200
Perry & Co Bow	122851	1200
Clarke Sons & Co	430082	1200
Ransomes Sims & Head	250500	1200
North British Rubber Co Ltd	313190	1200
Walter Scott & Sons	230817	1191
A & A Galbraith	191016	1186
Thornliebank Calico Printworks	175000	1170
A & J Inglis	160001	1158
James Drummond & Sons	221743	1158
Glasgow Corporation Gasworks	1000000	1150
Haines & Co	600618	1150
William Fison & Co	218597	1140
Manchester Corporation gasworks	982541	1135
John Chadwick & Co	173030	1134
Henry Briggs	216151	1126
Cooperative Wholesale Society Ltd	508406	1125
Clark & Co (John Clark Junior)	700000	1120
James Templeton & Co	200000	1120
Richard Hornsby & Sons Ltd	310000	1112
T & J B Jubb	213181	1109
Cwm Avon Companies Ltd	117400	1100
Lochgelly Iron & Coal Co Ltd	60000	1100
Gilmours Anderson Ward (Maryport Hematite)	281980	1100
Hamilton's Windsor Ironworks Co Ltd	127007	1100
Samuda Brothers	80000	1100
James Laing	120487	1100
Midland Railway Carriage & Wagon Co	405554	1100
Glasgow & SW Railway workshops	218000	1100
James Chadwick & Brother	250000	1100
Langworthy Brothers & Co	110000	1100
George Mayall & Co	100000	1100

Eccles Shorrock Brother & Co	95000	1100
Joseph Smith	126183	1100
John Haslam & Co	247120	1100
Merrall & Son	211610	1100
Joseph Hargreaves	211610	1100
John Fowler & Sons	369430	1100
W & J Knox	122544	1079
F W Grafton & Co	135428	1079
Perry & Co Ltd	272865	1060
David & William Henderson & Co	225000	1060
Parkgate Iron Co Ltd	195000	1050
James Collinge & Sons	120981	1050
Crewdson Crosses & Co Ltd	200000	1050
William Lund & Sons	202885	1050
Whiteabbey Flax Spinning Co Ltd	69534	1050
John Sharp & Sons	228076	1050
R & T Birkin	171407	1050
John Brinton & Co	192700	1050
Marcus Ward & Co	153270	1050
Pim Brothers & Co	70487	1050
Dunlop & Co (Clyde Ironworks)	149930	1044
John Gilby	118381	1025
Henry Bayley Son & Co	100000	1025
John Fergus & Co	116377	1019
McConnel & Co Ltd	100000	1018
Erskine Beveridge & Co	120000	1010
Gourock Ropework Co	150000	1005
Edward Ripley & Son	176968	1005
Joseph Verdin & Sons	108015	1002
Shropshire Iron Co Ltd	127947	1000
Acklam Iron Works	162359	1000
New British Iron Co/Ruabon Ironworks	357955	1000
William Jessop & Sons Ltd	370610	1000
Falkirk Iron Company	164715	1000
Panteg Steelworks & Engineering Ltd	168827	1000
Rylands Brothers Ltd	80000	1000
Sparrow & Co Osier Bed Ironworks	127947	1000
Llynvi & Tondu Ltd	449589	1000
William Hamilton & Co	140104	1000
William Doxford & Sons	173000	1000
Harvey & Co of Hayle	295500	1000
Thomas Royden & Sons	99125	1000
P & W McLellan	241816	1000
Birmingham Railway Carriage & Wagon Co Ltd	474558	1000
Scottish Waggon Co Ltd	483339	1000
Saxby & Farmer	176198	1000
Thomas Dugdale Brother & Co	115783	1000
J & A Leigh	115783	1000

Robert Hyde Buckley & Sons	150000	1000
Clyde Spinning Company	75600	1000
Middleton & Tonge Cotton Spinning Co Ltd	161764	1000
Globe Cotton Spinning & Manufacturing Co Ltd	179734	1000
Thomas Taylor & Co	155000	1000
Robert Platt	115783	1000
Benjamin Whitworth & Brothers	95172	1000
Rouse & Co	194168	1000
Martin Sons & Co	300000	1000
John Shaw & Sons	250000	1000
Christopher Waud & Co	194168	1000
Daniel Illingworth & Sons	194168	1000
John Paton Son & Co	196986	1000
Norton Brothers & Co Ltd	200000	1000
Gibson Robertson & Co	114426	1000
Northern Spinning Co Ltd	200000	1000
Acheson Harden Ltd	23995	1000
Herdman & Co	66546	1000
Harry Walker & Sons	66546	1000
William Ritchie & Sons	67122	1000
J & T M Greeves	66546	1000
James Clendinning & Sons	10000	1000
James Glass & Co	66546	1000
Messrs Lea	169552	1000
Thomas Adams & Co Ltd	277885	1000
Storey Brothers & Co	154434	1000
Maple & Co	159047	1000
Salis Schwabe & Co	150000	1000
Thomas Cross & Co	126457	1000
Edmund Potter & Co	130000	1000
Ellison Glass Works	25000	1000
Spottiswoode & Co	70249	1000
W S Hodgkinson & Co	91809	1000
Cassell Petter & Galpin	341500	1000
William Clowes & Sons Ltd	130000	1000
William Collins, Sons, & Co Ltd	176000	1000
Distillers Co Ltd	852000	1000
WB Foster & Sons	300000	1000
Dunville & Co Ltd	500000	1000
Edward & John Burke	800000	1000
William Fraser & Co	53016	1000
N Corah Sons & Cooper	87174	1000
Mann Byars & Co	115995	1000
Swanston & Bones	67459	1000
Fairbairn Kennedy & Naylor	135000	1000
Howard & Bullough	96315	1000
Prince Smith & Son	134184	1000
J Ruston Proctor & Co	187592	1000

Birmingham Small Arms Metal Co Ltd	162520	1000
Fawcett Preston & Co	141384	1000
Reckitt & Sons Ltd	150700	1000
Cape Copper Mining Co Ltd (Neath works)	140000	1000
Broxburn Oil Co Ltd	170750	1000
Devon Great Consols Co Ltd	10240	1000
Kynoch & Co Ltd	114000	1000
J & J Colman	81427	1000
Henry Tate & Sons	98212	1000
John Moir & Son Ltd	150000	1000
Aerated Bread Co Ltd	92378	1000
W J Shaw & Sons	80728	1000
ALL ≥1000 EMPLOYERS	188508051	928227