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The sources of scale: Large employers in Britain in 1881

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ABSTRACT

The article assesses the relative weight of different sources of workforce size, using both relative marginal effects and proportion of variance explained for the 545 largest British firms in 1881. Despite data uncertainties, integration is shown as the largest contributor to scale. Integration with mining had even larger effects, raising employment by 35%. Internal capital intensity reduced labour for the majority of firms by about 4 workers per £10,000 capital, but much more for tramways. Place-based externalities had greatest marginal effects for agglomerations (measured by population size). Generally, sectoral localisation was insignificant, but for small localities with more than one firm in a single sector, firm size increased 26–30% compared to diversified localities. Local monopsony (measured by workforce proportion of local population) explained a large proportion of variance because it occurred in a large number of small places. Of other variables explored, only legal form is of major importance.

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1. Introduction

The sources of economic advantage that enabled large firm development in nineteenth-century Britain have been long recognised. Lee (1979, pp. 4–6, 17–18) summarised the key elements as specialisation to achieve higher rates of return, agglomeration in trade, aggregation around natural resources (particularly coal and iron), and locations with growing markets from rising population and urban concentration generating externalities that fed into the foci of the transport system, especially railways. This was particularly important for manufacturers' comparative advantage in export markets (Varian, 2020). These operated at the plant, firm and locational level. Marshall (1920, pp. 267–277), looking back on the nineteenth century, identified firms' internal economies of scale and externalities from clustered industries reinforcing each other, especially within 'industrial districts' with related industries. Historical districts and industrial clusters have been assessed in case studies and regional and national analysis (Belussi & Caldari, 2008; Checkland, 1964; Crafts, 1985,

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1997; Wilson & Popp, 2003; Wilson et al., 2022). Other recent commentary has enlarged on this interpretation by emphasising endogenous benefits of clustering which facilitated the introduction of new products and services, learning-by-doing, innovation and R&D, access to human capital investment in education and training, and institutions, public policy and social capital (David & Rosenbloom, 1990; Krugman, 1991; Romer, 1986). This benefitted all firms, large and small. But large firms potentially gained monopoly and prime mover advantages over suppliers or markets. This could be in local markets (Bresnahan & Reiss, 1991; Marshall, 1920, pp. 477–499) or at regional or national level (Campbell & Hopenhayn, 2005).

Despite this wide recognition, there has been less attention given to the *relative* importance of the different sources of scale, and the situations that gave rise to them: what was most critical to which type of firm? This has been mainly because data on large firms has been too limited to provide for robust comparative statistical analysis. Instead historians have tended to rely on understanding large firms through case studies or samples from those with the best surviving records, for specific industries (Landes, 1969), or focused on generic productivity improvements at the macro-level (Broadberry, 1977; Crafts 2021; Feinstein, 1976; Pollard & Feinstein, 1988), or theoretical experiments (Hart et al., 1990). However, several studies have assembled data on samples of the incorporated (Acheson et al., 2015; Guinnane et al., 2017), or the population of the largest – often the top 50 or 100, or those over 1,000 employees (Acheson et al., 2016; Hannah, 1983, 2014; Jeremy, 1991; Nicholas, 2000; Shaw, 1983; Wardley, 1991, 1999).

Recently it has become possible to access individual data for the population of business proprietors in Britain over the period 1851–1911 using digital encoding of the records of the population census through *The Integrated Census Microdata* (I-CeM) (Schürer & Higgs, 2014) and extraction for individual business proprietors in the *British Business Census of Entrepreneurs* (BBCE) (Bennett et al., 2020). These have allowed the total population of proprietors, trends in their numbers, shifts between sectors, and changes in the scale of employers compared to own account self-employed to be understood for the first time (Bennett et al., 2019). It has identified firms that were previously unknown as large, which together with data on over 500,000 small- and medium-sized employers provides ground-breaking scope for research on what Payne (1988, p. 22) called 'the regiments of the anonymous'. For 1851–1881 the census gathered data on the workforce size of employers, which has been used by Hannah and Bennett (2022) to assemble a database for manufacturing firms with 1,000 or more employees in 1881. This article enlarges that database to include all large firms in the rest of the economy for traded services to assess scope for wider future research to look at the whole population of firms, small as well as large. The new data covers 545 firms employing 1.5 million people.

The 1881 census year is chosen as the latest census to record workforce numbers, but also at a critical point in Britain's economic evolution. It was arguably at the 'climacteric' in economic growth where national total factor productivity was just beyond its peak over 1856–1873 (Crafts & Mills, 2020; Crafts, 2021). It thus captures firms at almost their most buoyant, but also at a point where competitiveness and other pressures were beginning to exert strong force to change behaviours. It is thus a critical base-line for subsequent researchers examining development up to and after WW1 and questions of British relative decline, as well as for understanding previous developments from the earlier nineteenth century, and widening coverage to include small- and medium-sized enterprises.

The article's central contribution is to identify the *relative weight* of different sources of scale for the largest employers. Employment size is used as the most accurate measure of scale available for this period: in the general absence of output data, and capital data that often has to be estimated. The article first outlines the data in more detail. The second section enlarges on the different sources of large firm size. The third section then assesses their relative weight. The analysis leads to the conclusion that, generally, integration followed by internal capital intensity and then externalities, were the most important sources for achieving scale, both for manufacturing and non-manufacturing sectors. In the special case where local monopoly by firms allowed control of local factor inputs, this was also a major source. Legal form was also significant. Compared with the dominant form of partnerships, public corporations and government entities were most closely associated with the largest firms, followed by private corporations. Where government entities are included their monopoly status gave them dominant weight. The article offers a foundation for further work, with the main data on firms given as Supplementary Material Appendix 4 allowing a range of further research to be developed.

2. The data

The census asked employers to identify their employee numbers. However, it is now established that there were non-responses from many employers (van Lieshout et al., 2021). Although non-response appears to be random by firm-size class, it was significantly higher for corporations than other proprietors as a result of the census completely ignoring how directors or managers of firms should respond. However, response rates by size do not differ significantly *within* legal status categories (Bennett & Hannah, 2022). Hannah overcame this deficiency by using a wide range of other primary and secondary materials to develop what is believed to be a full population of large manufacturers with 1,000 or more employees (Hannah & Bennett, 2022). This article uses Hannah's data for manufacturers in 1881 and expands it to service and distribution businesses.[1] Data for non-manufacturers was derived from the same materials – census, newspapers, parliamentary reports, Grace's Guide, directories, and business histories. However, additional sources also had to be developed. Large manufacturers responded to the census in about 37% of cases, and 50% for those that were not incorporated, but because of the census instructions, non-manufacturer responses were lower.

The article covers the whole economy of traded services but excludes independent mining firms and non-traded public services such as education, medical and religious services.[2] Workforce is estimated for full-time direct employees. Part-time or outworkers are adjusted to full-time equivalent, where they arise and sources allow, but this will be imperfect; it is a source of potentially high variance in the data. All of the firm's portfolio of activities are included if under the same business and management (where ascertainable), with cases of distinct businesses within loosely connected groups with 1,000 or more employees separately assessed. For international firms, adjustments were made to workforce and capital to include only their British-based workforce (i.e. excluding Ireland and foreign). Foreign-owned firms include only their British workforce, e.g. for the US sewing machine companies of Howe and Singer. Mobile workers on shipping based mainly abroad are excluded; e.g. the extensive share of workers within P&O, British India Co, and Pacific Steam Navigation Co on ships that rarely if ever visited Britain. Similarly

excluded are overseas agents, substantial overseas subsidiaries engaged in sales, distribution or mining, and all foreign-based mining and plantation companies though registered in the UK. However, the 41 firms with substantial overseas presence were coded additionally as multi-national businesses to allow assessment of any differences.

The total number of firms with 1,000 or more employees was 545, made up of 407 primarily manufacturers and 138 primarily non-manufacturers, as shown in Table 1.[3] This total is close to the only previous estimate of firm numbers for this size in 1881, derived from re-weighting BBCE numbers to account for non-response, suggesting it is probably an accurate assessment of the whole population, but as with all such historical data is only a best estimate.[4] The majority of the workforce was used to allocate to the principal sector, with more disaggregated information also used below. Sectors follow Feinstein's (1972) definitions, but with different levels of disaggregation to reflect the most numerous sectors among large firms; 17 in all. The top six sectors account for 67% of the firms, of which only shipping is primarily non-manufacturing.

The table also shows the firms by their legal form, using Hannah's definitions as public corporation, private corporation (unlisted or restricted shareholding), government, partnership, and sole proprietor. The vast majority of firms were still very personal enterprises controlled directly by entrepreneur(s). Britain was still dominated by traditional personal capitalism: over half were partnerships, which together with private companies that were often no more than the partners incorporated as a group made up 70% of the total; with sole proprietors, personal control was 75%. Less than a quarter were public listed corporations, and even some of these may have had de facto restrictions which maintained personal control by directors (Guinnane et al., 2017). Hence, as observed by Hannah (1983), Foreman-Peck and Hannah (2012) and Guinnane, the foundations of the shift towards large public corporations that dominated twentieth-century Britain was only slowly emerging in 1881, even for its leading firms.

Table 1. The population of firms with 1,000 or more employees in 1881 by sector, legal form and mean workforce size.

	Sector	*N*	%	Govt.	Public Co.	Private Co.	Partners	Sole
1	Iron & Steel	86	15.8	–	16	35	31	4
2	Engineering	81	14.8	2	21	4	49	5
3	Cotton	84	15.4	–	9	9	60	6
4	Other textiles	61	11.2	–	7	1	48	5
5	Chemicals & Gas	38	7.0	3	12	3	19	1
6	Pottery & Bricks	8	1.5	–	1	–	7	–
7	Paper & Printing	11	2.0	–	1	3	7	–
8	Apparel	25	4.6	–	3	1	21	–
9	Food & Drink	13	2.4	–	2	2	9	–
10	Construction	21	3.9	–	3	1	14	3
11	Dock Operation	8	1.5	–	8	–	–	–
12	Railway	28	5.1	–	28	–	–	–
13	Tramway/bus	4	0.7	–	4	–	–	–
14	Shipping	54	9.9	–	13	14	26	1
15	Carrier	4	0.7	1	–	–	2	1
16	Distribution	18	3.3	–	2	1	14	1
17	Insurance	1	0.2	–	1	–	–	1
Total		545	100	6	131	74	306	28
%				1.1	24.0	13.6	56.2	5.1
Mean workforce		2,681		14,410	4,154	2,188	1,789	2,399

3. Sources of scale

Whilst various sources have been long recognised in the academic literature as explaining the increasing size of firms, it is important to demonstrate that these sources were well understood by contemporaries and hence influenced the behaviour of entrepreneurs and managers such that they can be estimated and validly interpreted in historical data.

First and foremost, as identified by Alfred and Mary Paley as contemporary observers during extensive factory visits in the 1870s and 1880s (Marshall & Marshall, 1879; see also Marshall, 1919, 1920), increased scale reduced costs per unit of output, most often derived from investment in capital goods and machinery. Thus, at face value, capital reduced workforce size. For example, in 1877 James Bertram described the St Rollox chemical works of Charles Tennant & Co., as a 'model establishment' with 'upwards of 1,200 in constant employment'. 'The benefits of a manufactory conducted on such as scale is the reduction of the price at which useful goods can be sold … where expensive machinery has been patiently devised … in order to save labour and quicken production'; i.e. St Rollox used capital intensity and innovation to reduce unit costs (Bertram, 1877, p. 296). This behaviour also shows how capital also increased workforces. Many manufacturing industries required extensive capital investment in large scale machinery, but these in turn required a lot of labour to keep the machinery active, and to transport materials and products in and out of the factory. Thus whilst capital will be generally inversely related to labour, large capital often required large labour.

This is clear for the 1881 firms' capital intensity shown in Table 2, measured by the capital-labour ratio.[5] This uses paid up-capital in public companies and comparable enterprise capital for private and closely-held firms.[6] Large firms of all sectors exceeded Feinstein's estimate of capital stock of £83 per employee for all manufacturers, as expected – indicating they were much more capital intensive than firms of small- and medium-size.[7] Attention in Table 2 should not focus on minor differences or extreme data outliers. There was no standardised accountancy definition of invested capital at the time, with varied conventions on

Table 2. Mean paid up capital by primary sector of workforce for firms with 1,000 or more employees in 1881.[a]

Sector	Total (£m)	Mean (£m)	Capital per employee (£)
Iron & Steel	49.405	5.744	187
Engineering	42.509	0.524	183
Cotton	21.318	0.253	145
Other textiles	18.125	0.297	184
Chemicals & Gas	27.563	0.735	356
Pottery & Bricks	2.974	0.372	205
Paper & Printing	2.582	0.235	167
Apparel	6.514	0.261	134
Food & Drink	7.801	0.600	352
Construction	8.569	0.408	164
Dock Operation	41.827	5.228	3,743
Railway	614.857	21.959	2,254
Shipping	23.460	0.434	237
Tramway/bus	2.355	0.588	545
Carrier (exc. PO)	0.300	0.100	70
Post Office	7.275	7.275	100
Distribution	6.922	0.348	291
Insurance	1.982	1.982	190
Total	886.342	1.626	360

[a]Sectors are more aggregated for manufacturers than those in Hannah and Bennett (2022, Table 3).

depreciation, retentions, partly paid shares and undistributed profits of directors and partners, as well as unreported informal loans, etc. Moreover, as 40% of capital data is estimated it is generally less accurate than workforce numbers. Nevertheless, despite data constraints it is clear that capital–labour ratios fall into two distinct groups: the docks, railways, and to a lesser extent tramways; and the rest.

Excluding docks, railways and trams for the moment, the most capital intensive were heavy manufacturing of chemicals/gas, food and drink manufacturers (chiefly the brewers and distillers), followed by bricks/pottery, and shipping which had high capital and low labour giving high capital per employee. However, distribution was also capital intensive through its high requirements for property, often in high rental locations. Hence, while we generally expect capital to substitute for labour, with workforce size negatively related to capital intensity, most large capital intensive manufacturers and distributors had high labour as well as capital levels.

By far the lowest capital intensity was for carriers (including the Post Office despite its enormous size). These required only horses, mostly small carts and stables, which was the same as firms in all sectors at this time, and their only other major asset was warehousing/storage, which was usually small and mostly relied on others to/from whom they carted goods (although the Post Office also had telegraph offices, fixed wires, and the asset values of way-leaves). Also low was apparel and construction. Apparel was still a trade with high labour inputs, machining all requiring single operators for stitching, with some workers still without machines even in the largest firms. Construction was very labour intensive, all large projects needed many navvies (for building railways, tramways, large industrial plants, reservoirs, drainage) and was undertaken by firms that were often more contract managers than fixed-asset businesses. They had very substantial machinery and other assets like steam shovels, locomotives, brickworks and quarries, but these were often bought in and sold off at the end of major project because the next project was in a distant location; only locomotives were often retained as they were mobile. Hence, construction capital levels were relatively low compared to their huge labour requirements.

Docks and railways were the major exception, with capital-labour ratios ten times those of other industries; tramways were less exceptional but still more than twice most sectors. Docks and rail had enormous accumulated capital in fixed assets in their docks or rail networks compared to their workforces; the fixed network assets also characterised trams but at a much lower level than rail as covering shorter distances and were much more recent (essentially since 1870).[8] In docks there is the added complication that the majority of their labour was either casualised, under gangs and subcontractors, or employed by other operators using the docks – chiefly shipping companies, as well as distributors, warehousemen, and the railways (Davies 2000; Taplin, 2000): what Phillips and Whiteside (1985, p. 262) called a 'complex and fragmented business structure of the British dock transport system'. Some railways also contracted labour requirements to other firms: for manufacture of locomotives, wagons and carriages, and to other carriers to carry goods to/from stations; although 18 out of the 28 railways fully integrated their manufacturing. However, whilst railways and docks had the highest capital requirements of all firms, they also had the highest labour requirements. Their size was only possible with huge workforces. Apart from the state monopolies of the Post Office and Royal Dockyards, the 10 largest railways were the largest firms. The very different nature of capital intensity for railways, docks and trams is separately controlled for in the following analyses.

A second source of scale was integration. This was also recognised by Bertram at St Rollox chemical works through backward integration: 'making its own gas, barrels, bricks, timber work, and machinery, and by extensive use of waste products … everything required for carrying on a gigantic business is made within the place'.[9] Integration and diversification were a major aspect of most of the largest businesses. For analysis here, however, because the direction of evolution and diversification cannot be readily determined for each firm, integration and diversification are referred to under the single term 'integration'. As shown in Table 3, backward integration was almost universal for large iron and steel firms into mining, understandably since assembly costs of its major raw material were saved by close integration on site and many of these manufacturers originally forward-integrated from mining. Integration with mining was also frequent for engineering and chemical manufacturers. The other highly integrated sectors were railways into loco and carriage manufacture, cotton producers into machinery manufacture, and for most large retailers into manufacturing. Forward integration also benefitted firms, for example some mining firms developed their own iron, shipping and export operations, some retailers established large scale carriage operations for distribution and mail order departments, and some shippers developed large scale wholesale merchanting. Despite capital being re-established for each project by many construction firms, as noted above, construction integration was as frequent for major project firms as for general builders operating in more local/regional markets with their own brickyards, quarries and timber mills. As well as integration a few firms diversified into unrelated sectors. This offered economies of management, internal use of capital, and advantages from opportunistic entrepreneurism to develop into new markets. This can appear disjointed in retrospect but was used to bridge downturns in the main business, and explore new opportunities that then became the main business, as with Walter Scott who added coal mines to construction and then added publishing;[10] it also presaged twentieth-century conglomerates and business groups.

Table 3. Proportion of large firms that were integrated and/or diversified in 1881, and mean employment by aggregate sector.

	All integrated	Integration includes mining	Manufacturers employment	Non-Manufacturers employment	Mining employment	Total
Sector	%		Mean employment			
Iron & Steel	75.6	74.4	1,693	2	1,416	3,111
Engineering	22.2	17.3	1,986	94	64	2,143
Cotton	60.7	3.6	1,683	32	85	1,730
Other textiles	11.5	3.3	1,539	16	5	1,559
Chemicals & Gas	39.4	13.2	1,482	75	108	1,666
Pottery & Bricks	3.8	3.8	1,900	0	156	2,056
Paper & Printing	9.1	0	1,519	23	0	1,542
Apparel	24.0	4.0	1,894	287	32	2,212
Food & Drink	30.8	0	1,410	140	0	1,550
Construction	57.1	4.8	304	2,213	67	2,583
Dock Operation	12.5	0	0	1,852	0	1,852
Railway	64.2	7.1	1,552	9,937	20	11,508
Shipping	59.3	9.3	93	1,523	156	1,771
Tramway/bus	0	0	0	1,063	0	1,063
Carriers (exc. PO)	0	0	0	1,657	0	1,657
Post Office	0	0	0	72,543	0	72,653
Distribution	72.2	0	520	1,047	0	1,567
Insurance	0	0	0	10,383	0	10,383
Total	43.3	16.5	1,394	1,021	266	2,681

The scale of the workforces shown in Table 3 demonstrates that for iron and steel the average employment in manufacturers and mining was almost equal, whereas integration with mines in other sectors was significant for only a few firms and mine employment was generally small.

A third source of scale was externalities. In the sense identified by the Marshalls in the 1870s externalities primarily changed the relative competitive position of firms: different locations and transport access offered different unit costs for capital and factor assembly. They recognised that internal economies were usually the most important, but firms could also achieve scale from suitable locations. These can be separated into '*urbanisation economies*' where scale resulted from the large range of factor inputs and access to markets available in cities, and '*localisation economies*' where scale was achieved by the concentration of industries or specific sectors in a location (Belussi & Caldari, 2008; David & Rosenbloom, 1990; Lee, 1979; Marshall & Marshall, 1879; Marshall, 1920, pp. 397–419; Rosenthal & Strange, 2003). These externalities of course were available to all firms in a given place, not just large firms; and much modern use of Marshallian externalities focuses on the benefits to small firms, which the Marshalls also recognised. However, here we are concerned with how externalities provided an additional set of benefits for large firm development.

For analysis here each firm was coded to the *primary location* of its workforce. For firms with a single plant or group of premises this was straightforward, or if it its workforce was mainly sited in one place with only minor activities elsewhere (e.g. having only a registration address or minor workforce in London, or only agency arrangements elsewhere). Genuinely multi-plant and multi-branch firms with several separate plants or premises were coded to the wider area these covered, ranging up to whole regions for some railways, carriers, construction firms and networks of wholesale or retail branches. This means that firms were assigned to different types of primary location, ranging from very small towns up to large cities, city regions, whole economic regions,[11] all England and Wales, Scotland, and all of Britain. This reflects the varied market areas over which their workforce operated.

Table 4 compares the number of firms at their primary locations (101 different places). Individual towns and cities were the commonest type of location (76% of places), but most of these had only one, or 2–3 large firms, leading to them having only 35% of large firms. Most large firms were in city regions or counties, which covered only 19% of locations. They had 322 (59%) of all large firms, within which the six largest city regions had 243 (45%) of firms: London had 67, Glasgow 55, Manchester 42, Liverpool 34, Newcastle 25, and Bradford 20. Next followed Birmingham with 12, Teesside with 11 and Sheffield with 10. There was

Table 4. Location types, number of locations with different N of firms, and the number of firms in each type of location.

		Number of locations with N size-groups of firm				
Type of location	N of locations	1	2–3	4–10	>10	No of firms
Individual towns & cities[a]	77	40	19	16	2	197
City regions & counties	19	3	–	7	9	322
Regions	2	1	–	1	–	7
England and Wales	1	–	–	–	1	12
Scotland	1	–	1	–	–	2
Britain	1	–	–	1	–	5
Total	101	46	20	25	11	545

[a]<200,000 population.

clearly a major gap of large firm location between the very largest city regions and the smaller towns and cities. Definitions of locations are clearly fuzzy, with Birmingham's surprisingly small number of firms changed if it is combined with the Black Country: jointly they had 20 of the largest firms.[12]

Despite the high level of city-region concentration, it is clear that in 1881 a wide range of different types of locations hosted large firms. Hence, urbanisation economies were operating at both the small town/city level, but primarily in city regions which had externalities at a very different scale. In addition, 26 firms (5%) primarily operated at scales greater than city regions. This was chiefly special cases of railways, major construction project firms, government monopolies, carriers, food and drink manufacturers, and the Prudential.

The importance of urbanisation economies is brought out more clearly in Table 5. Nearly half of primary locations of large firms were small. However, less than 10% of large firm workforces were in places under 50,000 population, averaging one firm for places under 11,000, and only two firms for 11,000–50,000 population. In contrast, two-thirds of firms were located in 52% of places with 200,000 populations or greater; of which nearly one quarter was in places with over one million. The 200,000+ places employed three-quarters, and the one-million centres 44% of the large firms' workforces. This was because both the number and size of firms generally increased with the population of their locations.

Externalities also include the sectoral specialisation of places: 'localisation economies'. Specialisation within a place gave advantages of a highly skilled labour market in a narrow range of fields as well as interrelated subcontractors: 'the advantages which people following the same skilled trade get from near neighbourhood to one another' and 'a constant market for skill' providing risk-pooling (Marshall, 1920, p. 27; also David & Rosenbloom, 1990, pp. 350–353). The assessment of these is affected by the extent to which detailed sector definitions are used, by the multi-sector spread of most large firms, as well as the difficulties of attributing location to their operations. This is understandably fuzzy. However, in general it was the smallest locations that had the highest degree of potential localisation economies resulting from sector specialisation: most had only one large firm and hence only one sector. But even the largest of the smaller places with up to 15 large firms (Blackburn, Bolton, Dundee and Preston) had a narrow sector range, with the latter two only having one sector in each. In contrast, the city regions had much wider sector coverage: an average of nearly five sectors per location, covering 30% of the 17 sectors. But this varied, ranging downwards from London with 14 (82%) of sectors, Glasgow with 10 (59%) and Manchester with 9 (53%); lowest for the Black Country and Potteries each with 3 (17%) and Sheffield 2 (12%). The most specialised are as expected from the established historiography: high specialisation in Sheffield's complex of specialist steel and cutlery; the Potteries earthenware, iron and steel; and the Black Country's iron and steel, nails and engineering.

Table 5. Number of firms in locations of different population size.

Population size of primary location	N of places	N of firms	Firms per place	% of firms	Employment in large firms	Mean firm size	% of large firm employment
<11,000	24	24	1.0	4.4	34,883	1,453	2.4
11–50,000	24	51	2.1	9.4	96,530	1,893	6.6
50–200,000	26	120	4.6	22.0	231,778	1,931	15.9
200,000–1 m	16	219	13.7	40.2	448,742	2,049	30.7
>1 m	11	131	11.9	24.0	649,047	4,955	44.4
Total	101	545	5.4	100.0	1,460,980	2,681	100.0

A fourth source of scale could derive from monopoly control of markets. This was recognised by Marshall for the nineteenth century and has been a focus of much modern literature to regulate anti-trust and rent-seeking behaviour. There were two potential aspects for large firms in 1881. First, monopoly had been sanctioned for the largest British business, the Post Office, and also included state enterprises like the Royal Naval Dockyards and Royal Ordnance. In addition, railway, dock, tramway and gas companies were incorporated under parliamentary Acts which raised entry thresholds for competitors thus opening opportunities for de facto monopolies over most of their networks. These effects are included in the analysis using comparisons of legal forms and sectors.

A second aspect of monopoly was de facto *local* control over production or supply, and/or monopsony in purchasing, allowing large firms to set prices or prevent workers or suppliers from seeking alternatives. This allowed higher returns than achievable in fully competitive markets.[13] This was only possible for large firms in smaller and remoter locations where an enterprise could influence factor input prices and/or limit access by competitors; special cases of Hart et al., (1990) with either scarce resources or scarce supplies stimulating increased scale. Some evidence of this in 1881 has been found in the higher profits of smaller and medium-sized firms in some remoter towns (Bennett et al., 2022).

Local monopoly/monopsony is potentially important in 1881, where many large firms were located in very small places so that their employees made up a near-majority of their local workforces. There were certainly opportunities for monopsony control. This could be used to increase profits with no increase in scale, or maintain profitability and competitiveness otherwise not possible, which could maintain scale, or various other permutations. Hence, the outcome would vary. Daniel Gurteen, the 'little king of Haverhill', had one of the greatest potentials for monopsony, but claimed to pay higher wages than average to their 2,800 apparel workers (local and neighbourhood population of only 4,000) in order to retain skilled staff and maintain markets; they also built new housing, major local philanthropic projects, and were a major force to improve the local railway;[14] similar claims were made for the 1,000 workers in Clark's shoes in Street (population 3,000), as well as others. However, Corbett's salt manufacture was notorious for low wages and poor working conditions in Stoke Prior (population 2,000), and similarly for Broxburn Oil Co Ltd, whilst firms in sweated trades with local employment monopoly were likely to pay at best only the going rate. Hence, localisation economies could easily become de facto means of monopsony control over wages and other local factor prices which can explain why some large firms survived in increasingly challenged locations

Legal form and management structure were also potentially important sources of scale. All the firms in this database, given their large size, involved managers and foreman, teams or managerial hierarchies with extensive delegation. Hence, the specific observations made by Chandler (1990) regarding the lack of professionalisation or managerial development of British firms did not really apply to the firms considered. However, legal form might interact with management structure to ensure some were more professionalised than others. Forman-Peck and Hannah (2023, Table 2) showed for the manufacturers among this 1881 population that government entities and public corporations tended to have larger management teams with the largest proportion of professionals. Professionals were 12% higher in public compared to private companies, 30% more than partnerships, and 60% more than sole proprietors. This tended to be associated with larger size: about twice the average workforce of the other legal forms. As also recognised by Acheson et al. (2016) for

corporations over 1862–1900, performance was strongly influenced by the interaction between ownership and control; whilst Guinnane et al. (2017) observed some association between strength of director control in public companies in 1892 and their size of capital. Hence, legal form interacted with managerial structure and both could be sources of larger firm size.

4. Comparative assessment and relative weight

The sources of economic advantage that enabled large firm development in the late nineteenth century have not been thoroughly examined for their relative roles, in general, and for different types of firm. The new data for 1881 allow the first investigation of their different weights at this important stage of the British economic development.

We know from Table 1 that the large firms were still very personally controlled but we need to be assured that their size resulted from adjustment to the general and specific economic conditions they faced, at least on average. We have employment as the most reliable measure of size, with capital as a complementary but less accurate measure in these data. In a competitive economy the employment size of large firms in 1881 is used as an indicator of their accumulated performance, with differentials between firms reflecting the effects of managerial decisions and entrepreneurial skills in the face of their market options, as indeed Marshall and Marshall argued in 1879 (pp. 116–117). It may be that some were more slothful and not fully employing all factors efficiently (Payne, 1988 for review), but the British economy was largely tariff-free, open to importers as well as exporters, capital was fairly freely available, the labour market was buoyant due to rapidly rising population, market entry and growth was unimpeded by much regulation, so the existence and maintenance of the largest firms in 1881 was likely to be closely adjusted to market conditions. Hence, their employment should be adjusted to, and a good indicator of, competitive position. Moreover the level of competition between large firms was high, despite some increases in merger activity, so that the development of anti-competitive trusts was limited (except for the government entities and government-sanctioned monopolies). Contemporaries recognised that continued population growth gave a strong spur to investment and the search for efficiency through economies of scale. Craigie (1888, p. 466), reflecting on the period 1867–1887, stated 'Now the manufacturer … has at hand and day by day a ready-made and always extending market opened, simply in the growth of our home population.' Indeed Marshall believed that the nineteenth-century British 'general market' was open, 'the capital required to enable a business to command the most efficient and economical methods of production then known was relatively small'. Similarly, Keynes believed that conditions in nineteenth-century wages and prices brought them closely in line with returns 'sufficient … to establish a schedule of marginal efficiency of capital which allowed a reasonably satisfactory average level of employment' (Crafts, 2020; Marshall, 1919, pp. 581, 1920, pp. 363–380, pp. 455–461; Keynes, 1936, pp. 307–308). Hence, our assessment should be able validly to differentiate the sources behind the economic adjustments leading to differences of workforce size of large firms (which is our dependent variable).

The assessment process followed here first focuses on the main sources of scale, then adds additional possible secondary or interrelated features, controlling the complexity of how interrelated factors affect each other. Because total employment of firms is strongly skewed (larger numbers of firms closer to the 1,000 employee size, and smaller numbers of

the largest), log employment is used. Internal capital intensity is measured by the capital–labour ratio, as summarised in Table 2. Because of the different situation of railway, dock and tram operators noted earlier, we separate their capital intensity from the rest of firms (through an interaction estimate). Integration is assessed through a category variable for non-integrated, integrated, and integration that included mining (as Table 3). Urbanisation initially uses a simple division into size categories of the population of the firm's primary location (as Table 5, col 1). Localisation economies are included at a later stage.

Legal form indicates different forms of control, and potential for monopoly by government entities. Sector is used an indicator of different market opportunities and adjustments, and as potential for monopoly/monopsony effects for railway, tramway, dock and gas companies incorporated under parliamentary Acts.

The results for the initial stage of analysis are summarised in Table 6 which reports the *marginal effects* of each covariate, allowing different relative effects to be judged; for the category variables as discrete changes from their base levels. Significance is reported using 2-tailed tests. Model (1) confirms the expectation that internal economies of scale through capital investment are significant for all sectors (except docks where heavy use of casualised labour makes this estimate unreliable and it is marginal). As expected, labour in general declined as capital increased. Simplistically, excluding the other factors, this was for most

Table 6. Estimates of regression model for log total employment, marginal effect coefficients and standard errors.

	(1)		(2)		(3)		(4) Excl Govt	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Census data			0.013	0.049	0.036	0.053		
Incorporation date			0.001	0.003	0.001	0.003		
SE listing			0.171	0.151	0.125	0.145		
Multinational			0.222	0.140	0.188	0.157		
Sectors †			**–0.683	0.245	0.001	0.007		
Capital–labour (base all others # sector)								
All others	*–0.0004	0.0002	**–0.0004	0.0002	*–0.0005	0.0002	*–0.0003	0.0002
Railways	*0.240	0.120	**0.246	0.118	**0.247	0.119	*0.208	0.107
Trams	***–0.303	0.068	***–0.192	0.059	***–0.314	0.065	***–0.298	0.065
Docks	*0.148	0.084	*0.167	0.086	*–0.157	0.086	–0.114	0.071
Legal form (base partnership)								
Private corporation	*0.156	0.085	*0.143	0.074	0.120	0.082	*0.146	0.080
Public corporation	***0.242	0.073	0.629	0.400	0.531	0.387	***0.236	0.077
Government	*1.147	0.561	**1.289	0.571	**1.247	0.581		
Sole proprietor	0.140	0.098	0.110	0.101	0.134	0.101	0.138	0.097
Integration (base specialised)								
Integrated	**0.206	0.093	**0.226	0.090	**0.200	0.093	***0.243	0.086
Integrated with mining	***0.460	0.085	***0.382	0.083	***0.477	0.082	***0.477	0.081
Population size class (base <11,000)								
11–49,999	**0.233	0.087	***0.263	0.085	**0.233	0.088	**0.233	0.088
50–199,999	*0.198	0.104	**0.227	0.092	*0.193	0.101	*0.194	0.104
200,000-1 m	**0.224	0.098	***0.447	0.103	**0.220	0.096	**0.235	0.096
> 1 m	**0.487	0.185	***0.749	0.172	**0.456	0.187	**0.450	0.178
Constant	***7.073	0.096	***6.444	0.602	***6.51	0.582	***7.049	0.094
F(14,26)	***37.57		***69.34		***100.1			
F(19,26)							***37.01	
R-squared	***0.267		***0.308		***0.276		***0.261	

2-Tailed test ***$p \geq 0.001$, **$p \geq 0.01$, *$p \geq 0.05$; $N = 545$, except Model (4) $N = 538$; † Model (2) uses primary sector defined here; Model (3) uses Lee (1979). All with robust least squares estimator using clustered residuals within regions.

sectors at a rate of about 4 workers per £10,000 of capital invested (with large variation between sectors).[15] The coefficient estimates for other sectors are relative to this base. For trams, the coefficient shows labour demand was 30% times lower than the general base, reflecting their capital intensity, economics of compact fixed networks, and cheap labour.[16] Railways (and docks) were the exceptions. They had *decreasing* returns to scale. Both estimates must be treated with caution as docks had high labour but casualised, and railways had wide variance in their activities (and hence underpinning economics) beyond rail transport. But estimates are consistent across alternative specifications, e.g. separating railways that manufactured from other railways. Rail capital investment increased labour requirements reflecting their massive networks and high manpower requirements. This is consistent with Arnold and McCartney (2005) and David's (1969) assessments that, once fairly fully developed as railways were in 1881, there was at best a constant-returns production function, though for users railways gave advantages of significant increasing returns (David, 1969, p. 524). Decreasing returns might also perhaps derive from their large boards and diffuse shareholding leading to weak controls of performance and poor management (Acheson et al., 2016; Crafts et al., 2008). Contemporary lobbies claimed that rail monopolies led to excessive freight rates, and that performance would be improved if some of their goods and parcel carriage, hotels, shipping and other interests were restricted and opened to other operators (Alderman, 1973; Parris, 1965). Such concerns indeed stimulated development of rival railways for Hull and Penarth, both of which also tried to overcome dock monopolies.[17]

Integration was highly significant compared to specialised non-integrated firms, especially if this included mines. It was generally the largest contributor to firm size for non-state industries. Integrated firms were 21% larger than specialist firms, and those integrated with mining 46% larger.[18] The latter may reflect cases highlighted by Hart et al. (1990) where locally scarce resources needed to be controlled to assure supply and control its costs.

Externalities related to location measured by the size of local population in firms' labour markets is significant for all size classes compared to base category of the very smallest places. Each size class from 11,000 to one million population has similar externality effects to each other, giving firms that were about 20% larger than the smallest places. But the biggest difference is for firms that drew on externalities in the very largest places over one million population, where firms were nearly 50% larger than the base. Hence, most locations offered agglomeration economies but there was a marked increase from medium to the largest agglomerations. Effectively this meant the main city-regions: London, Manchester, Birmingham, Glasgow and Liverpool. All the locations with large firms had good rail connections; if localities had lacked rail access these major firms had sponsored or lobbied the railways to provide the links. But only the major agglomerations were highly connected transport hubs.

Legal form produced by far the highest marginal effects. This was chiefly for government entities which offered size benefits over 100% higher than the partnership base; for public corporations and then private corporations the size effect was, respectively, 24% and 15% higher. The size of sole proprietor firms does not differ significantly from partnerships. Hence, government monopoly carried huge benefits compared to all other legal forms and all other sources of size; public corporations were also more favourable to large firms but with marginal benefits comparable with many other sources. This is usually attributed to their wider access to capital, benefits of broader board oversight with perhaps greater openness to innovation (as suggested by Cottrell, 1980; Foreman-Peck & Hannah, 2023). It may also reflect

their greater extent of director and managerial control and professional management (Acheson et al., 2016; Foreman-Peck & Hannah, 2023; Guinnane et al., 2017). Public corporations and government entities also usually had more highly developed management. As noted earlier, legal form and management structure interacted. Hence, there is some evidence to confirm Chandler's (1990) view that greater firm size was supported by more professional managers and hierarchies, though unfortunately we do not yet have the data for all these firms to test this thoroughly.

A second stage of analysis, shown in columns (2) and (3) of Table 6, tests the marginal effects of additional variables. An important finding in this table is that the source of information on these firms is not significant: data derived from non-census sources does not systematically differ from the census. This is true for all alternative model specifications tested throughout this article. This has important implications for further research, indicating that the census can provide a valid sample, though extension to other firm-size classes requires fuller testing of representativeness. Incorporation date and Stock Exchange listing, though positive, are not significant. Multinational operations are also positive but not significant.

Sectors, as defined in Table 3, have low significance; also re-estimating with 17 interacting sector dummies as a robustness test shows little sector variation (reported in the Supplementary Material Appendix 2). This applies also to chemicals and gas, which has relatively high capital intensity and also benefitted from quasi-monopolies (for gas) and potential for cartels (as in salt), they do not differ significantly from the other sectors except at a very marginal level for the equivalent of model 1, and not at all in other estimates. This justifies their exclusion from capital-sector interactions in the rest of the analysis. As expected, the main sector differences are in capital intensity for rail, trams and docks, which are already controlled. The use of Lee's (1979, Appendix C) sectors does not differentiate well between the specific sectors in the population of large firms; it is expected to be less sensitive and it is insignificant. Table 6 reports inclusion of these variables together. Each was also tested separately, with almost identical results. Indeed a range of other tests for including variables with alternative definitions gives almost identical results, including alternative interactions for capital–labour intensity including gas and chemicals, separated rail manufacturers, and workforce percent manufacturing and non-manufacturing. Hence, the basic estimates are very robust to alternatives. Exclusion of government entities tested in model (4) makes little difference to the marginal effects. These findings also apply to robustness tests of all subsequent tables.

A third stage of analysis addresses the inherent estimation challenge deriving from endogeneity as a result of the factors overlapping with each other in a given location. Large firms shared the same externalities in the same or similar locations. The effects of locational clustering (such as a large proportion of the sample in a few city regions: see Table 4) have been largely controlled in Table 6 by robust estimation allowing correlation of errors within clusters, but independent between them. A preferred approach is an instrumental variable (IV) estimator that controls for the endogenous effects of local factors. Unfortunately, there are few variables available that are truly endogenous instruments. One possible solution is physical geographical features that remain at least quasi-constant and are independent of firm size and other variables. Sometimes presence of railways or geology is used in this way (e.g. Glaeser et al., 2015). However, all large-firm locations were connected to rail at this time, and mining geology is endogenous to many firms. Port status offers one potential: it is highly correlated with local population and uncorrelated with workforce size.[19] Alternatives of using

port volumes of trade, shipping tonnage, and similar measures are strongly correlated with location size and hence invalid instruments.

The results of IV estimation with population size class instrumented by port status are shown in Table 7.[20] The results (5) are consistent with those in Table 6 for all aspects, but as expected from controlling for endogeneity, the significance is generally strengthened, particularly for capital intensity and legal form. The instrumentation allows inclusion of the firm's workforce as a percentage of the local population in (6) and (7). This separates *local monopoly* effects from *agglomeration* economies. The firm's workforce percentage is significant, both including and excluding government, indicating that potential monopsony occurred in both the private and public sectors. Though the effect is possibly higher for government, as the coefficient is higher in (6) than (7), given the fuzzy nature of the data, not too much should be drawn from this.

Localisation economies are investigated in Table 8, again with the port instrument controlling endogeneity. Measures of sectoral specialisation of places that might give localisation advantages (of an attuned skilled labour market and subcontractors) were introduced through a range of indicators: the number of local sectors or local firms, local sectors per local firm, and a code combining number of firms and number of sectors. Including most of these variables together with the local workforce percentage produces a level of collinearity and unstable estimates, confirming they often measure similar things. Indeed Marshall often treated agglomeration and localisation jointly. The exception is the firm-sector code reported in Table 9. This is consistent with previous estimates above, and when government is included (8) or not (9). However, the sector-firm code shows only one localisation effect significant – locations with one sector and more than one firm. These increased employment size by 26–30% compared to diversified locations. These had the purest form of localisation economies, where a single sector of several large employers dominated the locality. As noted earlier, such localities included major towns/cities like Dundee, Preston and Halifax, and also Sheffield if cutlery is viewed as part of iron and steel. Each of these had four of more firms

Table 7. IV estimates of marginal effects including agglomeration economies.

	(5)		(6)		(7) Excl Govt	
	Coeff	SE	Coeff	SE	Coeff	SE
Population size class/ Port instrument	**0.167	0.071	**0.275	0.109	**0.232	0.108
Local workforce %			**0.003	0.001	**0.002	0.001
Capital–labour (base all others # sector)						
All others	**–0.0004	0.0002	**–0. 0004	0. 0002	*–0.0003	0.0002
Railways	***0.241	0.077	***0.239	0. 076	***0.208	0.069
Trams	***–0.312	0.108	***–0.344	0.113	***–0.329	0.106
Docks	*0.140	0.075	*0.144	0.074	*0.112	0.066
Legal form (base partnership)						
Private corporation	*0.142	0.074	*0.135	0.074	*0.129	0.072
Public corporation	***0.224	0.071	***0.213	0.071	***0.213	0.071
Government	**1.096	0.556	*1.055	0.543		
Sole proprietor	0.136	0.111	0.097	0.120	0.103	0.118
Integration (base specialised)						
Integrated	***0.182	0.068	***0.189	0.067	***0.230	0.064
Integrated with mining	***0.462	0.076	***0.411	0.077	***0.434	0.077
Constant	***6.736	0.249	***6.278	0.408	***6.415	0.403
Wald Chi Sq	***113.57		***119.66		***120.14	
R-squared	***0.243		***0.261		***0.264	

$N = 545$, except Model (7) $N = 538$; other definitions as Table 6.

in one sector. There were also 11 other places with two or three firms in one sector. It is important to note that this localisation was not unique to specific sectors since 6 different sectors were involved, though all were manufacturing and two-thirds were textiles in Lancashire and the West Riding. Even with low significance, this form of localisation is distinct from monopoly/monopsony in localities with very high proportions of the population working in a single firm (measured by local workforce percentage), and also distinct from agglomeration economies measured solely by the local population size.

An alternative way to assess relative sources of economies of scale is made in Table 9. This examines the spread of the sample's variance, whereas the previous tables look at the marginal effect of each covariate. There is very wide variance among the 545 large firms, with

Table 8. IV estimates of marginal effects with agglomeration and localisation economies.

	(8) Incl Govt		(9) Excl Govt	
	Coeff	SE	Coeff	SE
Population size class/Port instrument	**0.357	0.148	**0.300	0.147
Local workforce %	***0.003	0.001	**0.002	0.001
Sector-firm code (base ≥3 sectors & firms)				
1 sector and 1 firm	0.091	0.183	0.037	0.181
1 sector and >1 firm	**0.309	0.144	*0.260	0.144
2 sectors and 2 firms	0.139	0.299	0.076	0.271
2 sectors and > 2 firms	0.223	0.137	0.178	0.137
Capital–labour (base all others # sector)				
All others	** −0.0004	0.0002	*−0.0003	0.0002
Railways	***0.242	0.076	***0.211	0.069
Trams	***−0.351	0.113	***−0.337	0.106
Docks	**0.148	0.075	*0.115	0.067
Legal form (base partnership)				
Private corporation	**0.156	0.077	**0.147	0.074
Public corporation	***0.195	0.074	***0.198	0.073
Government	**1.048	0.535		
Sole proprietor	0.084	0.124	0.091	0.121
Integration (base specialised)				
Integrated	***0.185	0.066	***0.223	0.064
Integrated with mining	***0.349	0.089	***0.380	0.088
Constant	***5.914	0.58	***6.115	0.579
Wald Chi Sq	***122.84		***124.49	
R-squared	***0.253		***0.261	

$N = 545$, except Model (9) $N = 538$; other definitions as Table 6.

Table 9. ANOVA of main variables used in model (8).

Source	Partial SS	df	Mean SS	*F*	Probability
Model	164.4	24	6.85	9.38	***0.000
Agglomeration: Population size class # Port status	31.5	9	3.50	4.8	***0.000
Monopsony: Local workforce %	16.8	1	16.81	23.04	***0.000
Localisation: Sector-firm code	1.2	4	0.30	0.42	0.7933
Capital–labour # rail, tram, dock, rest	33.1	4	8.26	11.32	***0.000
Legal form	24.3	4	6.07	8.32	***0.000
Integration	24.9	2	12.45	17.06	***0.000
Residual	379.6	520	0.73		
Total	544.0	544	0.73		

Data are standardised to give comparable sum of squares (SS) estimates between variables. N of observations 545; $R^2 = 0.302$; Root mean square error 0.854; Adjusted $R^2 = 0.270$.

each tuned to its markets and local factor conditions. The table uses analysis of variance (ANOVA) to partition the total variance between main sources. The method is essentially the same as previous estimates but presents them differently as aggregates. Externalities are additionally labelled with their interpretative terminology. In proportion of variance explained for *most* firms the rank order is the same as previous tables: integration, internal capital intensity, legal form, and agglomeration (localisation is not significant). However, across the data, the proportion a firm employs of the local labour force, indicating local monopsony, has by far the largest source of variance (mean SS). This is because it explains the variances at the extremes, as a feature primarily of firms in the smallest local labour markets. Small places were the most numerous primary locations for firms in 1881: nearly half of locations had under 50,000 population, and nearly a quarter had under 11,000. They are the main source of wide variance of size between large firms in different circumstances (Table 5). They are the main element in the wide variance of size between firms in different circumstances. Given the inevitable uncertainties of how a primary location is defined this should not be over-interpreted, and these large firms sold into markets beyond their immediate locality, most nationally or internationally. Nevertheless, local monopsony was clearly of significance and helps to explain how small places mainly with a single large firm continued as a major feature of late Victorian Britain.

To complement these analyses the Supplementary Material Appendix 3 reports the extreme outliers by adding a dummy variable for each primary location to the previous models. Seven primary localities differ positively and 17 negatively at $p \geq 0.01$. These include only 28 firms (5%), 4 places with 2 firms, 20 with one, all in manufacturing. Almost all have small or very small populations. The assessment is fuzzy and sometimes inconsistent, as to be expected from estimation for unique data points, and experiences of firms varied widely. However, it is clear that several of the firms in the smallest locations succeeded well into the twentieth century, and some were outstanding firms in 'unusual' locations such as Huntley and Palmer in Reading or 'traditional' locations such as Gurteens in Haverhill. They succeeded by different strategies of innovation, integration and foreign expansion. If they exercised monopsony it seems to have been to ensure success in challenged locations. In contrast, for struggling firms, smallness of locations and limited externalities were rarely primary; more important for their decline was lack of innovation, failure to respond adequately to competitors, distraction by political activities or building estates, and the inevitable cycle of mineral depletion where dependent on mining and processing.

Finally, it is important to note that a significant level of variance among firms remains unexplained, although this is similar to many other related research analyses. All the models have disappointingly low R^2; the highest is 0.31. Similarly, the ANOVA explains only 30% of the variance. The main reasons for disappointing explained variance are seven fold. First, the data have very high variance. Second, the variance is heteroscedastic and there are many extreme outliers which are a big limitation on high R^2 and cannot be fully controlled even by the generalised method of moments used for IV estimation. Even the estimate with 101 locational dummies, used in Table A.2, has an R^2 of only 0.44. Third, some of the data are very noisy and may contain errors or other distortions resulting from the inconsistent reporting and unsatisfactory questions in the census, the variable ways in which other sources of data are derived, difficulties of controlling for part-time and out-workers, potential errors in how British and foreign workforces are attributed, perhaps some effects of seasonality on derived data, and lack of standardised reporting of capital, depreciation, partly paid shares and

undistributed profits, etc. Fourth, sector definitions are generalised and cannot embrace all firm variances by type of activity, with many firms having multi-sector spreads. Fifth, there are effects of endogeneity which cannot be fully controlled in the estimation or interpretation – such as from place-based variables, legal form, and monopoly. Sixth, major improvements may be possible by replacing the many categorical variables by more complex measures. Seventh, but perhaps foremost, agency, personality and individual entrepreneurial characteristics which usually explain a lot of the variance in modern entrepreneurship are not measureable in our historic data. Our analysis of outliers demonstrates the importance of examining individual performances suggesting that the characteristics of the entrepreneurs and managers, and the management structure, are perhaps the most important variable currently excluded.

5. Conclusion

The key aim of the article is to assess the relative weight of different sources that contributed to the scale of large firms. It has examined both relative marginal effects and proportion of variance explained for the 545 largest firms in Britain in 1881. Despite uncertainties in the data, the analysis shows that, generally, integration and capital intensity were the largest sources of scale. *Integration* was generally the most important and widely used, both by manufacturers and non-manufacturers, raising employment by 21% on average and 46% for integration with mining. *Internal capital intensity* reduced labour requirement for the majority of firms by about 4 workers per £10,000 capital; the network benefits of trams reduced this 30% further. But large capital investment in this period usually also required high labour inputs so that highly capital intensive firms were nevertheless large employers. At the extreme, railways generally did not gain economies from capital intensity: instead their labour increased more rapidly than their capital with size, by about 24% on average, indicating that claims of inefficiency of their monopolies and management had some truth. This was also true for docks where capital increased labour by 15%, but significance is low and casualisation and decentralisation of most of their workforce makes these estimates uncertain.

The article gives a lot of attention to place-based sources of externalities. *Agglomeration* externalities had the greatest marginal effect on firm size, measured here by local population size classes, confirming that large cities and city regions increased scope for meeting business needs with greater collective sharing of infrastructure, communications and local markets. They were an important part of the economy: 200,000+ population centres employed three-quarters, and the one-million centres 44% of the large firms' workforces. More detailed analysis of 'outlier' places that differed significantly from the general pattern showed varied experiences. There were outstanding firms in 'unusual' locations such as Huntley and Palmer in Reading or in some very small places like Gurteens in Haverhill that succeeded by different strategies of innovation, integration and foreign expansion. But many of the firms in smaller places struggled in the years following 1881, especially if they failed to innovate, responded inadequately to competitors, or depended on minerals that became depleted.

Local monopsony, measured here by firms employing large proportions of the local population, was also important. As measured by proportion of variance explained it had major association with firm size because in occurred in a large number of smaller places (nearly

half of all large-firm locations). Monopsony did reduce wage rates in some cases, but also seems to have given confidence to some firms to continue investing and increase workforces. Local monopoly could reduce risks if used effectively and not merely for extraction of rents. For this and other reasons small places could still thrive in 1881, even though they offered no agglomeration benefits. However, these firms became increasingly challenged in subsequent years suggesting that continued investment in small places reduced adaptability and resilience of some of these firms in the longer term. This may have had some impact on the economy as a whole, but the main weight of large firms was in the major agglomerations so that locational fixedness contributed little to any subsequent declines in the relative competitiveness of the British economy.

Generally *sectoral localisation* was insignificant, but for the localities with more than one firm in one sector there were, as Marshall observed, potentially large effects: an increase of 26–30% in workforce compared to more diversified localities. Indeed it is likely that Marshall framed his theory from specific observation in such places as highlighted here (Halifax, Burnley, and Preston, as well as the nine other places that had single-sector concentration).

We have also investigated a number of other sources of scale. Of these, only *legal form* is of major importance. Although there are limitations on estimation arising from possible endogeneity effects of legal form, it is clear that government monopolies increased marginal firm size by over 100% compared to partnerships. More generally public corporations and less strongly private corporations increased marginal firm size by 16–19%. When government entities are excluded the marginal effects are similar demonstrating the general robustness of the estimation process. Legal form per se may be less important to these effects than the larger development of professional management in government and public corporations; this merits further investigation. Tests on multinational activities and sector differences (other than those controlled by the capital–labour ratio) were not generally of significance, and for public corporations neither was Stock Exchange listing nor incorporation date. The tests of robustness reinforce the confidence that can be placed on the conclusions drawn, even though the level of significance and variance explained is relatively low. Further progress might be made by developing case studies of more of the outlier firms to explore the effects of different management structures, and the agency, personality and individual entrepreneurial characteristics which are not available at scale in the database that has been assembled.

Space limits this article to 1881, but applying the techniques exemplified here could facilitate comparable estimates using the census and other sources back to 1851 and open opportunities to understand dynamics. With the reassurance here that census and other sources do not differ in the relationships assessed, this could even be done using the census as a sampling base. This would also justify extending the analysis to small- and medium-sized enterprises on a sampling basis which would allow valuable contributions to understanding market share and better analysis of monopoly effects. Looking forwards to track the future evolution of individual firms through secondary sources introduced at the end of the article illustrates how the 1881 data can be used to develop a base for comparisons into the twentieth century. Hence, the database and this article should facilitate further research and contribute a benchmark for a year that was at an important stage in Britain's economic evolution and help resolve questions about the roots of its future relative decline.

Notes

1. In this process some of the Hannah data is supplemented or adjusted to fully cover non-manufacturing so that the data in the Supplementary Material Appendix 4 in this article differ for some firms.
2. Independent mining firms are excluded at this stage of the research because of the challenges of assembling reliable data for 1881 (before they are fully reported in official papers). However, all mining companies that were integrated with manufacturing, services and distribution are included. This allows scale economies to be assessed for all sectors except *within* mining.
3. The manufacturing total differs from Hannah's 438 because it covers Britain and not UK, and some of these firms were primarily non-manufacturers. Full listing of individual firms in Appendix 4.
4. Bennett et al. (2021) estimate 527 firms of 1,000 or more employees in Britain in 1881, including firms solely in mining, but with no attempt to compensate for non-response from corporations.
5. Capital information is derived as far as possible from published accounts and reports covered in *Burdett's Official Intelligence* (1882) and *Investors' Monthly Manual* (April 1881); otherwise from newspapers, business histories and for gas, railways, docks and tramways from Parliamentary Reports.
6. For capital data for manufacturers see Hannah and Bennett (2022, pp. 842–843). Partnerships and sole traders only occasionally reported invested capital, which was often informal from family and other networks, and frequently depended heavily on retentions as firms grew. Where subsequently incorporated this usually provided an accumulated capital figure, and changes of partnership sometimes reported buy-out proportions from other partners. However, published capital data was found for only 327 (60%) of firms, 65% in manufacturing and 46% in non-manufacturing); the rest are estimated. Manufacturing estimates are based on log employment, incorporation date, industry, region, non-manufacturing employees, organisational form and LSE-listing: Hannah and Bennett (2022, n. 58, Appendix 4). Non-manufacturing capital for shippers estimated from adjusted shipping tonnage combined with rescaled Hannah estimates for shipbuilding etc.; construction, carriers and distribution were estimated from adjusting and rescaling comparable peers; the Prudential uses the value of its Industry and ordinary assurance funds; the Post Office uses Pollard and Feinstein (1988, Table 5.18), adjusted to Britain from UK and to 1881 prices, and includes additional site/premises and erection costs, pillar boxes, furniture, fittings and other expenditures comparable to other firms that Feinstein excluded in his property assets valuation.
7. Pollard and Feinstein (1988); a calculation drawn from Hannah and Bennett (2022 n. 62).
8. One tramway company also operated a major omnibus service (the Glasgow Tramway and Omnibus Company). London General Omnibus Company only had buses, but it had almost the same capital–labour ratio as tramways so appears to be governed by similar economics: it had no rail investment, but required larger horse teams to move the same load (Brash 1971; Day, 1973).
9. Bertram (1877, p. 300).
10. Turner (1992); *Mineral Statistics*, 1881.
11. The regions used in the analysis are the economic planning regions, as defined by Lee (1979, Appendix A).
12. Even together they had a small number of large firms which accords with previous historiography, with the West Midlands interpreted as having smaller firms compared to Lancashire and Yorkshire (Smith et al. 2020).
13. Recognised by Marshall (1920, p. 477–499), Bresnahan and Reiss (1991), Campbell and Hopenhayn (2005). This is distinct from cartels that existed in some industries but were generally short-lived, most notably in salt manufacture. Robinson (1933) coined the term monopsony for a dominant single firm in buying relationships.
14. *Bury & Norwich Post* 18.4.1882; Payne, 1988.
15. exp (0.459).

16. The estimates from interacting sectors with the capital labour ratios were tested against separate sector and C/L ratios. The results are similar but unstable for other variables, reflecting the reduced degrees of freedom, wide variance of capital levels shown in Table 3, and uncertainties about contemporary capital measurement.
17. Hull, Barnsley and West Riding Junction Railway and Dock; and Penarth Harbour, Dock and Railway (linked to the Taff Valley Railway).
18. excluding all other factors: 100 (exp (coeff) – 1).
19. It is also measured without error, critical to binary instruments which otherwise inflate estimates.
20. The IV estimation uses the generalized method of moments which is less demanding on assumptions than 2STS and robust to heteroscedasticity in the residuals. Tests of additional variables, as in Table 6 (2) and (3), are all insignificant, again confirming no differences between census and non-census sources.

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