The Internalisation of Locomotive Building by Britain's Railway Companies during the Nineteenth Century

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> Locomotives do not concern me in the slightest, but from the shareholder's point of view I am certain the moment a railway company becomes a manufacturer it plunges into a business which it cannot possibly conduct as economically as the specialist manufacturers of its different requirements.
>
> - "Manufacturer" [*The Times Engineering Supplement,* 1905, p. 324]

By the early 1870s the majority of Britain's larger railway companies were building locomotives in their own workshops, only occasionally turning to external suppliers. Such a policy stands in stark contrast to that followed by foreign lines, with the exception of the Pennsylvania Railroad which met much of its own locomotive requirements internally from 1875 [Brown, 1995, p. 30; Simmons, 1991, p. 73; White, 1997, p. 19; Channon, 1998]. The internalisation policies of Britain's railway companies attracted considerable debate, and private builders, aside from the loss of business, failed to believe that the reasons behind the decision to self-build were legitimate. This proved to be a source of discontent well into the twentieth-century.

Contemporary challenges to the internalisation policy were based on claims that railway companies would gain a superior product by relying on outside specialist firms, due to their broader knowledge of railway and mechanical engineering. It was also claimed that contractors could produce cheaper locomotives, even after accounting for their profit, due to economies of scale. Once railway companies had internalised locomotive production to a significant extent, a different type of argument, focusing more on the implications of such policies, was advanced. In evidence submitted by the private builders' trade association in 1925 to the Balfour Committee on Industry and Trade, it was claimed that internalisation was a "fundamental handicap" to private industry, and that "it would be difficult to find a parallel to these conditions in any

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Table 1: *Estimates of Internalisation of Locomotive Building by Britain's Railway Companies*

Railway Company	Number of Locomotives		Scale of Internalisation
	1872	1900	
London & North Western	2,004	2,984	internal from 1871
Great Western	1,009	1,988	internal from 1866
North Eastern	1,017	2,121	largely internal
Midland	984	2,615	many external
Great Northern	919	1,315	largely internal
Caledonian	587	902	internal and external
Lancashire & Yorkshire	566	1,360	largely internal
Great Eastern	442	1,041	largely internal
North British	417	801	from 1870s 40% external
London & South Western	299	733	largely internal
South Eastern	243	697	largely internal
London, Brighton & S. Coast	233	489	largely internal
Manchester,Sheffield & Lincolnshire	207	848	evenly internal and external
London, Chatham & Dover	114		
North Staffordshire	103	161	largely internal from 1870
Total listed	9,242	18,055	
Total British locomotive stock	10,435	20,385	
% listed	88.6	88.6	

Sources: BPP, 1873; BPP, 1901; Lowe, 1975; Simmons, 1991, p. 74
Notes: Only those companies with more than 100 locomotives in 1872 are listed. `Largely internal' is intended to imply that these companies built the vast majority themselves, but occasionally ordered from outside firms. The Manchester, Sheffield & Lincolnshire Railway became the Great Central Railway. The South Eastern and the London, Chatham & Dover merged to create the South Eastern and Chatham Railway in 1899.

Table 2: *Suppliers of Locomotives for Railways in Scotland*

Period	Internal	External	Total
	No.	No.	
Pre 1840	1	25	26
1840-44	0	65	65
1845-49	29	163	292
1850-54	34	84	118
1855-59	118	108	226
1860-64	80	230	310
1865-69	105	257	366
1870-74	264	255	519
1875-79	219	212	431
1880-84	276	126	402
1885-89	383	30	413
1890-94	362	114	476
1895-99	555	90	645

Source: Vamplew, 1972, p. 326.

other country ... and it is impossible to avoid the conclusion that they constitute grave disadvantages when viewed from a national standpoint" [Committee on Industry and Trade, 1927, p. 927]. These sentiments echo those of Alfred Marshall, who wrote that "it is possible that British locomotives might have nearly the same commanding position in the world as is possessed by her ship and marine engines, if British railway companies adhered more closely to the general practice of British shipowners in buying their ships" [Marshall, 1927, p. 323]. Similar expressions of frustration at the paucity of the home market had been commonplace since the 1870s, and private builders became dependent upon overseas markets [Saul 1967, p. 117; Saul 1968, p. 199].

Explanations as to why railway companies in Britain internalised locomotive construction have been varied. At the time, the inability of private manufacturers to meet the demands of a swiftly expanding railway network was seen as the primary cause. In order to avoid delays and ensure quality, railway companies were forced to build locomotives themselves, thereby also escaping the price increases imposed by the private manufacturers in times of heavy demand. Having embarked upon internal building, the railway companies consistently maintained that it was more economic to build than to buy. While these reasons for internalisation are the most probable, there are other potential factors that emerge when the growth of railway companies is considered. Large engineering works were constructed in order to maintain their increasing numbers of locomotives, and in times of under-utilisation, these may have provided the opportunity to build new locomotives.

Attempts have been made to analyse some of these reasons for internalisation, though often parenthetically [Drummond, 1995, p. 45; Kirby 1988, pp. 290-292; Kirby, 1991, pp. 36-37; Simmons, 1991, pp. 73-74; Vamplew, 1972, pp. 329, 335-338]. It is not the intention here to propose a single alternative explanation, rather to add substance to those suggested previously and to frame some of the discussion in the context of recent work on information asymmetries and the boundaries of the firm [Raff and Temin, 1991; Lamoreaux and Raff, 1995; Lamoreaux, Raff and Temin, 1997]. The following seeks to measure the scale of internalisation, and to examine, with reference to the issues outlines above, how it might be explained. Motives for self-building are considered in three sections. Firstly, attention is given to the uncertainties over supply relating to quality and timing. The subsequent section assesses whether the ability to monitor the manufacturing process, thereby eliminating the problem of information asymmetry, played a role in the decision to internalise. Finally, the issue of cost is debated, and its eventual centrality in the decision by railway companies to continue to self-build is confirmed.

The Scale of Internalisation

Previous discussions of the logic of internalisation have failed conspicuously to ascertain the extent of the problem. In part this may be due to the difficulty in obtaining a reliable data series on the building of locomotives, a prob-

lem compounded by frequent mergers and the absorption of smaller railway lines into larger companies. Reliance has been placed on the validity of general statements suggesting that all the larger lines built for themselves. This impression is reinforced by studies of the great railway towns, especially Crewe, of the London and North Western Railway, and Swindon, of the Great Western Railway [Drummond, 1987, p. 1; Drummond, 1995, ch. 2]. There is an implicit, but untested, assumption that they are representative of all railway companies.

Table 1 estimates the extent of internalisation in the latter portion of the nineteenth century. The results are impressionistic, as they are derived mainly from qualitative sources, but clear support emerges for the received view that internalisation was the predominant policy. The experience of the North Eastern Railway is representative; they built internally when they could, and relied upon contractors as a reserve source when necessary. Due to increasing traffic and lack of engineering capacity the North Eastern bought 364 locomotives from outside suppliers between 1869 and 1876. A similar situation emerged between 1908 to 1911, when 70 were bought [Irving, 1976, p. 108]. A more complete quantitative view is available for railways in Scotland (Table 2). As might be expected, locomotives supplied by outside engineering firms dominated for the early phase of railway development, with a stronger, though by no means complete movement to internalisation, apparent from the 1870s [Vamplew, 1972, pp. 329-330].

Those companies described in Table 1 account for nearly 90 percent of the locomotive stock of Britain's railways, leaving few potential orders for private industry, even if none of the other companies internalised. Even the smallest company on the table, the North Staffordshire, built 197 locomotives between 1868 and 1923, though in addition others were built by outside firms [Lowe, 1975, pp. 533-537]. Most of the smaller companies that are missing from the table ordered locomotives from the private locomotive engineers, though this did not preclude some limited internalisation. The Taff Vale Railway for example built eighty-four locomotives by 1923, it having 198 in stock in 1900 [Lowe, 1975, p. 629; BPP, 1901], and the Highland Railway built forty-one locomotives between 1869 and 1906, its total stock being 145 in 1900 [Lowe, 1975, pp. 331-334; BPP, 1901]. From the 1840s, railway companies had been building locomotives for themselves, but not necessarily in isolation from outside orders. However, from late 1860s internalisation was the dominant policy followed.

Demand, Risk and Product Diversity

With rapid expansion during the 1830s and 1840s in route mileage and traffic carried, the demand for locomotives was tremendous, and was exacerbated further by the increasing demand from abroad. The engineering firms supplying railway companies with locomotives and rolling stock had difficulty in meeting demand. Either orders were not taken, or delivery times became increasingly long [BPP, 1839, p. 290]. A deputation from the London and

Brighton Railway (later the London, Brighton and South Coast Railway) touring northern engineering towns in 1838 even found difficulty in securing delivery in eighteen months [PRO RAIL 386/45]. These delivery lags continued into the 1840s. In the summer of 1845 an offer of an order for twenty-one locomotives brought response from only six firms, "it appearing that other engine makers better known were so engaged as to be unable to deliver engines for the year 1847" [PRO RAIL 386/22]. "Under these circumstances," wrote Lardner, "the railway companies saw themselves reduced to the alternative, either of suspending their progress, or of fabricating for themselves" [Lardner, 1855, p. 108]. An alternative solution was found by the Birmingham and Gloucester Railway, who bought locomotives from Norris of Philadelphia [Hunt, 1997]. Buying locomotives from abroad at times of high demand in Britain was not confined to this period. During the surge in orders during the late 1890s, locomotives were also bought from the USA, as were other items of machinery [Hunt, 1997; Nicholas, 1980, pp. 571-2, 585; Saul, 1960, p. 20].

The argument that industry was unable to meet the demand appears secure, though it has also been suggested that firms were unwilling to tender for large batch orders [Kirby, 1988, p. 290]. An alternative interpretation might be that given the evolving technology, and the inevitable spawning of new firms, it is possible that railway companies were also pursuing an active risk avoidance strategy. Indeed, there is no solid evidence that locomotive firms actually were refusing larger batch orders. There is, however, evidence of railways spreading their orders, for whatever reason. For example, in the summer of 1836, the London and Birmingham Railway placed orders, each for six locomotives, with R & W Hawthorn, Mather Dixon & Co., Benjamin Hick, Peter Rothwell and Edward Bury. Each locomotive cost £1,120 [PRO RAIL 384/265-9].

Whether through risk avoidance, through necessity for speedy delivery, or because of denial by private builders of large orders, railway companies undoubtedly were faced in the early 1840s with locomotives (and other rolling stock) of a plethora of designs, from many manufacturers, and of varying quality and performance. In 1841 there were 837 locomotives on Britain's railways, an average of 21.5 per railway (the median being 13). These had been built by fifty different engineering firms. There were only 4.5 locomotives on each railway from the same builder (the median being 5), and it is unlikely that even these were all of exactly the same design [BPP, 1842, pp. 189-225]. This diversity in conjunction with maintaining different, even unique, engines may well have been a strong motive for internalisation. Problems with maintenance and obtaining replacement parts provided additional impetus.

Information Asymmetry and Company Capabilities

Many of the reasons suggested for internalisation may be summarised as those of contractual difficulty associated with information asymmetries, moral hazard, opportunism and bounded rationality. In particular, problems over the quality of material and workmanship, delays in delivery, and flawed or poor

design, all may be regarded as the result of contractual ambiguity between a principal (the railway company) and an agent (the private engineering firm).

Certainly, railways found themselves with unreliable locomotives due to poor quality construction by external suppliers [Kirby, 1988, p. 291; Kirby, 1993, ch. 4; PRO RAIL 635/296]. Some of these problems were associated with a design that either was flawed because of poor engineering knowledge, or because experimentation had triumphed over proven design. Resolution of these problems only was possible once design had moved away from experimentation and towards adaptation and evolution, and once there was not such a pronounced asymmetry of information in favour of the contractor. That is to say, when the railway companies had developed expert knowledge in the field, they were more able to assess the quality of those locomotives built for them. Under these conditions the railway could, in addition, demand certain design characteristics and materials, but even this did not ensure the quality of the finished locomotive, as there would be uncertainty over the agents' actions during construction.

Problems with the quality of the finished product led companies to increase the level of monitoring of the contract.[1] This constituted demands for frequent progress reports on the stages of construction, or railway company engineers going to the contractor's works. These were largely ad hoc monitoring solutions that were resorted to where necessary, but they evolved into a more formal monitoring system. Contracts began to include clauses that allowed railway companies to inspect all the work and materials whenever they liked, as well as having the power to reject any work or materials that were inferior or imperfect.

In an attempt to navigate the risk of moral hazard, railway companies instituted a guarantee system. As early as 1836, the London and Birmingham Railway made the following stipulation to a builder of its locomotives: "each engine to be guaranteed to run one thousand miles in a time not exceeding 14 days from the day on which placed on the railway in working order without any repairs or alterations whatever..." [PRO RAIL 384/268]. Final payments would only be given after this trial period. It was also typical practice to specify that sub-contracting was forbidden, and that there would be some financial penalty for late delivery.

These attempts at monitoring contracts evolved during the century as the locomotive itself became more complex, as design could be more closely specified, and as railway companies became more knowledgeable of the engineering involved and of the contractors. By the 1890s the contract documents were substantial legal and technical documents. Running to fifty pages or more, they

[1] Information on the contractual relationship between railway companies and the locomotive engineering firms presented here is impressionistic. An attempt has been made to synthesise information on the contracting process from the records of numerous railway companies in the Public Record Office. Particularly good sets of contracts may be found for the London, Brighton and South Coast Railway [RAIL 414], the South Eastern and Chatham Railway [RAIL 633].

included an initial hand-written legal agreement for delivery, price and the terms and conditions, followed by a printed technical specification document. The monitoring ability had been increased, so railway companies not only could inspect construction and test all materials, but also had to approve all materials. Furthermore, great detail was given on the sources of materials. Often just one or two suppliers were given for a particular material or component, and, to reduce further the level of monitoring and to avoid the risk of opportunism by the contractors, all materials were to be identified with the maker's name wherever possible.

A question remains over the authorship of the specification. The assumption is that railway companies wrote the contracts, though modern contracting practice might suggest otherwise. Specifically, it is unclear as to whether suppliers of materials and components were dictated by the railway companies or by the contractors, who presumably preferred certain suppliers above others. There is no clear indication that the outside firms were authoring the contracts, but this does not discount the possibility. Given the dominance of railway locomotive superintendents, one might presume that they would not deign anyone else to specify their engines. There is also evidence that railway companies circulated detailed specifications as part of the tendering process, before a decision was taken on who would win the order.

As the engineering works of railway companies undertook, and became more adept at, maintenance and heavy repairs, the knowledge of external locomotive engineering firms was no longer unique. Constructing a new locomotive came within the capability of a railway company [Kirby, 1988, p. 291; Kirby, 1991, p.36; Vamplew, 1972, p. 329], who had the advantage over external suppliers in knowing the operational characteristics of particular designs. Understandably, railway companies took advantage of this information asymmetry in its favour, and moved towards internal production [Simmons, 1991, p. 73]. Moreover, it would have been inefficient for a heavy engineering works capable of maintaining a large fleet of locomotives to be idle or under-used at any time. The building of engines during these slack times would ensure full utilisation of the capital invested, and would maintain the skilled workforce. As elegant a solution as this might appear, if the experience of the Eastern Counties Railway is representative, there was always a backlog in repairs [PRO RAIL 186/106], which would only have been exacerbated by the building of new locomotives.

Controversy over Costs

There are two issues relating to the cost of locomotive production. Prices rose when the demand for locomotives was at a height, which might have been persuasive in the argument for internalisation. Certainly, prices increased dramatically during the railway manias. The Great Western Railway reported to a Parliamentary Committee in 1839 that locomotive costs were "more than we anticipated," while the London and Croydon Railway indicated that costs had

increased recently by 42% [BPP, 1839, p. 854, p. 1452]. By contrast, the Newcastle and Carlisle Railway considered that the simple reason for escalation in price was the increase in the size of locomotives [BPP, 1839, p. 3837]. The experiences of price rises, whether due to technology or demand, may indeed have encouraged some lines to consider internalisation.

Secondly, and more critically, there emerged a belief by railway companies that they could build the same product as external suppliers but at a lower cost, justifying, for them, the impulse to self-build. However, from the 1860s onwards private industrialists challenged the validity of the claims [Vamplew, 1972, pp. 335-336]. Although commenting on practice in the USA, John Converse of the Baldwin works was adamant that "it is absolutely impossible for any railroad company to build its locomotives as cheaply as can be done in a works devoted exclusively to that special industry" [U.S. Congress, 1901, p. 231]. Despite this, claims in Britain of a 30-40% cost advantage to railway companies persisted. Representing the private firms, the Locomotive Manufacturers' Association (LMA) had long argued: "that such percentages are a self evident absurdity is patent to anyone with even an elementary knowledge of commercial manufacture" [Committee on Industry and Trade II, 1927, p. 928]. These percentages may reflect in part deliberate exaggeration by the LMA for rhetorical purposes; a representative of the railway companies suggested that they could only build at 15-20% less than private industry [Committee on Industry and Trade III, 1927, p. 1309].

Subsequent historical analysis tends to concur that the cost advantage lay with the railway companies, though this is often accompanied by substantial caveats [Simmons and Biddle, 1997, pp. 275-276; Kirby, 1991, p. 36]. The key problems identified by contemporaries and those later, are of accurate cost accounting and of due consideration for overhead costs. On these issues there is confusion. According to Kirby, the North Eastern Railway made an allowance of 15% on total wages per engine, and the Great Western Railway made an allowance of 12% [Kirby, 1991, p. 36]. However, closer examination of the records indicates that these are underestimates. The North Eastern Railway allowed nearer 75% [PRO RAIL 527/1397; Irving, 1976, p. 109] and the Great Western Railway, which, while having a 12% allowance for "Rents, taxes on foundry, interest on capital outlay for land, works and equipment," also allowed a further 60% of wages for factory expenses [PRO RAIL 254/19]. These revised rates are comparable with those used by the private manufacturers, and possibly are even higher [Irving, 1976, p. 109; Heap, 1992, p. 31].

Assuming that allowances and cost accounting were accurate, or no less accurate than private manufacturers, how did prices compare? In resolving this question more difficulties are confronted over comparison of like with like, a task that is possible only rarely, as construction of the same product at the same date would be required. Cost per ton may be a suitable proxy, though even here this is not ideal, as presumably there were economies of scale in building the larger locomotives. Nevertheless, the cost per ton proxy will have to suffice. Using this, it is clear that there was considerable fluctuation in price from firm

Table 3: *Comparative Prices of Goods Locomotives for the North Eastern Railway, 1872-1876*

	Firm	Number	Price per engine	Cost per ton (£sd)
1872-3	Stephenson	30	2395	49.18.00
1873	Hawthorn	20	2390	49.15.10
1873-5	Stephenson	30	3145	65.10.05
1874	Hawthorn	10	3145	65.10.05
1874	Neilson	10	3250	67.14.02
1875	Stephenson	20	2666	55.10.10
1875	Dubs	20	2640	55.00.00
1875-6	Sharp Stewart	20	2615	54.09.07

Source: PRO RAIL 527/1397 p. 41-2.

to firm. Table 3 shows the manufacturers of goods engines for the North Eastern Railway from 1872 to 1875. Cost per ton ranges from £49 15s 10d, to £67 14s 2d.This example reveals how much cost per ton data is subject to variation, and furthermore how ultimately the price may be determined by the underlying price of iron.The price of iron peaked in 1873, subsequently dropping through the remainder of the 1870s [Mitchell, 1962, p. 493]. Furthermore, Robert Stephenson & Co., who built engines for the NER in three batches during the period covered in Table 3, was unlikely to become so incompetent that its price fluctuated from £2395 for an engine delivered in 1872, to £3145 each in 1873.The dramatic rise in the price of iron between 1871 and1873 is a much more probable explanation.

The data for Table 3 is drawn from an official North Eastern Railway publication, which also lists prices per ton in detail for the engines built by the company in the later 1880s. Perhaps unsurprisingly, the prices per ton are substantially lower than those of external suppliers (as low as £44 per ton in 1888). The choice of example data may have been a calculated decision, as it shows the North Eastern Railway's works in the best light.Also, the price of iron was low in the later 1880s [Mitchell, 1962, p. 493]. Indeed, it is possible that the belief by railway companies that they were cheaper producers, be it calculated or genuine, may be explained by the price of iron.

All this suggests that variation in price per ton is to be expected, and that differences between the prices of internal and external building may not be valid unless they relate to exactly the same product, built at the same time. Further, even when these conditions are met, there may be mitigating circumstances that account for the differences. Between 1899 and 1908 substantial price differences have been reported [Simmons and Biddle, 1997, p. 276]. Drawing on the North Eastern Railway again, in 1908 its Darlington works built 10 P3 freight locomotives for £2,986 each. At the same time, orders for the same were given to Stephenson (£3,537 per locomotive), North British Locomotive (£3,500 per locomotive) and Beyer Peacock (£3,550 per locomo-

tive), making a considerable cost saving on the internally built engines [Irving, 1976, p. 109]. However, these higher prices may reflect high levels of demand rather than absolute cost. Outside firms were awash with orders and could afford to increase prices [Saul, 1968, p. 198].

Conclusion

Railway companies are the prime example of a British industry internalising production of its machinery requirements during the nineteenth century [MacLeod, 1992, p. 301]. This internalisation was controversial, attracting criticism and scepticism from manufacturers. Nevertheless, the venture into locomotive building by the railway companies proved to endure both the criticism and the pressures of continued railway expansion. They probably gained financially, ensured greater control over specification and quality, and avoided the protracted delivery times for externally built locomotives. This was especially valuable at times of high demand. It is hard to refute Kirby's conclusion that internalisation was "an entirely rational response to engineering uncertainty in the early phases of railway development" [Kirby, 1991, p. 26]; the evidence presented here illustrates that rationality. Initially, the railway companies internalised because of contractual uncertainty, and subsequently became aware of the financial advantages. They built their own locomotives when they could, despite, in some cases, the risk that internalisation could lead to "expensive mistakes, technological dead-ends, inefficient and even obsolete machinery" [MacLeod, 1992, p. 301]. Few became entirely self-sufficient, and at times of absolute necessity contracted out to external builders. Private manufacturers, then, retained a small home market, but increasingly they became dependent on overseas markets which were themselves proving evermore difficult to secure in the face of competition from German and American builders. Ultimately, internalisation had some benefits for Britain's railway companies, but may have been to the detriment of the wider railway engineering industry.

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