The contribution of the Stephenson Company, engine manufacturers to the genesis of the British railway industry c.1823-1840

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Abstract

The paper seeks to understand the part played by the Stephenson Company in the rapid development of the railway industry by exploring its business model in its formative years. The Company capitalised on a pre-existing and well-developed business and technological infrastructure in the North-east of England that provided the building blocks for the creation of a new industry. The Company gained from its linkages with two social networks which provided it with a financial safety-net during the locomotive development phase and the mechanical expertise to achieve its aims: the closed Quaker business network and the regional network of colliery and mechanical engineers. Whilst bridging between and across these social networks facilitated the Company's development, it was not central to its strategic decision-making. Rather, this was shaped by the externalities of market conditions, which the Company sought to influence by producing a viable product that would convince customers of its utility, and investors of the potential gains to be had through investing in railway construction.

Keywords: early railway development; engineering; accounting evidence; social capital; social networks; capital conversions; intangible assets

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Introduction

The study focuses on the early development of the British railway locomotive industry with reference to the records of Robert Stephenson and Co, "Engineers, Millwrights, Machinists, Brass and Iron Founders" (the Stephenson Company) during its first 17 years of operation to 1840. Specifically, it seeks to understand the part played by the Company in the rapid development of the British railway industry by exploring its business model in its formative years. The Company built the first locomotive factory in the world, which continued in operation until the 1960s. It also built marine engines, stationary winding engines for railways, trackwork and colliery engines, as well as supplying tools and replacement parts.

The 19th century saw the industrialisation of Western Europe driven by steam and coal (Fernández-de-Pinedo et al., 2020). The period witnessed the development of international networks of technology and expertise, and with it, the dissemination of novel technologies and processes derived from the invention of steam power to the peripheral regions of the world economy, including the tropical plantations that produced commodities for global markets (Fernández-de-Pinedo et al., 2020). The export of railway technology from Tyneside is an example. For example, in 1846 Derosne and Cail obtained a contract to construct 22 locomotives using plans developed by the Stephenson Company. It was during this period that such networks consolidated their role in the international transfer of technological knowledge, machinery, and innovation processes. These networks were ultimately the result of the ever-increasing expansion of industrial processes and the rise of an interacting global economy, involving dynamic information flows and exchanges (ibid).

According to the ledger, the Stephenson Company manufactured its first locomotive and tender in April 1826 for the owners of Mount Moor Colliery in County Durham. The earliest exports were to France in March and April 1828 followed by one to the U.S. in October 1828. The company concerned was the Delaware and Hudson Canal Company (ROB 5/2-3), which carried coal from the coalfields of north-eastern Pennsylvania to their outlet on the Hudson River. The rising demand for railways and steam locomotive power is illustrated by the speed at which rail networks were developed in Britain and overseas post 1830. Up to 1830 the Company had no serious competitors. The situation changed after 1830 with new entrants to the market, notwithstanding the Company retained its position as market leader for the remainder of the period under consideration. Other players included Sharp, Roberts and Co. (Manchester, 1830) and Charles Tayleur and Co. (Liverpool, 1831) – Robert Stephenson was originally a partner – together with "numerous small firms that were probably little more than 'jobbing foundries'" (Drummond, 1989, p. 9). For his part, George Stephenson had been designing and constructing colliery locomotives to replace the work of horses since 1814, but the foundation of the new firm in 1823 marked the start of the serious commercialisation of the industry and its rapid globalisation (Kirby, 1988, p. 289; Brown, 1995, p. 5).

By 1850, the skeleton of a national railway network had been established in Britain, and the full network completed by about 1870 (Divall, 2006). The situation was mirrored widely in Europe, the United States, the British Empire and elsewhere. The present study contributes to previous literature by elucidating the catalytic role the Stephenson Company played in this transformation. Specifically, this is achieved through exploration of its business model through the lens of the Company's accounting documentation and procedures. The paper is therefore consistent with a body of archival research which views the modes of accounting adopted as a reflection of the mentalities of the parties concerned, and therefore a window into their intentions (Oldroyd, 1999; Bryer, 2005). By accounting procedures, the paper is not just referring to the income statements, balance sheets, and cost accounts, but the planning and control procedures adopted, and what the partners chose to account for as well as what to leave out. Thus, the paper examines the company's minute books, memoranda, various books of account, financial reports, and related correspondence.

A notebook analysing the costs and profit margins of a sample of locomotives of different "weights" constructed in 1834 is particularly significant as taken together with the evidence of pricing uncovered through the records prior to that date, reveals a fundamental shift in the Company's operating strategy in the early 1830s, probably from 1833 (GPB, MS 612, Bidd 27/8). As the paper discusses, the early years of the Company were devoted to demonstrating the viability of this new form of transportation by developing reliable locomotives that were capable of hauling heavy loads over long distances; finding the capacity to meet demand; and selling the engines at prices that were market rather than cost driven. Whereas from 1833, with a market that was now established both at home and abroad, and starting to accelerate, the Company paid more attention to recovering its direct and indirect costs and returning a profit.

Before proceeding, it is necessary to sound a note of caution about the extant accounting evidence. The documents we are seeing comprise only a partial record. For example, Clause 9 of the original partnership agreement refers to the cash book which is missing (ROB 1:4). The so called "ledger" is only a typed copy of extracts from the original ledger that were discovered at Hebburn on Tyne Shipyard in 1928 (ROB 5/2-3). The emphasis in the records on locomotives constructed and their technical dimensions discussed below may reflect the interests of later generations who decided what was worth preserving. One must therefore be careful in ruling something out simply because it is not mentioned in the records. However, a degree of triangulation is obtained from the Pease/Stephenson family papers. These comprise the accounts sent to Edward Pease and his son Joseph by Michael Longridge, the managing partner, together with related correspondence between the two Pease family members and Longridge and also Cook. He who was in charge of the counting house. Filling in the gaps is also aided by the careful chronological numbering of the locomotives in the records which enables one to pinpoint dates.

The collections consulted are housed in the National Railway Museum in York (GB 756 1970-473), the Durham County Record Office (D/PS), and the Science Museum Library (GPB, MS 612). 1840 has been chosen as the endpoint of the study as the focus is on the foundation of the new industry. According to Kirby (1988, p. 289), the major innovations in locomotive engineering had been introduced by 1840.[i] Also, the period thereafter seems to have experienced a shift. Drummond (1989, p. 9) writes that given the "surge of locomotive demand in the years 1839-42 no private firm could fully meet the individual needs of one of the new larger railway companies"; and railway companies in Britain began to develop their own locomotive building capacity (Kirby, 1988, p. 290). Thereafter, the Stephenson Company increasingly focused on overseas markets.

The history of the railway industry is a field of formational importance for the broader histories of business and management (Turner and Tennent, 2021). Chandler and Daems (1979) derived their theorisation from the growth of the vast railway systems in the 19th century in Europe. Gourvish's (1972) history of the London and North-Western Railway developed a similar narrative in the UK context, pointing to the development of hierarchies and managerial elites; further developed by Gourvish (1973) and Turner (2013). Likewise, the organisation of railways has long been regarded as an exemplar of managerial hierarchy, and a precursor to the emergence of the modern corporation (e.g., Chandler, 1977; Gourvish, 1972; Edwards, 2013). Edwards (2013) argues that the railways were the first entities to deal with complex issues of control, communication and decision-making on a day-to-day basis, and were at the vanguard of those firms striving to introduce new ways of working. Casson's

(2009) study of the railway system from its inception to 1914 offers a comprehensive account of the competitive and co-operative instincts of proprietors and their managers. Economic and social historians have viewed public transport, and especially the railways, as a driver of urbanisation from the late-19th century, particularly in Europe, North America and Australasia (Barker, 1980; Capuzzo, 2003; McKay, 1976).

However, most of this research relates to a later period than the present study and is focused on the railway companies which built and operated the lines rather than the independent engine manufacturers. Also, none of it addresses the *chicken and the egg issue*, which as we shall discuss was the principle strategic concern of the Stephenson Company following its foundation, i.e., that railway companies which required hundreds of thousands of pounds worth of investment could not be contemplated unless the market were convinced of the existence of an effective mode of traction to enable them to run. Likewise, there could be no significant market for engines without the existence of railway companies willing to build lines.

The study shows that the means adopted by the Company of answering this conundrum hinged primarily on the synergies achieved by bringing together a managerial team of individuals possessing their own specialist knowledge and social networks, who were committed to the new idea of long-distance, affordable rail transportation. Through these personal connections the Company gained immediate access to financial resources, business trust, production management skills and technical know-how. The synergistic benefits gained through these people and their networks working together is the embodiment of what Burt (2000, p.347) describes as *the social capital metaphor*, "that the people who do better are somehow better connected".

In similar vein, various authors highlight the collective nature of technological progress in the British industrial revolution (e.g., Allen, 1983; Meisenzahl and Mokyr, 2012). Rauch (2001, p.1200) argued that transnational networks generate surplus for their members "by alleviating problems of contract enforcement and providing information about trading opportunities". Network analysis has also been seen as a means of "linking micro and macro levels of sociological theory", which would include the formation of social capital through the interaction of individuals weakly or strongly connected (Granovetter, 1973). The growing literature on such networks confirms the value of comparisons as a method not only of revealing more of their rich diversity but also of assessing their effectiveness as systems of social capital formation.[ii]

Thus, the paper links with debates in business history over the significance of networks in the construction of social capital. *Social capital* is a diverse concept which is defined rather by its function in particular contexts than the entities that comprise it. The common features of social capital are that they "all consist of some aspect of social structures, and they facilitate certain actions of actors – whether persons or corporate actors – within the structure", which otherwise would not be possible (Coleman, 1988, p.S98). According to Burt (2000, p.348), there is general agreement that the essence of social capital lies in the "competitive advantage" that social structure "can create for certain individuals or groups … in pursuing their ends", which can be multifarious. In that regard, he argued in favour of concentrating on "the specific network mechanisms responsible for social capital" as the means for researchers to derive "more compelling results" (ibid., p.346).

With regard to the two main sources of benefit of social networks identified by Burt (2000, pp.349-353) as "affecting the flow of information", *network closure* and *brokering across structural holes*, the experience of the Stephenson Company spanned both. On the one hand, it became linked through the agency of two of the partners, Edward Pease and Thomas Richardson, with the closed Quaker network of business connections, where sanctions existed in terms of social exclusion for untrustworthy behaviour (McLean et al., 2022). On the other, it was also part of the network of mining and mechanical engineers in the North-east of England, which by this time had formed itself into a distinct profession. Through these connections, the Company was able to bridge the gap between these two social networks, acting as a *broker across structural holes*.

As the paper explains, where the experience of the Stephenson Company was distinctive lay in the tradition of information sharing by the region's engineers allied to the Company's mission which went beyond its own economic success. Thus, the Company deliberately sought to open its innovative locomotive designs to competitors rather than close them off in the early part of its history, where the key constraint to achieving its ultimate ambition of creating a market for railways was not access to information and resources, but its lack of manufacturing capacity to supply the burgeoning lines by itself once the technology had been proved.

The ideas of Bourdieu (1986) relating to the formation of economic capital through social interaction, yielding power over competitors, are also relevant. This is especially so in the entrepreneurial context where, as is the case for the Stephenson Company, the initiators come together bringing with them their own personal capitals, and through synergistic interaction convert them into the economic capital of the organisation. Other studies where Bourdieu's (1986) concept of *capitals* have been utilised in examining entrepreneurial processes and behaviours, include Harvey et al. (2011) and Wong and McGovern (2023).

According to Bourdieusian thinking, *economic capital* is the dominant form of capital which encompasses the ownership and control of financial capital and other tangible and intangible business assets. *Cultural capital* is seen to exist in three forms: *embodied*, which refers to acquired knowledge, ways of communicating as well as the influence of parents' cultural capital on the social status and social mobility of their children; *objectified cultural capital* comprises possessions such as books, paintings, and instruments; and *institutionalised cultural capital* includes academic or professional qualifications. In a business context, *social capital* is seen as a bridge building process (Anderson and Jack, 2002), comprising an entrepreneur's network of relationships and access to embedded resources (Westerlund and Svahn, 2008). Some entrepreneurs will have sturdier bridges that provide access to higher quality and more abundant resources and information than others. *Symbolic capital* refers to accumulated prestige and renown and is "the most enduring form" of capital because it enables the possessor "to name or consecrate that which is seen as legitimate, further enhancing the value of that form" (Everett, 2017, p.114). These various forms of capital "are transmutable, although they differ in their liquidity" (Harvey and Maclean, 2008, p.107); and capital conversions are a normal part of business transactions (Wong and McGovern, 2023).

As far as the Stephenson Company was concerned, the notion of *symbolic capital* is particularly relevant as it was this which the business model was designed to create in order to convince investors of the viability of railways. The Company did acquire economic and symbolic capital as the market leaders in the manufacture of locomotives during the period under consideration, notwithstanding that their position as market leader subsequently declined as British railway companies established their own engine building facilities, and home-grown engine manufacture took hold in key markets overseas.[iii] Likewise, George and Robert Stephenson gained reputation in their own time as leading industrial pioneers and have been sanctified by history as "great men" of the British industrial revolution. But what as we shall see was most at stake for the Stephenson Company in its early years went beyond its own or its founders' economic capital or prestige. The Bourdieusian *field of power*, or "arena of symbolic and material struggle" in which they were engaged (Everett, 2018, p.114), was wider than market competition; and might more precisely be described as *hegemonic sectoral capital*, reflecting the power the Company sought to attain for the railway industry over all other forms of overland and inshore coastal transportation.

To summarise, the historical objective of the paper is to uncover and explain the Company's business model during its formative years; and from a theoretical perspective, to do so with regard to the social processes involved. The remainder of the paper is organised as follows. The next section discusses the pre-existing industrial base on Tyneside relating to coal transportation and steam technology which provided the technical, financial, supply chain, professional and employee skillset on which the Company could build. The paper then considers the networks bridged and synergistic benefits derived through the association of the original partners, before turning its attention to explaining the Company's business model in its formative years through the eye of its accounting.

Regional industrial base

Authors such as Meisenzahl and Mokyr (2012, p. 443) and Nuvolari, et al. (2011, p. 292) emphasise the importance of tracing the "backward linkages" and regional variations if one is to glean "a proper understanding of the processes of economic change" during the British industrial revolution. Given the long prior history of steam technology and horse-drawn and later steam-powered railways (wagonways) on Tyneside, the regional aspect and backward linkages relating to the North-East are crucial to understanding the resources the Stephenson Company was able to exploit from the time of its formation.

Steam engines were in widespread use in the region's collieries by the early 19th century for pumping operations and for raising coal to the surface (Kanefsky and Robey, 1980, p. 170; Oldroyd, 2007, p. 14). The less efficient Newcomen engines tended to be favoured over the Watt's models owing to their lower capital cost. Also, high fuel consumption was not a significant factor in an area where coal was cheap and the simpler design meant they were easier to erect and maintain (Franken and Nuvolari, 2004, pp. 423, 445; Nuvolari et al., 2011, p. 297; von Tunzelmann, 1978, p. 75). However, it was the adoption of Watt's improved double-powered or double-acting steam engine in the 1790s that allowed for the opening-up of deeper coal seams in the region, previously inaccessible owing to flooding, which required significantly greater capital investment (Brackenborough et al., 2001).

The idea of transporting goods by rail had a long history on Tyneside stretching back to 1605, although really only taking off during the first half of the 18th century. The wagonways' advantages in terms of transport costs and ability to move large volumes of coal became critical as the shallow coal seams near the Tyne became worked out, and coal mining expanded south-westwards into County Durham, increasing the distances of transporting coal to the outlets on the river. By the early 1700s, wooden wagonways had become the main means of transporting coal from the major collieries of Tyneside and Durham to staithes on the Tyne for onward shipment to London and the Continent (Oldroyd, 2007, pp. 10-12); and by 1800 the network was extensive. These wooden wagonways

> … are not to be demeaned as simple tram roads. They were the main transport arteries of a major industry and they carried large quantities of freight amounting to over 100,000 tons per annum on the main lines; they represented the largest civil engineering projects of their age [and] required a major investment of capital to finance the building of bridges, cuttings, embankments and the railway itself; they were operated by dedicated teams of drivers and maintained by skilled permanent staff (Turnbull, 2012, p.3).

Metal began to be used in the construction of the wagonways from the late 18th century as improvements in iron manufacturing took place and the prices fell. It was at this point that "steam traction – stationary and locomotive – was fitfully developed as a cheaper alternative to horses" (Divall, 2006, p.196; McLean, 1997, p.15), with colliery concerns making their own bespoke engines.

Ironmaking had been established in the region since 1691, when Ambrose Crowley's iron works were established in Winlaton, County Durham. Hawks (later Hawks Crawshay) was founded in Gateshead in 1717; the Tyne Iron Company in 1797; and the Walker Iron Works of Losh, Wilson and Bell in 1809 (Morgan et al., 2013, pp.57-61), becoming "an important manufacturer of iron rails" (Turnbull, 2012, p.27). The level of investment occurring in the region during the 18th and early 19th centuries in steam and wagonway technology is indicative of the availability of finance as well as technical knowledge.

Demand for metals, wagonways, steam engines, and latterly locomotives, increased in the Great Northern Coalfield, as coal output rose from around 1.25 million tons in 1700 to 3 million in 1775, and 7 million in 1830 (Hatcher, 1993; McLean, 1997). In 1830, the coalfield "was still the acknowledged leader in technology, the skill of its miners and in the expertise of its managers" (Flinn, 1984, p.28), known as *viewers*, who were highly trained mining engineers. Viewers combined the role of resident chief engineer with that of independent mining consultant (Oldroyd, 1996). They "were a mixture of manager, engineer, surveyor, accountant and agent" (Flinn, 1984, p.59). By the 1830s, schools of viewers had been established by leading members of the group with their own apprentices, defined modes of training and networks of associates stretching from Newcastle, County Durham, and Cumberland to Nova Scotia in Canada. One of the characteristics of this group was that they acted as a profession, distinct from the coal owners who employed their services, and hence shared technical information (Fleischman and Oldroyd, 2001). As discussed below, one of the distinctive features of the Stephenson Company in its early years was its open approach to sharing its designs.

The existence of engineering networks sharing knowledge did not end there. The export of Stephenson locomotives abroad helped facilitate the export of railway engine knowledge, especially as such consignments, some of which were transported in parts, were accompanied by an engineer to get the locomotives operational. From the mid-19th century, the inter-working of trains between systems encouraged the adoption of similar (but not always identical) technical and operating standards, and most engineers were used to sharing ideas through professional organisations and associations. Ideas and personnel were also exchanged with the private manufacturers of equipment (Divall, 2006). Similar conclusions appear to apply equally well to the United States, given the existence of comparable networks of engineers and skilled craftsmen, co-operative relationships, and education (Sinclair, 1974).[iv] This was also true of non-railway steam engine manufactures. By the end of the 18th century most "Newcomen (and, indeed, Boulton and Watt) engines were not built by any one person or works but were rather the product of several different concerns" (Kanefsky and Robey, 1980, pp. 164-5). Typically, components were manufactured by specialist firms and then transported to the required location where they were "erected by local craftsmen" (Nuvolari, Verspagen and von Tunzelmann, 2011, p. 299).

Returning to the Stephenson Company specifically, it is unsurprising that the Company had ready access to the supply of raw materials, components, and skilled labour from the start of operations given the pre-existing industrial base in the region. Bailey (1984, Appendix IX) lists the Company's suppliers up to April 1831. These comprised 8 suppliers of iron sections, 2 of steel components, 1 of iron castings, 21 of pig iron, 8 of brass castings, 3 of copper components, 2 of timber, 45 suppliers in all. Most of these firms were situated locally, although some ranged as far afield as Liverpool, Wolverhampton, South Wales, and Glasgow, testifying to the existence at this time of a widespread knowledgebase in metalworking throughout Britain. The ready supply of materials and components was paralleled by the availability of skilled labour locally. Analysing the wage bill, Bailey (1984, p.p. 35-45) estimates a payroll of about 35 craftsmen and juniors in 1827 rising thereafter to about 50 to 60 men, "including craftsmen, engineering and craft apprentices, labourers and clerical staff". The firm does not seem to have had difficulty in recruiting, taking on an additional 15 men in the spring of 1828 as the order book increased. Getting good boiler men seems to have been an exception as the Company had to go as far afield as Liverpool in 1830 to recruit them (Bailey, 1999, 254-255). Attention was also paid to training and the Company took on engineering and craft apprentices, some of whom later became eminent engineers in their own right.

To summarise, the combination of steam power and railway transportation in the local coal industry was well-established by 1823 when the Stephenson Company was formed. Steam engines, both stationery and locomotive were taking over from horses on the colliery wagonways; and local firms existed specialising in ironmaking and metal working. Industry on this scale could not have developed without access to capital and credit, supply networks of materials, components, and skilled labour as well as engineering and managerial expertise. Harnessing these ingredients in the establishment of a new industry required people of vision possessing the appropriate knowledge, experience and social connections. The next section of the paper examines the personal capitals of the founding partners of the Company and the social networks bridged and synergistic benefits derived through their working together.

Foundation of the partnership

The most significant bridging relationship in the formation of the social capital of the Stephenson Company in its early years was that which existed between its partners, Edward Pease and George Stephenson. Pease belonged to the closed Quaker network, and Stephenson to the network of mining and mechanical engineers on Tyneside discussed in the previous section. Here, bridging social capital connected these actors from the two social networks and provided the Company with the technological capability and financial resources on which its survival and competitive advantage came to depend. The Quakers can be regarded as a closed network because membership of the community conferred privileged access to information and resources and reduced risk by virtue of the members' belief that they were as accountable to God for their actions in business as for anything else. Hence miscreants faced the threat of denouncement in their meeting house, or even social exclusion in the worst cases, which apart from the stigma involved, would diminish their future business prospects (Boyce and Ville, 2002, pp.264-265; McLean et al., 2022).

From a Bourdieusian perspective, the bridge that was built between these two networks through Pease and Stephenson, and the associates they brought with them enabled the transmutation of their own personal capitals into the more powerful *economic capital* of the Company as a whole. For example, George Stephenson possessed considerable *embodied cultural capital*, in the form of the technical knowledge he had acquired as a result of experience and experimentation since youth (Rolt, 1984, p.8; Bailey, 2003, p.4; Davies, 2004, p.11; Morris, 2010, p.9), which was transformed into the *economic capital* of the Company in the shape of intellectual property on its formation. Likewise, by 1823 he had accumulated significant *symbolic capital* in the local coal industry as the leading go-to engineer to consult on matters relating to colliery railways, both engines and railway construction. He had built his first locomotive, the *Blucher*, in 1814 (Skeat, 1973, p.14). Stephenson's renown was the reason why Pease engaged him as the consulting engineer for the Stockton and Darlington railway in 1821, which opened four years later as the first public railway in the world (Ross, 2010, p.55). Thus, on the formation of the Stephenson Company, Stephenson's *symbolic capital* transmuted into the *economic capital* of the Company in shape of another intangible asset, *goodwill.* The combination of George Stephenson's reputation locally and the prospect of creating something remarkable, that in his own words, "one day will astonish all England"

(Jones, 1981, p.700), drew in other engineers from his circle possessing their own intellectual property, such as James Kennedy, William Hutchinson and Timothy Hackworth, which the Company was able to harness. Hutchinson was particularly significant on the shopfloor supervising the operations and through his practical ability in solving design problems.

The Company's social network also stretched to supply chains, and another form of *embodied cultural capital*, production management expertise in the person of Michael Longridge, with whom Stephenson had an established working relationship in the coal industry going back several years. With his experience in production management and business administration, Longridge became the Stephenson Company's first managing partner. Longridge in turn brought Thomas Nicholson with him as the Company's first chief clerk, who was responsible for the day-to day administration and bookkeeping. This was a symbiotic relationship as Longridge's Bedlington Ironworks supplied the Stephenson Company with materials and components. Longridge's involvement also extended the Company's social network further. It was his agent, John Burkinshaw, who had developed and patented wrought or malleable iron rails that were cheaper and safer than the traditional cast-iron rails. Following a visit to the Bedlington Ironworks in the summer of 1821, George Stephenson had recommended Burkinshaw's innovative rails for the Stockton and Darlington Railway (Ross, 2010, p.57), much to the consternation of William Losh of the Walker Iron Company, Stephenson's co-patentee of a rival cast-iron version (Rolt, 184, p.74).

The relationship was not to last. Eventually, Longridge became alienated from the Stephenson Company mainly because of the length of time he was obliged to spend in Newcastle owing to George and Robert Stephenson's prolonged absences after 1830 on construction projects as the national rail network expanded.[v] Tiring of his partners, Longridge set up his own locomotive manufacturing business at Bedlington in 1837, and withdrew from the Stephenson Company altogether in 1843 (Bailey, 1984, pp. 14, 19, 28, 128-9). But by this time, the formative work of the Company was complete, and its market position established.

However, the following section of the paper highlights that up to 1830s, the survival of the Company remained uncertain; the enterprise only starting to make significant profits from 1837, fourteen years after its foundation. Personal networks, or bonding social capital, are generally regarded as critical at the start-up phase of a business (Ostgaard and Birley, 1994). This was especially the case for the Stephenson Company as without the Quaker connection through the agency of Edward Pease, it would not have survived.

Edward Pease came from an established business dynasty of woollen manufacturers in County Durham. His entrepreneurial background provided him with the "enhanced cognitive resources" or *embodied cultural capital* needed to establish a new venture to exploit business opportunities such as those which the nascent railway industry provided (Baron and Henry, 2010, p.50). It was not just Pease's vision and business acumen that were useful to the Stephenson Company, but the *economic capital*, that he commanded – he bailed the Stockton and Darlington Railway out of financial difficulties prior to its opening in 1825 (Bailey, 1984, p.80). The Stephenson Company derived considerable strategic benefit from Pease's *symbolic* and *social capital* as a successful industrialist and member of a well-respected Quaker family, the latter linking the Company into a Quaker business and credit network and providing access to their embedded resources (Westerlund and Svahn, 2008).

Hence, the fourth of the Company's five partners was Pease's cousin, Thomas Richardson, founder of the London bank of Overend, Gurney and Co (Skeat, 1973, p.68). The bank kept the Company afloat with extended credit in 1825 to tide it over cash flow difficulties caused by the financial problems of two of its largest customers, the Stockton and Darlington railway and the Canterbury and Whitstable Railway (ibid., pp.94-5). Aside from the financial support, Pease and Richardson used their business contacts to gain work for the newly founded firm. The Quaker connection continued into the future. Edward's son, Joseph who married a Gurney, later became a partner himself.

The fifth partner to consider is George Stephenson's son, Robert who grew up in a family which provided him with a business supportive *cultural capital* (Light and Dana, 2013). Where his upbringing differed from that of his father was that unlike his father he was formally educated at school (Rolt, 1984, pp.15-16), university (Ross, 2010, p. 58), and as an apprentice colliery viewer under Nicholas Wood at Killingworth Colliery. Here his training would have "included mine surveying, and the design and operation of colliery and wagonway machinery" (Bailey, 2003b, p. 5). The cultural capital that is acquired from an elite education can readily be converted into social capital (Harvey and Maclean, 2008). Robert's upbringing made him less gauche than his father, and better equipped to deal with the social nuances of the professional middle-class, Victorian world. The combination of these factors left him in a strong position to develop his entrepreneurial capabilities and enhance the economic power of the Company (Light and Dana, 2013), through his possession of both *embodied* and *institutionalised cultural capital*, speaking in Bourdieusian terms.

However, none of this foundational knowledge and experience alone can explain Robert Stephenson's technical genius. It was he who designed the famous *Rocket*, which won the Rainhill trials in Manchester in 1829 and served as a protype for the heavier Stephenson locomotives that would run on the Liverpool and Manchester Railway (1830). He became the prime technological motivator of the Company (Bailey, 2003c, p. 173), initiating four development programmes: boiler design; thermal efficiency; transmission design; and suspension design. He also recognised the importance of draughtsmanship, recruiting George Phipps as a draughtsman in 1828, a move that was unusual at the time. According to Brown (2000, pp.200-201), "design drafting only became common in British metal working firms after 1840". It follows, engaging Phipps provided the firm with a new capability not generally possessed by competitors until later. Utilising Phipps' draughtsmanship combined especially with William Hutchinson's manufacturing experience and problem-solving skills enabled Robert Stephenson to translate his design ideas into the production of locomotives during the late 1820s and 1830s. Finally, a three-year absence abroad between 1824 and 1827 as the Colombian Mining Association's agent and chief engineer seems to have honed his management skills. According to Bailey (2003b, p.21), Robert Stephenson "gained maturity and independence" from his time abroad, and

> … developed strategic and tactical decision-making abilities … [and] management skills, especially the ability to motivate a workforce and earn their respect, which would serve him throughout his career.

According to Meisenzahl and Mokyr (2012, pp. 445-6), technological change in the British industrial revolution was driven by three main factors: major breakthroughs, cumulative micro-inventions, and skilled labour. The foregoing analysis suggests the picture for the Stephenson Company is more complex as one has to add in the personalities of the individuals concerned, the religious connection, the local and national credit networks, the access to financial resources, the knowledge and experience of the partners, the supply chains for raw materials and components, as well as the underlying business culture of the region.

Returning to the general theme of the formation of social capital through interaction amongst and between social networks – i.e., "that the people who do better are somehow better connected" (Burt, 2000, p.347) – this was clearly central to the rise of the Stephenson Company. Internally, the collaboration that was created between the various engineers and other connected parties allied to the coal industry enabled the development by the early 1830s of a viable commercial product fit for the new railway age, the Stephenson *Planet* and

Samson class locomotives. In terms of external relations, the bridge that was built between this colliery network and the Quaker one ensured the Company's survival whilst this development work was being undertaken.

From a Bourdieusian perspective, what we have described is the transmutation of the five partners' personal economic, cultural, social, and symbolic capitals into the economic capital of the Company, and the synergies which resulted. Effectively, by this we mean the creation of the Company's intangible asset base through the joining together of the partners and the range of key personnel they attracted into the organisation. The increasing significance in business of intangible assets is generally regarded as a modern phenonium dating from the 1980s. It is therefore interesting that in the Victorian era which is better known for its massive investment in plant and machinery, what was more crucial to the success of the Stephenson Company in its formative years were these intangibles. A possible parallel situation is the part played by the Newcastle Upon Tyne Electric Supply Company in the formation of a national electricity supply industry towards the end of the 19th century, in which the combination of "key individuals and networks" likewise proved significant (McLean and McGovern, 2017).

Finally, if the benefits derived from social capital lie in attaining "competitive advantage" (Burt, 2000, p.348), for the Stephenson Company this went beyond market dominance. As the following section of the paper relates, the Company deliberately opened up its designs to potential competitors, and thereby helped to create competition in the market rather than stifle it. The Stephenson Company was a comparatively small operation, situated in an inconvenient location, away from the rising industrial powerhouses of the north-west and west Midlands. It could not possibly hope to meet the future anticipated demand for locomotives if the partners' futuristic vision of a public rail network were to come to fruition.

Vision is a fundamental component of the entrepreneurial process, which impacts on decision-making and the deployment of resources (Bird, 1988; Hanks and McCarrey, 1993; Gupta, et al., 2004). The novelty for the Stephenson Company lay is in the transcendent nature of the partners' vision, summed up in a letter from Edward Pease to George Stephenson two years prior to the Company's formation:

> Don't be surprised if I should tell thee, there seems to us after careful examination no difficulty of laying a rail road from London and to Edinburgh on which waggons would travel and take the mail at the rate of 20 miles per hour, when this is accomplished steam vessels may be laid aside! (Bailey 1984, p.1).

Thus, what the partners ultimately sought to attain went beyond the economic power of the organisation over competitors, but the power of the railway industry over all other forms of overland and inshore coastal transportation. One might term this *hegemonic sectoral capital* following Bourdieusian type typology. The next section of the paper explains how this conclusion was arrived at through exploration of the Company's business model.

Business model

The business model of the Stephenson Company as reflected in its accounting procedures was dominated by two main objectives. The central objective was to facilitate the creation of a market for public railways which did not exist before. This in turn would create demand for railway engines, but none of this would be possible unless the technology could be proven. By the early 1830s, that situation had been achieved, but up to then it remained in doubt. The second related objective was to generate sufficient cash to keep the Company afloat during the technological development phase.

Creating a market: Given that the main focus of the Company's activities up to the early 1830s was on developing a viable product for long distance rail transportation, it is unsurprising that the large bulk of the Company's accounting records relate to tracking the technical progress of its designs and carefully logging which customers had bought what. Thus, the *engine description book* provided a technical specification of each locomotive constructed. Additionally, the Company maintained an *engines delivered* book (ROB 2/3/1), an *engines finished book* (ROB 2/2/1), a *particulars of engines book* (ROB 2/5/1), and an *engine record book* (ROB 2/6/1). Each engine was designated a number. The *engines finished* book looks like a neat copy of the *engines delivered book.* Both books recorded the date of delivery, the name of the customer and the engine number. The *particulars of engines book* recorded the technical dimensions of each engine in terms of the length, height, width, and diameter of the fire box, boiler, chimney, steam passage, and blast pipe in addition to weight of the engine, loaded with coal and water and unloaded. Again, the engines were cross-referenced to the name of the customer and engine number. The *engine record book* contains the same type of technical data notwithstanding it looks like a later copy.

These books provided the Company with a complete record of the technical specifications and customers of each of the engines produced, enabling this information to be retrieved at any point in the future. The relevance of the information in the books becomes clearer when one looks at the order books which cross-referenced the subsequent supply of replacement components to the number of the engine, to which they related (ROB 2/1). To make a railway viable by reassuring customers about the longevity of their locomotives, suppliers had to be able to offer a repair and replacement service for parts that would inevitably break or wear out through use. This was particularly important for the Stephenson Company in its development phase when it was continually adding modifications to models to improve their performance. The company had to know who had bought what to enable it to be repaired; and the detailed record-keeping in the various engine books and order books enabled them to do this, which was necessary in order to build and maintain consumer demand.

The policy continued beyond the early development phase too, as in addition to its standard designs of the *Planet* and *Samson* locomotives, the Company customised engines to meet the requirements of particular customers. This was the case for some of the *Samsons* supplied to the American market which were modified to include a bogie truck in order to lengthen the wheelbase and hence reduce the risk of derailment on inferior sections of track. The dimensions and weight of these engines also had to be reduced (Bailey, 1984, pp. 139, 252). The order books carefully recorded the customers' requirements, sometimes including rough sketches (ROB 2/1). For example, the 1834 order book contained the following entry:

> Nos 88 and 89. Two locomotives for the Belgian government to be fit up similar to No. 37 with two pairs of patent wheels 3ft.6in. diam. The adhesion of the middle wheels to be taken only which is to be 5ft. diam. To have 100 brass tubes and copper firebox. The engine to be capable of travelling with passengers at the rate of from 25 to 30 miles per hour or with a load ranging from 50 to 80 tons gross wt. at 20 miles per hour upon an inclination of ? in a 1000 ______________________________
> Tenders for the above engines capable of containing 500 gallons to be placed on 4 wheels with springs, also hauling springs complete …. (ROB 2/1: 81-82).

The order book then went on to specify the set of tools that would accompany the order as well as a duplicate axle for the engines.

The standardised designs of the Stephenson Company marked it out as unusual in the early British locomotive building industry where although "broad categories of engine type for particular traffic requirements had begun to emerge as early as the 1830s", there was a "chronic lack of standardisation of design" throughout the industry and within individual companies at a time when "the steam locomotive was still an experimental machine" (Kirby, 1988, pp. 287-290). The situation changed by the end of the 1840s, as the major British manufacturers began to recognise the production benefits of utilising common components (Bailey, p.168). Similarly in the US, standardisation increased markedly in the case of the Baldwin Company after 1850 as the level of output increased, more parts became interchangeable, and systematic production became more important. In the 1830s, therefore, the Stephenson Company was ahead of its time.

The rapid strides made by the Company in design improvements following Robert Stephenson's return from South America in 1827 is evident from the increasing level of detail recorded in the *engine description book* between 1828 and 1832. For example, Figure 1 shows the dimensions and components of the *Lancashire Witch* built in 1828, which stretched to just over half of the left-hand page only; compared to the entry for the *Pluto*, constructed four years later which now occupied a double page (Figure 2).

Figure 1: Description of *Lancashire Witch*, 1828 – left-hand page only (ROB 2/4/1)

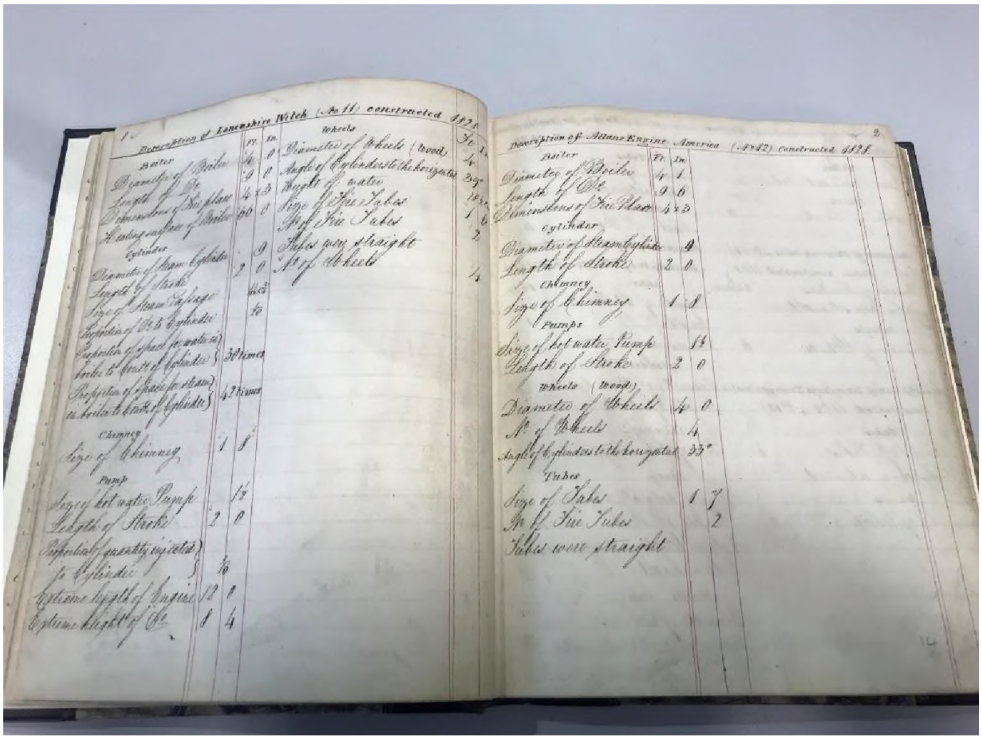
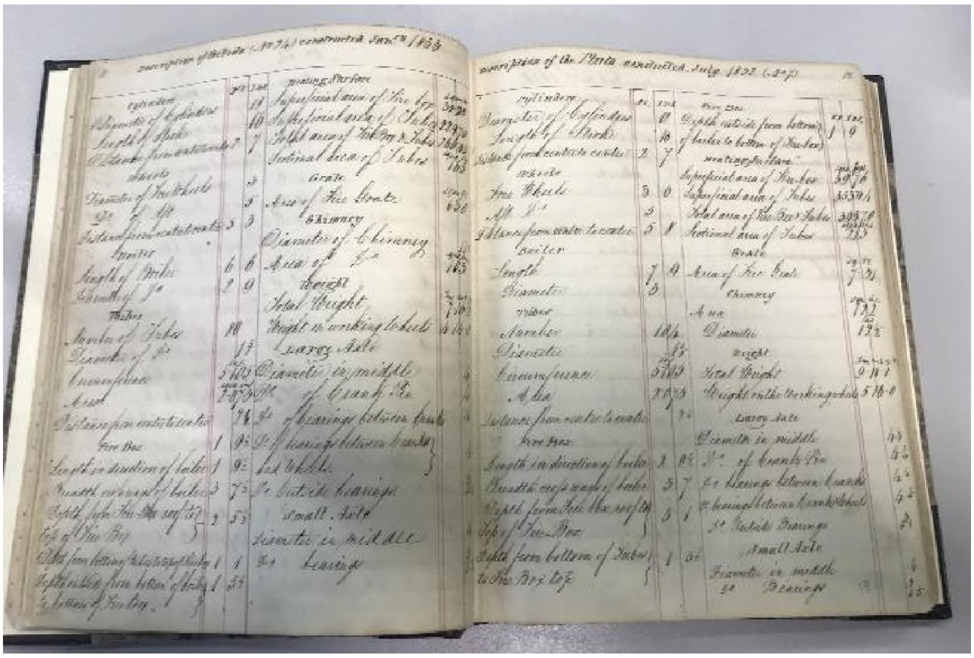


Figure 2: Description of *Pluto*, 1832 (ROB 2/4/1)



The second key aspect of the Company's marketing strategy up to the early 1830s lay in its pricing policy which was driven by what the partners believed customers would be prepared to pay rather than based on the full recovery of costs. Thus, if one looks at the prices charged to customers in the ledger, these were relatively static despite the increased technical complexity of the product. From April 1826 the normal price of a locomotive was £600, falling to £550 in March 1827, and continuing at that price until January 1830 when it was reinstated at £600, where it remained until September of that year. The reason for the price reduction to £550 was to pass on the falling price of iron to the customer (Bailey 1984, p. 76). These figures suggest the pricing of locomotives prior to 1830 at least was market rather than cost led. Given that the company had a virtual monopoly up to that date after which competitors started to appear, the only logical explanation for the relatively low prices is that the Company was seeking to induce demand for a technology that was still largely unproven. In these circumstances, it is unsurprising that annual profits remained low prior to 1837 despite the increase in sales activity, as discussed below.

The lack of attention to cost control which this implies is again borne out by the Company's accounting records. For example, the Company kept an *expenditure book*, which summarised the purchases and sales for the preceding month. Unfortunately, this has only survived up to 1831. The fact that the book analysed expenditure by supplier rather than cost-category, is indicative a lack of focus on cost-control prior to that date. The purpose of the book was to track its creditors to ensure they were accurately paid, not the construction costs. That situation is confirmed by entries in the minutes. For example, it was resolved at a meeting on 3 January 1833:

> That the finances of this Company having obtained a close investigation it appears that the utmost attention must be paid to this department of an order that sales may be effected as to mind the engagements of current expenses to which we are inevitably liable ---- It is recommended that all the sales of materials and engines contracted for with any purchasers may have a special reference to our pecuniary wants so as to bring back the capital timely to meet all our contingencies.
>
> Robert Stephenson
> Edward Pease
> Michael Longridge

The partners were expressing concern that they were not fully recovering the costs of production from the customers. Hence, it was not the cost of the products that had been driving price up to this point, but more likely, what the Company believed the customers were willing to pay.

An undated note appended to the minute book strikes the same tone as the above resolution:

> It is suggested to Robert Stephenson & Co that in all estimates whether such as are deemed Rough estimates or otherwise, that as much of the minutia and enumeration of articles be set down as possible, then assuming each particular leads to thinking of everything, and amongst these items, a portion of Rent, Taxes and interest should be included in every estimate with a proportion of Salary all which are omitted in the above [a rough estimate of the expenses of an engine at Brampton colliery]

The author of this recommendation is unknown. It is also unclear whether the Company was being criticised for the incomplete nature of their estimate at Brampton, or for not preparing estimates at all, but the implication is that the Company was under-recovering its costs.

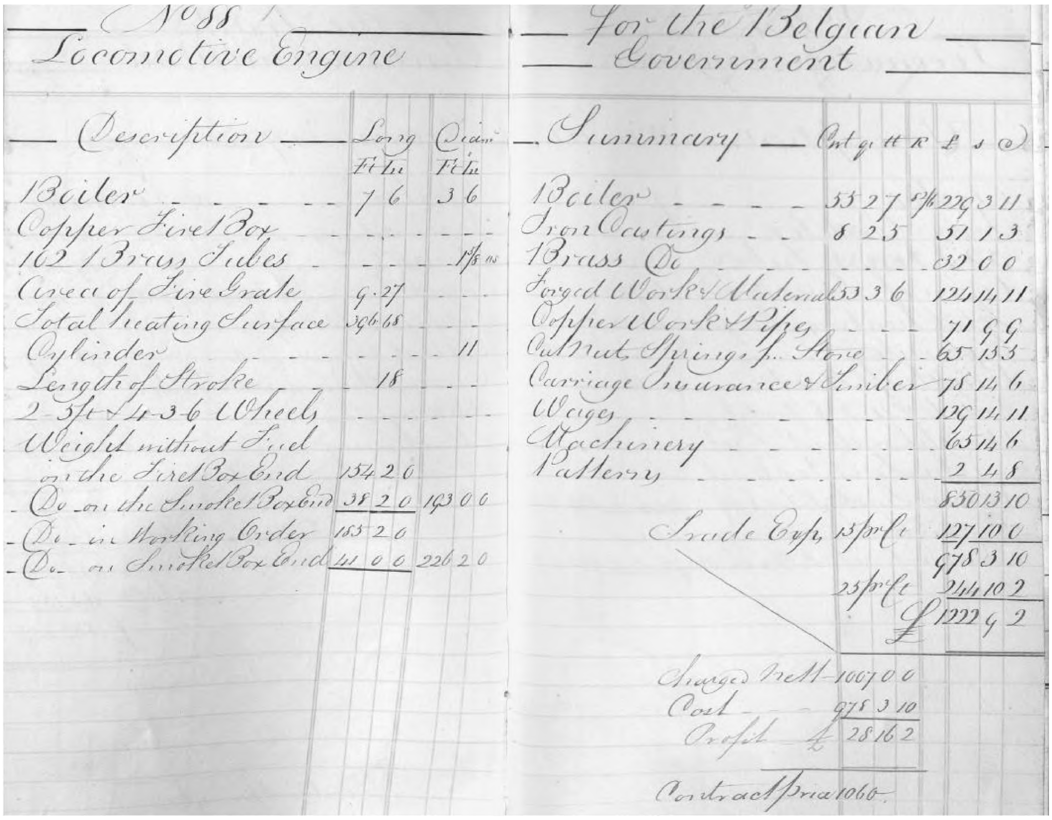
The survival of another accounting document, in this case a notebook, indicates that the policy changed from some point in 1833, and that from then on, the Company based its pricing decisions on estimates of total cost. By this time, the railway landscape had completely changed. The technology had been proven and railway mania was starting to set in. Referring back to the previous section, by now the Company had generated significant *symbolic capital*, or in accounting terminology *goodwill*, as the leading locomotive manufacturer. The date of the change is also significant, as it is consistent with the misgivings expressed in the minute book in 1833.

This was a "binary decision" where a threshold had been reached over whether to stick with the original policy of undercharging to the detriment of the Company's capital or adopt a more scientific pricing policy based on full cost-recovery, which was the course of action the partners opted for. This was a different type of *threshold* to the sort envisaged by Granovetter (1978, pp.1420, 1422, 1430) in modelling collective behaviour within social groupings, where the decision to act in a certain way is seen to depend on the number or proportion of parties within the group in favour of a particular course. Returning to theme of the formation of social capital through the interaction or exclusivity of social networks, the inapplicability of Granovetter's (1978) model to the above pricing decision illustrates, that while bridging between and across social networks was vital to the success of the Stephenson Company, it was not central to the Company's strategic decision-making, which instead depended first and foremost on the externalities of market conditions, which the Company sought to influence.

The notebook provides the most detailed evidence of the Stephenson Company's costing procedures from 1833. The book is part of the papers of fellow engineer, George Parker Bidder, who acted as executor of Robert Stephenson's will and presumably retained what he thought looked interesting. The document comprises a summary of the costs, sales value and profit of a sample of 14 locomotives of different capacities delivered in 1834, including two that were delivered in parts for assembly on site. It also contains the technical dimensions of each engine as well as a number of technical tables.

All the summaries followed the same format as the example shown in Figure 3, apart from the two sold in parts. The example in Figure 3 relates to an engine delivered to the Belgian government in September 1834. The lefthand side records the technical dimensions, the right the financial detail. Cost of £850/13/10 is analysed over ten headings including transportation. This figure is then increased by 15 percent for unallocated overheads and a further 25 percent for target profit of £244/10/2. The report shows that the actual profit fell short of the target by a considerable margin, coming out at £28/16/2. In fact, of the twelve locomotives sold as complete units in the book, only two exceeded the profit target, numbers 103 and 118, notwithstanding that in most cases the shortfall was not as pronounced as in Figure 3. In all cases the final selling price differed slightly from the contract price suggesting this was open to variation.[vi]

Figure 3: Costing summary of locomotive engine No. 88 (GPB, MS 612, Bidd 27)


No 88 Locomotive Engine — For the Belgian Government

Description	Long Ft In	Diam Ft In
Boiler	7 6	3 6
Copper Fire Box		
162 Brass Tubes		1⅝ ins
Area of Fire Grate	9.27	
Total heating Surface	396.65	
Cylinder		11
Length of Stroke	18	
2-5ft & 4-3-6 Wheels		
Weight without Fuel on the Fire Box End	15 4 2 0	
Do on the Smoke Box End	3 8 2 0	19 3 0 0
Do in Working Order	18 5 2 0	
Do on Smoke Box End	4 1 0 0	22 6 2 0

Summary	Cwt qr lb	£ s d
Boiler	55 2 7	229 3 11
Iron Castings	8 2 5	57 1 3
Brass Do		32 0 0
Forged Work & Materials	53 3 6	124 14 11
Copper Work & Pipes		71 9 9
Cutting Springs & Stone		65 15 5
Carriage Insurance & Timber		75 14 6
Wages		129 14 11
Machinery		65 14 6
Pattern		2 4 8
		850 13 10
Trade Exp 15 per ct		127 10 0
		978 3 10
25 per ct		244 10 2
		£1222 9 2

Charged Nett 1007 0 0
Cost 978 3 10
Profit £ 28 16 2
Contract Price 1060

We do not know what action the Company took in the light of this *ex-post* analysis of the contracts, but it does show the Company attempting to recover its costs and is therefore more likely to be related to pricing decisions than strategic decision-making. The detailed technical tables also contained in the book, such as “proportions of locomotive engines to the diameter of cylinders”, or “table of the sizes of crank axles to the size of wheels and weight on them”, are relevant in this regard, as these provided the standards that would have facilitated the Company in converting the various specifications of capacity in the order books into prices. This was clearly perceived as information that Robert Stephenson needed to be aware of as a note appended to the notebook confirms that it was sent to him while away, presumably on one of his civil engineering railway projects. The note reads:

> We have the cost of a greater number of engines than that are in this book, but have only put one of each description in. –
> The remaining of the weight of engines will be filled up the next time you return, in that book for more engines

The notebook provides a clear indication of when the Company started analysing costs in this way because each of the 14 engines in the notebook is cross-referenced to a volume containing the full details which has not survived. The first engine in the notebook, number 61 ordered in November 1833, is cross-referenced to main book as folio 1, suggesting this is when the new policy started. Such a date is consistent with the misgivings expressed in the minute for January 1833 mentioned above, that the Company needed to pay more attention to recovering its costs.

The conclusion that the pricing of locomotives up to 1833 was driven first and foremost by the need to create customer demand is consistent with the hypothesis already advanced that the prime motivation of the Company in its early years was to supply a nascent railway network with a demonstrably viable and affordable mode of transportation that would encourage its expansion, thus resulting in more orders for engines as new lines were added. This would in turn explain the quantity of data maintained by the Company on its railway engines compared to the rest of its accounting records. The commercial viability of railways powered by locomotives was not a given. For example, there was strong opposition to the building of the Liverpool to Manchester line, the success of which launched the railway mania of the 1830s and 40s; and George Stephenson suffered personal "ridicule and humiliation" for the evidence he presented to Parliament in support of the plan in 1825 (Skeat, 1973, pp. 17-18, 84-85).

Finally, there was the question of productive capacity. The development of efficient and reliable locomotives was a prerequisite if investors were to be persuaded to invest in railway companies. But developing viable locomotives would still not be enough unless sufficient numbers could be produced to operate the new lines. The Stephenson factory in Newcastle was situated at the centre of the Durham and Northumberland coalfield, which made it ideal for supplying and repairing colliery railways, engines and other machinery. However, with the opening of the Liverpool and Manchester Railway in 1830, the North-west was perceived as the new growth area, and Newcastle was not well placed geographically to service this market given the absence of a rail network for transporting products and supplies. Its manufacturing capacity was also limited. These limitations provided the rationale for a short-lived partnership between Robert Stephenson and Charles Tayleur. Tayleur's Vulcan works increased capacity and were conveniently situated near Liverpool (Skeat, 1973, p. 139). During the two-year arrangement, the two firms benefitted from being able to share orders, but the long-term effect was that the Stephenson designs assisted Tayleur in setting up in competition on his own account. Interestingly, looking ahead one hundred-and-twenty years, both companies lost their independent identity in 1955 when they were taken over by English Electric.

The policy of design-sharing with potential competitors was deliberate and probably can be explained by recognition of the need to increase capacity if Edward Pease and George Stephenson's vision in 1821 of a new railway age was to be realised. Not only did the Company not start registering its patents until 1831, but subcontracted production of its designs to other manufacturers. For example, two *Planet* class locomotives were subcontracted to the Leeds firm of Fenton, Murray and Wood after 1831 in order to keep pace with demand for locomotives on the Liverpool and Manchester Railway (Bailey, 1984, pp. 149-150). Likewise, the lack of patent protection enabled Edward Bury & Co to "circumvent much of the evolutionary work undertaken by the Stephenson Company" in producing its own engines (ibid., pp.140, 158-9).

The patenting of the Company's designs from 1831 could be seen as reflecting a more commercial approach to the marketing of its locomotives in response to the rise in demand following the opening of the Liverpool and Manchester Railway the year before and the entry of new competitors into the market. But, this explanation is precluded by the fact that the Stephenson Company still did not have sufficient capacity to meet that demand, even in relation to the number of locomotive orders from the Liverpool and Manchester Railway alone. Thus, the Company continued to share its intellectual property by subcontracting its designs in order to make up for the shortfall.

The culture of sharing technical knowledge on Tyneside amongst the network of mining and mechanical engineers, referred to previously, may have been a factor. Another possible explanation is that design secrecy was not practicable, given the number of

Stephenson Company engineers later setting up in business on their own account. This seems to have been the case in the United States where patent protection proved unenforceable from the 1840s, notwithstanding it was perceived to have "real value" prior to that date. (Usselman, 1991; Brown, 1995, pp.60-61).

However, in the context of the formative railway industry in Britain, it made sound commercial sense to maximise production of the Stephenson Company's designs in order to demonstrate the viability of the railways as a commercial proposition. The amount of capital required to set up a locomotive factory was relatively small compared to the vast sums needed to engineer a rail network, without which there would be little point to the engines. A letter from George Stephenson to Michael Longridge in 1824 estimated the subscriptions needed for a London to Birmingham railway at £700,000 (Skeat, 1973, p. 74). This compared to the capital of the Stephenson Company of £15,000 in 1826, as shown in Table 2 below.

To attract investors in new railways, the Company had to prove that railways were workable. In this regard newspapers could play a part in publicising the commercial viability of railways and their superiority over other forms of transport. For example, *The Caledonian Mercury* carried a detailed report on the Stockton and Darlington Railway (SDR) and noted many pertinent physical and financial data, citing a publication by Michael Longridge (1838, pp.17-18) claiming that the SDR was able to

> convey and deliver coals into the ships on the [River] Tees, at the rate of one penny per ton for each mile … The above fact of the low price of carriage is really surprising, and we believe quite unprecedented in the annals of inland traffic.

This was not simply about doing something that "one day will astonish all England" (Jones, 1981, p.700), but about reaping financial rewards; and not simply in terms of the general increase in demand for locomotives that would result as new railways were constructed. Both George and Robert Stephenson had extensive private practices as consulting engineers to railway companies, and

> believed that their responsibilities as railway engineers included the specification of locomotive requirements. As the specifications inevitably represented the latest design and material characteristics of their Newcastle products, they sought to influence orders to the factory without tendering (Bailey, 2003c, p. 175).

Although such exertion of influence led to conflicts of interest and disputes with some railway Company directors, it helped to provide a regular flow of business to the Newcastle works. Moreover, the high reputations of the Stephenson Company drew visitors and locomotive orders from overseas including Russia, France, Belgium, Prussia and the U.S. (Skeat, 1973, pp. 173-181; Ross, 2010, p. 158). Thus, a synergistic relationship developed between the Stephensons' work in engineering new lines and the work of the Company as locomotive builders. Indeed, Robert Stephenson regarded locomotive building as an "adjunct to the consulting service provided to his clients" (Bailey, 2003c, p. 163).

In this regard, one of the most noticeable features of the *engines finished* and *engines delivered* books (ROB 2/2-3), is the boost to orders from railway companies where the Stephensons were the engineers, notably the Liverpool and Manchester, Grand Junction, and London and Birmingham Railways. The Grand Junction Railway ran from Birmingham to Warrington, joining up with another of the Stephenson lines, the Warrington and Newton Railway, which connected it to the Liverpool and Manchester; thus, linking the two industrial heartlands of the North-West and West-Midlands. The London and Birmingham Railway linked this embryonic network to the capital and the South-east of England. Other newly formed railway companies supplying orders to the Stephenson Company in the 1830s included the North Midland Railway Company, the Manchester and Leeds, the London and Greenwich, the Great Western, and the Newcastle and Carlisle.

Keeping the business afloat: The second related focus for the Company was on maintaining sufficient cash flow to meet its obligations during the development phase, as without that, all its technological efforts would have floundered. Unsurprisingly, therefore, it was this aspect which also permeated the Company's accounting procedures. These included restricting the partners' drawings; tracking debtors and creditors to ensure what was owed was paid; monthly monitoring of orders, expenditure and cash flow; tracking the costs of site visits to ensure the customers were recharged for ancillary expenses. Considering the types of information observed in other British industrial revolution enterprises (Fleischman and Parker, 1997), the most noticeable omissions in the Stephenson records are costings relating to production prior to 1834,[vii] as discussed above. The Stephenson Company made progress empirically by carrying out trial runs to determine speed, haulage capacity and fuel consumption, relaying problems identified back to the workshop for further analysis and coming up with solutions requiring further testing (Bailey, 1984, pp. 134-8). This was an engineering rather than accounting led enterprise based on the belief that if the Company produced good enough engines the market and profits would automatically follow.

Few profit and loss accounts have survived in the archive for the period to 1840, but most balance sheets are available and are summarised in Tables 1 and 2. Although we do not have its breakdown, the figure of net profit for the year credited to capital in the balance sheet is available as shown in Table 2.

Table 1: Summary of balance sheets 1826-1840:
Assets (£'000)
(D/PS 2/1-3; 5-6; 9-13;15-17; 19)

	Property, plant and equipment	Stocks and work in progress	Debtors	Cash	Total assets
1826	8	5	5	2	20
1827	8	3	7	0	18
1828	9	4	5	0	18
1829	10	4	8	2	24
1830	12	6	9	0	27
1831	12	6	12	0	30
1832	13	8	7	0	28
1833	12	5	9	1	27
1834	13	5	6	1	25
1835		Balance sheet missing			
1836	13	15	3	0	31
1837	13	13	18	5	49
1838	13	18	17	16	64
1839	24	26	14	1	65
1840	24	22	15	1	62

Table 2: Summary of balance sheets 1826-1840:
Liabilities and Capital (£'000)
(D/PS 2/1-3; 5-6; 9-13;15-17; 19)

	Creditors	Advances on contracts	Total liabilities	Partners' capital, current and loan accounts	Total liabilities and capital	Annual profit included in capital
1826	5	0	5	15	20	2*
1827	3	0	3	15	18	2
1828	3	0	3	15	18	2
1829	7	0	7	17	24	1
1830	9	0	9	18	27	3
1831	13	0	13	17	30	2
1832	8	0	8	20	28	4
1833	11	0	11	16	27	1
1834	10	0	10	15	25	0
1835			Balance sheet missing			
1836	16	0	16	15	31	2
1837	17	6	23	26	49	13
1838	23	18	41	23	64	13
1839	19	20	39	26	65	16
1840	21	10	31	31	62	11

*The profits for 1826 covered a 21month period from 1.4.1825 to 31.12.1826

What stands out most clearly from the balance sheets is the difficult liquidity position of the Company in its early years and the emphasis on expanding capacity from 1838 as soon as surplus funds became available. For all the years between 1826 and 1836 the cash balance rarely exceeded £1,000 and for six of the years in question it was recorded at zero (Table 1). 1837 seems to have been a turning point for the Company when it started to receive cash advances from its customers for work in progress (Table 2). The more favourable payment terms offered by customers to the Stephenson Company reflected the changing fortunes of the railway industry. By 1837 the feasibility of railway transportation was no longer in doubt, and demand for new lines and the locomotives to run on them was booming at home and abroad.[viii]

As a result of advances by customers, the cash balances were recorded at £5,000 in the balance sheet in 1837 and £16,000 the year later (Table 1), which included surplus cash of £11,000 invested in a deposit account. However, cash balances were not allowed to stay at that level but were invested instead in additions to property plant and equipment of £11,000 (24,000-13,000) in 1839 (Table 1), including £7,000 on new buildings. By the end of 1839, cash balances had reverted to their normal level of about £1,000, illustrating that the priority of the firm was to expand production rather than to maintain a higher safety net of cash.

The period of greatest expansion was between 1836 and 1840 when the Company's assets, liabilities and capital doubled. It was from 1837 that profits started to increase. Prior to that they rarely exceeded £2,000. The relatively low profits prior to 1834 was a reflection of the Company's pricing policy discussed above, which was not based on the full recovery of costs. The low profit figures in Table 2 for 1834 and 1836 (the balance sheet for 1835 is missing) suggest a time-lag before the implementation of the more scientific costing system started to prove effective.

The prime purpose of these accounts was to restrict the partners' drawings in the year ahead to what had been earned in the previous year, thereby helping to maintain liquidity. There is no evidence that the partners used this information to calculate return on capital employed. The only performance indicators we have observed were from the costing data discussed above, which from 1834 compared target profit on each engine to the amount actually achieved.

The following minute confirms that determining the drawings was the central purpose of the balance sheets. It was the responsibility of Michael Longridge, the managing partner to prepare the accounts and send them to the others for them to scrutinise in advance of the annual meeting, at which they would signify their agreement by signing the minute. The minute receiving the 1827 accounts is an example:

> Present the undersigned
> The Balance Sheet ending 31st Dec. last was presented and examined, from which it appears that the capital and debts due by R Stephenson & Co amount to £16502.11.5 and the buildings utensils and other property belonging to them amount to £18414.4.0½ leaving a surplus of £1911.12.7½ whereof £500 were the undivided profits to 31 Dec 1826 and £272.4.10 then allowed for doubtful debts, leaving the net gain of the year 1827 (after paying interest on the borrowed money) £1139.7.9½ ---
>
> 1. Resolved that the sum of £1000 shall be divided among the partners upon the 31st March next
> 2. Resolved, the remaining sum of £911.12.7½ shall remain unappropriated until the next general meeting (ROB 1:29).

It was the partners' practice to restrict drawings to the previous year profits. Thus, the meeting to approve the 1841 accounts approved drawings of £12,500 payable in two 6-monthly instalments out of profits of £13,683. This was decided after scrutinising the order book and the "bankers book" in addition to the balance sheet (ROB 1:59). The key concern was not to undermine the operations by withdrawing too much cash which ran perilously low in the early years.

Monitoring cash flow was also undertaken regularly throughout the year For example, Clause 9 of the partnership agreement contained the following instruction:

> A meeting of the partners shall be held at Newcastle upon the second Tuesday in every Month. The Managing Partner shall at their Meeting lay before the Partners the Cash Book regularly balanced to the last day of the preceding Month, and also a statement of all Debts due to and from the Partnership with every other document which any Partner present may require …. (ROB 1:4)

The emphasis in the partnership agreement on the regular monitoring of cash, debtors and creditors was especially necessary given the Company's reliance in its early years on new railway companies that were also financially unproven and could run into financial difficulties with a knock-on effect in terms of their ability to pay suppliers. This was the case in the 1820s with the Stockton and Darlington and Canterbury and Whitstable railways (Bailey, 1984, pp. 93-96), Edward Pease and Thomas Richardson rescuing the situation.

The correspondence in the Pease/Stephenson papers reflects this ongoing concern over liquidity. Where accounting was discussed, it was only in the context of monitoring cash, debtors and creditors as indicated above, including thinking ahead as to how to improve the situation. Three examples are presented here. First, in an enclosure to a letter dated 7 December 1832, Longridge presented Pease with summary historical balance sheets at 31 July and 30 September 1832 together with a projected balance sheet "To be in future" (D/PS 2/35). Also itemised were "Book Debts to be reduced" by £5,033, given that the total had been allowed to run too high at £8,035. Second, a letter dated 22 December 1837 from Cook, head of the counting house, to Pease states that "our means of prospects are much improved" and discusses the firm's balance of "Cash and Bills" and potential cash flows (D/PS 2/38). Finally, a letter from Longridge to Pease on 23 July 1840 presented estimates of cash flow (D/PS 2/37).

Conclusion

The development of the railway industry from its humble beginnings in works' lines, notably the extensive network of colliery lines in the North-east of England, posed a unique challenge in financing owing to the massive investment required in plant and machinery to engineer national and international rail networks. None of this existed at the point of formation of the Stephenson Company in 1823. The Company was the first enterprise in the world to attempt to prove that such an idea was possible, which it set out systematically to do through its engineering design programme and marketing strategy. The business model was based on the assumption that once the locomotive technology were proven, investment in railway companies would follow, and profits would flow back to the Company through orders for its reliable and efficient railway engines.

In this regard, the Stephenson Company faced two main constraints at this early stage of railway development before the railway explosion of the 1830s and 40s took hold: lack of productive capacity and lack of liquidity. The Company addressed the lack of capacity through what at face-value might appear the counterintuitive move of sharing its designs with potential competitors by subcontracting production to other engineering firms. Sharing knowledge was part of the culture amongst the network of mining and mechanical engineers on Tyneside. However, the Stephenson's policy went further, as the partners recognised that the idea of public railways would flounder unless sufficient engines could be constructed to meet the demand of an expanding rail network, which was beyond the Company's capabilities. The Company did not even have sufficient capacity to supply the formational Liverpool and Manchester Railway (1830) with the number of locomotives it required, hence the partnership with another engineering firm that subsequently moved into the market of locomotive construction on its own equipped with the Stephenson Company's designs.

The second constraint was lack of liquidity during the development phase, which the partners attempted to manage through the careful tracking of debtors, creditors, and cash balances; and restricting partners' drawings to profits earned in the year before. The situation was not helped by the Company's pricing policy prior to late 1833, which was based on what the partners judged the customers were prepared to pay rather than the full recovery of costs. The survival of the Company was not guaranteed up to the early 1830s, therefore, and would not have happened without the support of two of the partners, Edward Pease an industrialist, and his cousin, Thomas Richardson a London banker, both of whom were well-respected members of the Quaker business network. The Quaker connection provided the Company with a financial safety-net as well as increasing orders via Pease and Richardson's network of contacts.

The role of social networks is regarded as instrumental in the formation of social capital in the business history literature, the idea that people do better who are better connected. In this respect, bridging between networks, was crucial to the Stephenson Company's success in this early period. On the one-hand, there was the connection with the closed Quaker network and the level of trust in business dealings and financial support which this conveyed. On the other, the remaining three partners, George and Robert Stephenson and Michael Longridge were part of the colliery engineering network on Tyneside, which provided the Company with the necessary skillset in mechanical engineering and production management to develop locomotives fit for long-distance public railways.

By connecting these two distinct social networks, the Company can be seen as *brokering across structural holes*, or bridging the divide between them, and so gaining access to the embedded resources of both in terms of financial security and technological expertise. However, whilst bridging between and across social networks facilitated the Company's development, it was not central to its strategic decision-making. Rather, this was shaped by the externalities of market conditions, which the Company sought to influence by producing a viable product that would convince customers of its utility, and investors of the potential gains to be had through investing in railway construction. The two aims were also of personal benefit to George and Robert Stephenson's civil engineering practice in providing them with new commissions as the rail network expanded. This was a symbiotic relationship as new appointments by railway companies translated into more orders for the Stephenson Company.

Finally, it is possible to apply the ideas of Bourdieu to the transmutation of the partners' personal capitals into the economic capital of the Company on its formation, which it then developed further through the success of its operations. Two interesting points stand out. The first is that if the area that is being contested is market position, the *economic capital* in that scenario is not simply the business hardware of a company, but a company's intangible asset base. As the paper relates, what the Stephenson Company gained most by consolidating the personal capitals of the partners and their associates into the economic capital of the organisation, were intangible assets such as intellectual property, supply chains, financial connections, and production management expertise, which it subsequently developed into an order book, good customer relations, enhanced reputation, an internationally renowned brand, more intellectual property, and goodwill. In other words, it was the development of the Company's intangible assets that was instrumental to its business's success in the period under consideration, not its tangible fixed assets. As an innovative organisation, this is what one would expect; but nonetheless noteworthy in a Victorian context, as the rising significance of intangible assets in business operations is commonly portrayed as a modern late-20th century phenomenon.

The second point that emerges from the paper relevant to Bourdieu, is that to analyse the conversion of the founders' personal capitals into the economic capital of the Company gives an incomplete picture of the exchanges taking place because as the paper explains, the field that was being contested by the Stephenson Company was not simply the Company's market position, but ultimately the power of the railway industry over all other forms of overland and coastal transportation; i.e., the industry's *hegemonic sectoral capital*, which represents another level of capital beyond the economic capital of particular entities. Moreover, the conversion of the Company's economic capital into the hegemonic capital of the railway industry, through for example, undertaking the formative development work which other engineering companies were able to pick up on and develop further, was not simply a mechanistic process. One should not underestimate the sense of mission of the partners and engineers they employed. It was not simply about providing a commercial product and creating a market that would result in financial benefits, but about a process of scientific and technical discovery and application, which they believed in words attributed to George Stephenson "one day will astonish all England" (Jones, 1981, p. 700). Drawing parallels is dangerous historically owing to the contextual anomalies and variations. But it would be interesting to explore the idea of the conversion of organisational capitals into sectoral ones from a Bourdieusian perspective in relation to the development of other transformational enterprise.

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- ROB 2/5: Particulars of Engines, 1828-1840
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[i] The quest to gain competitive advantage by producing larger steam locomotives with greater tractive potential than their predecessors continued right through to the demise of steam in the 1950s (Fleming et al., 2000), but from the 1840s these improvements were incremental.

[ii] In terms of accounting and finance research alone, Bianchi et al. (2023) identified 162 articles involving social network analysis between 2000 and 2021.

[iii] In the USA, for example, it was the Baldwin Company which dominated.

[iv] According to Usselman (1991, p. 1050), "American railroads *always* exhibited a high degree of cooperation in technical affairs…In technical matters, railroads harbored no secrets". Sinclair (1974, p. 7) noted that, "the mechanics' institute began simultaneously in Britain and the United States."

[v] "Other men of business were partners or employees in a single fixed enterprise, went to the counting-house … or factory in the morning and returned home in the evening. For the Stephensons, [home] was only the base from which they were conducting a range of large-scale undertakings that had no parallel at the time. Some were short-term jobs, others lasted for several years. In supervising or inspecting these projects, they were often only home for brief periods" (Ross, 2010, p.158).

[vi] The variation in selling price could not simply have been the result of an extra allowance from the customer for interest due to delays in the settlement of bills of exchange as Bailey (1999, p.294) suggests, as sometimes it was the other way round with the contract price exceeding the final selling price.

[vii] This was also the case at Baldwin Locomotive Works in the U.S., until the financial crisis known as the *Panic cf 1837* when cost control became paramount.

[viii] The ineffectuality of the British Government's attempts ending 1843 to restrict the export of technology commented on by Jeremy (1977), is reflected in the locomotive works list compiled by Bailey (1984, Appendix IV), which shows the Company exporting locomotives from 1828 and its export market accelerating from 1833.