The social and technological origins of the information society

An analysis of the crisis of control in England, 1830-1900

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Abstract

Purpose – The purpose of this paper is to examine the theory of a control revolution in nineteenth century England, and its social and technological implications for the information society. It takes up where most historical interpretations of the industrial revolution end, and before most analyses of the digital era begin. The work focuses on three distinct types of technological advance – in transportation, in communication, and in the processing of information – without adopting a technologically deterministic argument.

Design/methodology/approach – Historical analysis, based on both primary and secondary sources.

Findings – The article first considers the introduction of the railways, and makes a case in that there were two crises of control involving railway technology in the nineteenth century: a crisis of communication, and a crisis of organisation. It goes on to assess the growth of bureaucracy and organisation in commerce. The expansion of government surveillance power towards the end of the nineteenth century is also discussed.

Research limitations/implications – This paper is broad in its scope and therefore some necessary omissions and limitations have been made. Many of the terms used throughout have entire literatures on their meanings, but it is not the intention of this paper to engage further with these debates, and it is acknowledged that within this limited discussion there is room for some ambiguity surrounding terms. Such concepts have been defined as far as possible within the article. The impact of warfare and military organisation are key themes, and while extremely relevant, deserve fuller discussion elsewhere. Also, while there would have undoubtedly been effects upon the British Empire from English industrialisation and the resulting crises of control, it has not been possible to discuss the implications of differing socio-economic and political conditions within the Empire in this paper. The increasing sophistication of other professions such as finance and accounting in this period have not been considered, although again, this is an area which deserves individual study.

Originality/value – The research takes a step towards demonstrating that the origins of the information society can be traced back to the structural and organisational implications of the control revolution of the nineteenth century. The methods of control created the basic communication infrastructures still used in 2005, and set the precedent for government intervention and social surveillance. It concludes by discussing the potential crises of control within the information society.

Keywords History, Railways, Bureaucracy, Standardization

Paper type Research paper

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The theory of the control revolution

In his book *The Control Revolution: Technological and Economic Origins of the Information Society*, James Beniger (1986) proposed the argument that the American industrial revolution brought about a crisis of control due to the unprecedented rapidity of production and transportation across the country and around the world. Beniger makes a strong case that this new technology was operating in a society which did not have the structure to support it. Consequently, this brought about innovations in economic, technological, and processing control. These innovations, he argues, were the basis for microprocessors, computers and digital technologies with which the USA, and most of the developed world, is now living as we enter the twenty-first century.

Beniger's theory has not, however, ever been critically applied to parts of the world other than the USA. Warner (2000) has referred to the concept, but also concluded that it was nineteenth century America, as opposed to any other nation, that was dominant in the development of dissemination and speed of new types of information and technology. This paper argues that this premise is also particularly valid with regard to England, and attempts to see if it can be translated into a general theory for the origins of the global information society, or whether it is indeed unique to the USA.

The view of many in the information science field is that the so-called "information revolution" is a relatively new development of the last 50 years or so (Bell, 1973; Haywood, 1995; Oppenheim, 1996; Castells, 2000). By restricting the field and history of the discipline in this way, much of the potential to understand this field of study has been impeded. Recent thought such as Warner (2000) supports this argument, although his work focuses more on technology itself rather than the social context it was operating within. This research hopes to demonstrate that information science should not be restricted to the years after the computer and development of such technologies, but that the origins of the "information society" as we know it in 2005 can be traced back to the societal, structural and organisational implications of the industrial revolution of the nineteenth century.

The wider context

While historical interpretations of the industrial revolution and contemporary analysis on the information age abound, they are two largely distinct and separate research areas[1]. This work takes up where most historical interpretations of the industrial revolution end, and before most analysis of the digital era begin. That is, it will not examine the causes of change in the early 1800s, nor will it examine the actual discovery of the new technology. It is concerned with the periods after the first innovations, and the impact they had in terms of being controlled and harnessed by the existing structures. The theory of a control revolution, and the associated social, political, economic and technological variables, means that due to the constraints of time some generalisations have been necessary. Just as "information" is a hugely discussed topic within information science, the actual dates of the English industrial revolution are the subject of much historical debate[2]. However, since neither the origins of the industrial revolution, nor the concept of an "information society", are in themselves the subject of this paper, both phrases will be used as general umbrella terms[3]. In the context of this work, the term "industrial revolution" covers the introduction and application of the railway, the telegraph, and the telephone. These

technologies were introduced in the period 1830-1900[4]. This work concentrates on two areas believed to be of particular significance. These are:

(1) the railways, and

(2) the rise of bureaucracy.

It is also worth pointing out that although this work suggests links between the nineteenth century and the structural origins of the information society, it does not mean to adopt the argument that this was an inevitable progression[5]. Webster (1995, pp. 6-29) discusses how a technological definition of society (specifically an information society) is the most commonly accepted: where emphasis is on breakthroughs in processing, storage and transmission or communication of information, leading to social upheaval. If this view is to be adopted, then the same argument could be applied to the industrial revolution. This paper is not examining the theory that the technology of the industrial revolution *per se* caused the social and structural changes within England. Rather, it will explore the idea that they were intertwined, and that any crisis which did occur was brought about by unprecedented technological developments, encouraging a flurry of innovations to cope and control these new forces, and it was *these* which determined the changes in the organisational structure and communication networks of the early twentieth century.

Railway technology

The scale of change being brought about by the arrival and widespread use of the internet, e-mail, and other digital technologies has been widely discussed in popular literature as well as within academic circles. These technologies are undoubtedly revolutionising our way of life. Yet, it is still difficult for citizens of the twenty-first century to imagine the scale of change brought about by industrialisation in the 1800s. The urban giant of Victorian London was a leap away from the relatively small settlement that it was during the seventeenth and early eighteenth centuries. In 1801 when the first census was taken, the population of central London was 1.1 million, making it the largest city in the world. By 1901, it had risen to 4.5 million (Mitchell and Dean, 1962, p. 20, table 7A)[6]. Prior to industrialisation, the river Thames was the main source of traffic in London. Communication and transportation across the country were measured by how fast it was possible to walk, travel on horseback, or the speed of the wind in a boat's sails. In 1750 it took ten to 12 days to make the 413 mile journey to Edinburgh from London; 100 years later it took only 17.5 hours (Hobsbawm, diagram 16). Today one could make the journey in 4.5 hours. The magnitude of the speed revolution was unprecedented.

Between 1830 and 1850 around 6,000 miles of railway opened in Britain, and by 1850 over £240 million had been privately invested in rail (Hobsbawm, 1969, pp. 88-109). In 1841 the most common occupation for males in Britain, after the traditional area of agriculture, was building and construction, followed by transport and communication. This dominance remained constant until the end of the century[7]. When Hueffer wrote at the turn of the century that transport technology was "the modern spirit expressing itself in terms not of man, but of forces" he seemed to voice contemporary opinion (Hueffer, 1905, p. 40). One may make a strong case in favour of the argument that there was a crisis of control involving the railways and transportation technology in the nineteenth century. In fact, there were two:

(1) a crisis in terms of communication; and
(2) a crisis of organisation.

Crisis of communication

One of the fundamental contributors to the advance of speed in communication and transportation was the steam engine. There were many different railway companies in the nineteenth century – overland companies included the Manchester and Liverpool Railway, London and Northwestern Railway Company, Eastern Counties Railway, London and South Eastern Railway, Caledonian Railway, Stour Valley Railway and the Cheshire and Crewe Railway, to name but a few. Although it is true to say that a distinction could be made between the big London-based railway companies and the smaller branch railways in terms of their relative organisation and structure, in the sense being discussed here – that of effective communication and rationalisation of the service – the issues were very similar across all rail companies[8].

Since the beginning of the railways there was a need to communicate to the train crew the conditions ahead to ensure the safe and efficient operation of the line. Hand signalling was used on the early lines, but it became necessary at junctions to have fixed signal posts. Although semaphore systems had been developed both in England and France before the end of the eighteenth century, and were used for warfare purposes during the Napoleonic Wars, early signalling on English railways still depended on a combination of simple fixed signals and observance of time intervals. Various designs were in use, one common example being disc signals, which are typical of those used at the junctions of the Great Western Railway in West London circa 1844. The discs, hand-operated on site, could be rotated to show simple "stop" or "proceed" indications, and were often repeated on high posts so as to aid the train drivers in advance. This was made more complicated by the fact that each railway line company had its own system, the earliest of which had movable banners and flags with coloured lights at night (Hamilton Ellis, 1958, pp. 329-31). However, there were obvious perils of such systems, particularly as the volume of traffic increased, speeds rose, and night travel became increasingly common. Semaphore was invented in France in the late eighteenth century, and was introduced to rail signalling at the start of the 1840s by Hutton Gregory. The junction in Southeast London at New Cross Gate, on the London & Brighton Railway, saw the first installation of semaphore signals in 1841, which were to become the standard type of railway signals on all British railways.

Charles Walker, the telegraph engineer to the South-Eastern Railway Company, was the first to organise an efficient system of electric signalling for railways, and yet his own description of the signalling illustrates how complicated these early methods were:

> The ordinary position of the arms of the electro-magnetic telegraph semaphores will be down; that is to say, when the line is clear of all trains, and business begins [. . .] all the arms will be down, indicating that no train is moving. When the first train is ready to start [. . .] the signalman will give the proper bell signal to Belvidere – two, three or four blows, according as the train is for Greenwich, or North Kent, or Mid-Kent, or for the main line; and the Belvidere will acknowledge this by one blow on the bell in reply, and without raising the [. . .] red or left arm. This is the signal that the train may go on; and when the train has passed [. . .] he gives out the signal a second time, which the Belvidere man acknowledges, at the same time raising the red arm [. . .] behind the train, and so protecting it until it has passed him at

> Belvidere, when he signals to that effect [. . .] at the same time putting down the red arm there, as an indication that the line is again clear (Routledge, 1900, p. 110).

Not only were these signalling methods complicated, they were also fairly primitive and did not allow for verbal communication between driver and signalmen, to warn of potential dangers ahead. The 15 September 1830 was the opening day of the Liverpool and Manchester railway, which was the first ever "inter-city" railway, an event which "attracted the greatest number of men of eminence in the political and scientific world that had ever assembled" in the town of Parkside[9]. It was also on this day that the first ever passenger fatality occurred. Ironically the person who was killed was the MP William Huskisson, who had been a champion of the new railways, helping to get the Bill for its construction through Parliament. This event suggests that while the technology existed to construct these unprecedented vehicles, the methods of controlling them were not yet in existence. The fatality did not occur because the train (Stephenson's *Rocket*), came off the rails, but because it was devoid of brakes, and was not fitted with a whistle to provide an audible warning of its approach (Fry, 1998). Huskisson did not see its advance and his leg was crushed between the locomotive's wheel and the rail. A contemporary observer wrote that the accident "signalled to the government potential for disaster that were with these new railroads"[10]. The incident was not isolated[11]. In Staplehurst, on the South Eastern Railway, on 9 June 1865, a train was derailed on a bridge that was under repair. A flagman had been stationed too close to the work-in-progress to provide sufficient warning to the approaching trains. The foreman furthered this error when he misread his timetable and commenced work on removing rails unaware that a train was imminent. Ten passengers were killed and 49 were injured. The accidents at Parkside (1830) and Staplehurst (1865) demonstrate that the limited communication on nineteenth century railways, accompanied by human error in using the new technologies, could all too easily lead to serious accidents.

As an aside, there is also the issue here of public acceptance of new technologies – the public first became aware of the use of the telegraph not because of its role on the railways, but rather because of its employment in situations of a more social standing. These situations ranged from its use to convey the news to London that Queen Victoria had given birth to her second son in August 1844; or by helping police to catch a murderer who was attempting to escape by train between Slough and Paddington in 1845; or to the telegraph bringing the result of the Derby to those stationed in the Empire in 1871, taking just five minutes to bring the news from England to Calcutta. (For further discussion of the length of time it can take for social acceptance of new technologies see Haywood, 1995, pp. 128-80.)

Although other counties were also developing telegraphs for the railways at this time, the focus of this study is on England. The South Eastern Railway had installed the electric block-telegraph on its main line in the 1850s, yet there remained no effective way of enabling contact with workmen on the line. Where major work was carried out, reliance was placed on notices to operating staff and strict adherence to the rulebook to ensure the safe passage of trains (Fry, 1998). As Staplehurst illustrated, this was not a particularly successful method. Cooke and Wheatstone patented their version of the electric telegraph in 1837, and after getting permission from London and Birmingham Railways, they installed telegraphic signalling apparatus between Euston station and the engine house at Camden Town. The system worked, but the railway company

refused to adopt it, instead choosing to remain using the method of signalling by pneumatic warning whistle (Clayton, 2000, p. 76). Therefore, even when the technology to facilitate communication was proven to work, it was not automatically seen as an advantage to the old system. The first railway company to successfully adopt the telegraph into railway use was Great Western Railways. It was installed along 13 miles of track between Paddington and West Drayton in 1839, and was such a success it was extended to Slough in 1843 (Hall and Preston, 1988; Clayton, 2000, pp. 76-8). This was also the first commercial use of electricity, an indispensable tool of the information society. While the telegraph alone could not prevent accidents caused by excess speed or lack of effective brakes, it certainly helped to avoid them by facilitating communication between drivers and signalmen (Routledge, 1900; Standage, 1998; Taylor, 2001). It also created new opportunities in the communication of news and information, which opened up entirely novel areas of industry – information exchange that had previously been expressed through letters, or housed in coffee shops, could now be exchanged faster than ever before[12].

The very scale of the rail and transport revolution made scientific technology increasingly necessary. The technological developments of the second half of the 1800s were increasingly scientific based, eventually paving the way for the development of computing in the 1960s[13]. In 1871 the result of the Derby sped from England to Calcutta in only five minutes through the use of the telegraph (Finer, 1997, p. 1619). The telephone, patented by Alexander Graham Bell in March 1876, allowed for instantaneous two-way communication. Compared to the previous delays of hours if not days, this speed of communication had profound effects upon transportation, where drivers and staff in many cases had almost literally been driving blind. The ability to send messages at such speed had major effects throughout England, which will be discussed later in more detail.

Rail technology itself also adapted to facilitate communication through the traditional delivery of postal mail. In 1839 around 76 million letters passed though the English postal system in a year. With the introduction of Rowland Hill's "Penny Post" in 1840, this leapt to 169 million a year. Ten years later, over a million letters were being posted a day. Similarly, in 1840 there were only 4,028 places in the United Kingdom open for receiving letters; but only 40 years later, a staggering 26,753 pillar-boxes and offices could be counted (Fleck, 1958, p. 816; Uncle Jonathan, 1895). The German Max Schlesinger (1853) observed in his *Saunterings in and About London* that "with the general penny postage for England, Scotland, Ireland, and the Channel Islands – with a regular, rapid, and frequent transmission of the mails from and to the provinces, there is, moreover, an admirable system adopted for the distribution of letters throughout the metropolis". He went on to praise the simplicity and efficiency of the English postal service. However, by the latter end of the century traditional horse van or train delivery methods could not cope with the increased volume of mail, caused by rising literacy rates, and cheaper and more accessible postal services. A letter to *The Times* in 1881 illustrates the growing public disillusionment:

> I believe the inhabitants of London are under the impression that letters posted for delivery within the metropolitan district commonly reach their destination within, at the outside, three hours of the time of postage. I myself, however, have constantly suffered with irregularities in the delivery of letters[14].

As a solution to this growing problem, engineers turned to rail technology. In June 1855, Rowland Hill, Secretary to the Post Office, submitted a report to the Postmaster General advocating an underground tube to convey mail. A contemporary engineer, Thomas Webster Rammell also advocated a network of mail tubes beneath the city (Rammell, 1857; Daunton, 1985). Trials of such ideas did take place in May 1861, but were proved to be ineffective because of the "various irregular curves and gradients"[15].However, the truth of the matter was more likely that the Post Office was simply not interested in pursuing what would be an expensive service to introduce, as it was already suffering from competition with the telegraph and telephone companies. It agreed to a limited service in December 1873, but the journey time was not much different to that of a horse van and it was abandoned by October 1874 (Daunton, 1985; Clayton, 2000, p. 132). However, these ideas did eventually lead in the early twentieth century to the Post Office Railway, which ran from Paddington station to the East London sorting office in Whitechapel. It successfully managed to bypass the busiest streets of London, allowing for faster collection, sorting and delivery of post. This service is still in use today under the name "Mail Rail", and around four million letters travel below London each day on automatic, computer-controlled trains, around 70 feet below the ground (Daunton, 1985).

Crisis of organisation

The second crisis faced by the railways was that of their organisation. Prior to the introduction of the railways any form of business organisation, with the exception of government, had only been necessary at a very local level, because the communication and transportation technologies did not exist for anything more extensive. Even in the early stages of industrialisation there remained a very decentralised and disintegrated business structure in most English industries. The most common pattern was of very specialised firms of medium size, which were often extremely localised (Hobsbawm, 1969, pp. 47-8). A reliance on these traditional structures proved to be impossible on the railways, which were operating across geographically huge areas, with large numbers of staff and passengers. As discussed above, communication technologies were adapting themselves to this problem. However, increased speeds and volume of trains caused havoc with the old scattered decentralised means of organisation.

There are many areas of the organisational crisis that could be examined, not least the rise of central administration within the train companies. However, as the development of bureaucracy in business will be discussed more fully later, the two most significant controls to the organisational crisis on the railways were the introduction of timetables and the creation of standardised time.

On the South Eastern Railway line to Folkestone the timings of trains differed each day, and therefore were not published in the regular timetable. The trains became know as the "Tidals", because the service coincided with the Channel crossings. Owing to the shallowness of the harbour at these times, the trains could only enter and leave at appropriate states of tide. However, the special arrangements of these trains were well known as the times were published in a special timetable. Company employees concerned with the running of trains had to ensure that they were certain of the date when looking up a particular train (Fry, 1998; Clayton, 2000). These trains had no back-up control, and were reliant upon the foreman looking up the correct date. Misreading of timetables was responsible for many rail accidents, and was

compounded by train companies sharing lines, but using different timetables. Local timetables were complicated affairs, crowding train departure times, maps of lines, and information on several geographical regions into one small booklet. An examination of several contemporary local timetables shows that departure times were listed in local time, and arrival times were rarely registered to avoid the confusion of a train departing at one local time, and arriving on a different one (Eastern and North Eastern Railway, 1851; Great Western Railway, 1851). Timetables in this form had never been known before; the previous speed and volume of transport had made them unnecessary. However, this type of timetable formed the basis for those that are in use today. Our transport technology may have improved further, but the basic principle of timetabling has remained. One could argue that these timetables formed a new kind of information resource, and while there is not room for a fuller discussion here, there are certainly research possibilities on this subject. In the mid-nineteenth century there were increasing attempts at integrated timetabling, including *Kelly's Rail Directory* of 1859, *The ABC; or Alphabetical Railway Guide* published in 1870, and *Bradshaw*, which was the first attempt at a national timetable, and remained so until the mid-twentieth century. However, local time remained a stumbling block for efficient communication and transportation.

Originally local time had existed because the sun rises ten minutes earlier in London than in Bristol. Therefore, England used to work to "local time", which varied across the country. When journeys took days to complete this was not so much of a problem, yet as speeds of travel improved it became increasingly impractical to work to different time standards. In 1750 it took three days to travel from London to Liverpool, but by 1850 this had been reduced to just over seven hours. Five years later, it was reduced by almost another hour (Hobsbawm, 1969). By the middle of the nineteenth century, when passenger travel had become not only faster but also more frequent, local time was no longer practical, yet it took until 1845 for MPs to lobby Parliament for standardised time across the UK. England was the first country in the world to set the time throughout a region to one standard time. The railways were most affected by the inconsistencies of local mean time, and they effectively forced a uniform time upon the country[16].The first railway to adopt London time (as it was originally called) was the Great Western Railway in November 1840, other railways followed suit, and by 1847 most railways were using London time. On 22 September 1847, the Railway Clearing House (an industry standards body) recommended that GMT be adopted at all stations as soon as the General Post Office permitted it (the role of the Post Office here is significant, as it further illustrates the increasing importance of communication networks in England). By 1855 the vast majority of public clocks in Britain were set to GMT, although some, like the great clock on Tom Tower at Christ Church, Oxford, were fitted with two minute hands, one for local time and one for GMT. The last major holdout was the legal system, remaining on local time for almost 40 years after the first use of standard time was introduced on the railways. The legal system finally switched to GMT when the Statutes (Definition of Time) Act took effect, receiving the Royal Assent on 2 August 1880. International time standards were not agreed until the Prime Meridian Conference of 1884, which established international standard time that is still used in 2005 (Standage, 1998; Blaise, 2001)[17]. This rationalisation of time meant that accurate and efficient timetables could be produced for the first time. It facilitated not only the organisation of railway travel, but also of sea travel, as previously the oceans

were full of competing "prime meridians" and ships of varied national loyalties. The introduction of GMT also marked a fundamental change in the social and economic structure of England as business activity was increasingly orientated towards social, as opposed to natural, time schedules.

Implications for the information society

Charles Francis Adams described the railroad system as "an enormous, an incalculable force practically let loose suddenly upon mankind [. . .] precipitating upon us novel problems which demand immediate solution" (Adams, 1868, p. 335). It becomes clear that there was indeed a crisis of control in transportation technology during the nineteenth century. This was not limited to one "crisis" but an evolving problem over the century, which continued into the 1900s. These issues fell into two broad groups. The first was communication. New transport technologies meant that for the first time goods and people could move faster than human pace. Traditional communication technologies were not able to cope with this change of pace, nor were there the necessary infrastructures available until much later in the nineteenth century. Secondly, a knock-on effect was that increased speeds and volume of trains caused havoc with the old scattered decentralised means of communication and organisation. Not only for reasons of safety, but also in order for train companies to operate profitably, there was a need for rationalisation and efficient processing of information.

Cables for telegraph and telephone systems were largely buried underground, and London was the first city in the world to have a substantially complete underground communications distribution system (Clayton, 2000, p. 79). Contemporary discussion illustrates how the underground train companies, and electricity and telegraph companies, formed partnerships to share the tunnels under London, with subsidised services for each other in return, and section 22 of the Railways Clauses Consolidation Act 1845 made this legally binding (Adams, 1868; Railways Clauses Consolidation Act, 1845; Routledge, 1900, pp. 572-80). In fact, this Victorian underground infrastructure now forms the basis of modern media and internet services, which can transmit over 10 million, million bits of information a second through optical fibres the width of a human hair. The network for the networked society began in the nineteenth century.

The railways and the communication techniques they employed therefore required a greater degree of rationalisation and standardisation if they were to operate effectively. National timetables and the official adoption of GMT in 1880 created organisational processes that were on an unprecedented scale in any industry, in any country.

Feather (1998, pp. 5-14) has argued that the exploitation of steam power led to a new economy of travel and commerce, which reordered the patterns of work, and the structures of society and political organisation. While it is certainly the case that steam power had profound effects upon society and economic structures, Feather's argument overlooks a crucial point. Steam power could not be effectively used within the existing social and economic structures, because the necessary level of organisation and co-ordination simply did not exist. Railways could not operate profitably in the existing structures, and financial and operational crises of control were commonplace (as discussed by Ahrons, 1952; Hobsbawm, 1969, pp. 88-109; Olsen, 1976, pp. 86-90). The reordering of patterns and processes which Feather attributes to steam power were actually more to do with the methods of control in organisation and

rationalisation which were adopted and developed in order to allow the exploitation of railway steam power.

Therefore, by the end of the nineteenth century, the numerous crises led to varying forms of control that helped to establish a system of communication and organisational networks and infrastructures across England never possible before. The train, telegraph, telephone, timetable, standard time, communication and transportation networks and infrastructures were all control solutions to the crisis Adams was discussing in 1868. The crises of control precipitated by the railways were not isolated, and both crisis and control had an impact upon the development of bureaucracy and commerce, which will be discussed below. These developments formed the social and technological origins of information society on the most basic level.

Development of bureaucracy

It has been asserted that the crisis of control on the railways forced new systems of communication, and information processing to be adopted. However, the railways themselves triggered an unintentional crisis in English commerce, as people and goods were mobile in a way never before experienced. Weber (1904) puts forward the idea that prior to the nineteenth century, commerce was dependent upon religious and family loyalties, which had to be overcome before "modern" rationalisation and a capitalist economy could develop. This much has also been asserted by the work of Hoffman (1949), Hobsbawm (1962, 1969), Ashton (1968), Perkin (1969), and Floud and Johnson (2004). The railways, and the developments brought about by their control revolution, had a major impact on the social and economic structures of England. The transportation of goods and workers became easier, faster and cheaper. Communication through the use of the telegraph and telephone allowed businesses to expand geographically and trade with areas that had hitherto been unreachable. The fluidity and movement made possible by these technologies revolutionised the way commerce could operate.

Prior to industrialisation, the government had poor central control of peripheries, large dependence on local elites to maintain order, and limited public policy. Before the nineteenth century, the government had really only been responsible for tax, the law, the army and foreign policy. It was not until industrialisation, and the social issues it brought with it, that the government was forced to provide some sort of centralised control, and welfare state (although traditionally England has never looked to the government in the same way as many European states have, relying more on private investment and entrepreneurs). Prior to 1800, the government had always been subordinate to the monarch, and the nineteenth century saw a switch of roles with the monarch in a more ceremonial role, and parliament wielding the real political power (Richards, 1991; Anderson, 1983). These are huge topics in themselves, but the important point is that the period between 1830 and 1900 saw a profound expansion in government power and responsibility[18]. It is this growth which has caught the attention of academics such as Giddens (1985) and Dandeker (1990), and which shall be discussed in more detail later.

According to census returns, in 1841 public administration accounted for only 0.79 per cent of the labour force (the two largest sectors were building and construction with 7.4 per cent, and agriculture with 28 per cent). By 1911, the figure had increased to 2.1 per cent (Mitchell and Dean, 1962, p. 60, Table 1.B). At the outset, one may expect the

later figure to be substantially higher than it is, in order to account for the growth of bureaucracy during the nineteenth century. However, on reflection the low figure is not so surprising. If the 1841 census showed a small labour force in public administration, could it not be exactly because there was no effective system of public administration, or bureaucracy? This would tie in with the theory of a crisis of control through the very absence of rational administration. The 1911 statistic, although showing a relatively small increase, could signify two things:

(1) the fact that the crisis was not entirely over by the end of the century and the real growth in bureaucracy came in the twentieth century; or

(2) the possibility that the introduction of new techniques, processes and rationalisation meant that fewer people could organise the same amount of information.

With this in mind, the following sections examine the two most significant areas of bureaucratic and administrational development, and focus on the crises of control faced by commerce and government.

Crisis of commerce

Beniger (1986) puts forward the theory that market control had been used even in simple societies using kingship, religion and law since the thirteenth century, but the crucial difference of the nineteenth century was the gradual change from commercial capitalism to industrial capitalism (Beniger, 1986, pp. 121-168). By this he meant that through the railways and communication networks the transportation and distribution of goods and of the labour force had become accessible to everyone, were faster, and cheaper. The industrial revolution had seen a huge rise in private investment in business and in industry, and consequently the banking system had grown and developed (Collins, 1998). Not only the transport system, but also the telegraph and telephone, were allowing commerce to expand geographically, and trade with areas which had previously been unreachable for many small businesses. In Beniger's theory of the control revolution in America, this unprecedented speed and scope of industry led to more efficient ways of managing and organising commerce, through the development of bureaucratic structures and processes. However, here one fundamental difference becomes clear between the control revolution in America, as discussed by Beniger, and the application of a control revolution in England.

While the new technologies certainly revolutionised the dimensions of commerce, the administrative and bureaucratic structures that appeared in America did not develop so quickly (in relation to domestic industrialisation) in England, and the real growth in bureaucracy came after 1900. The numbers employed by local government rose from 83,000 workers in 1881 to over 960,000 in 1979. Similarly, the number of civil servants employed by the state increased from 107,782 in 1902 to 547,000 by 1980 (Perkin, 1990, p. 21; Cohen, 1941, p. 164). There is currently little detailed empirical research on this topic making it difficult to draw any firm conclusions on why bureaucratic development following industrialisation was so much slower: however, some general comments can be made. First, England was the first country in the world to industrialise, which gave her a position of dominance unrivalled until the last quarter of the nineteenth century. With no foreign rivalry in markets or goods, there was no crisis of internal or external competition until the late 1870s, when America,

Germany and France began to industrialise. Unlike the USA and Europe, who faced a competition crisis immediately, there was simply not the pressure on English commerce to change the structure and systems that had served effectively for centuries (Allen, 1933, pp. 1-20; Ashton, 1968; Henderson, 1972; Berg, 1994; Floud and McCloskey, 1994).

Second, as discussed below in more detail, there was practically no direct state intervention in English industrialisation itself. (Although the Victorian period sees an interesting paradox where the English tradition of *laissez-faire* and non-intervention began to be challenged by the very crises of control brought about by industrialisation. Therefore, one begins to see the rise of the early welfare state, more focused social legislation, and the nationalisation of certain industries during the second half of the nineteenth century.) Rather than the state funding the actual process of industrialisation as in Europe and the USA, private investors funded machinery and research. Although this worked well while there was no competition for markets or goods, when Europe and America began to industrialise under the control of government, the English authorities did not step in as quickly as they could have to protect the country's trade. One recognised example of this is the English retention of liberal free trade during the "Great Depression" of the 1870s, while Europe, particularly Germany, was becoming increasingly protectionist, therefore making English trade vulnerable to competition and high prices (Hobsbawm, 1962; Cannadine, 2001, pp. 6, 61). The extraordinary growth in government during the twentieth century can partially be explained by increased government intervention in business and law, and a 30-fold rise in national government expenditure in real terms between 1897 and 1978 (Perkin, 1990, p. 22). Again, because there had been no pressure for government intervention and regulation for the first three quarters of the century, the government was slow to recognise that the situation had changed.

Thirdly, during the last quarter of the nineteenth century when Europe (specifically France and Germany) and the USA were industrialising, these countries managed a faster growth in productivity and technology than England during her equivalent period (Hoffman, 1949; Hobsbawm, 1969; Floud and McCloskey, 1981; O'Brien and Quinault, 1993). This was because of European and US government control and organisation, and due to the fact that they could effectively "leapfrog" ahead using technology already established. However, after 1900, England had difficulty maintaining her global position, because industry and government clung to the processes and methods that had brought success and dominance in the past (Allen, 1933, pp. 3-19; Walker, 1980, pp. 19-37). It was this inertia that precipitated crises in production, procedure and organisation in the face of global competition and rivalry towards the end of the nineteenth century. It was not until later in the twentieth century, faced with the threat of war, that the need to rationalise industrial and business structures became more immediate.

One should be able to see therefore, that the very factors that allowed England to industrialise first, ultimately hampered English dominance by the end of the nineteenth century (Hobsbawm, 1962, 1969; Walker, 1980; Henderson, 1972; Collins, 1998; Cannadine, 2001). The crisis of control in English bureaucracy did occur, but much later than one might expect for a country which began to industrialise 50 years earlier than anyone else. As Beniger (1986) illustrates, in America, the crisis of control transpired sooner after industrialisation because industrialisation itself occurred in the

1860s and 1870s, within an environment of rivalry and competition. It was also government-led, and therefore more centralised in structure from the start. These characteristics can also be found in much of continental European industrialisation, which would suggest that the crisis of control and the development of bureaucratic systems of organisation in much of Europe would also occur closer to the period of industrialisation. More detailed research needs to be undertaken with regard to European industrialisation and the crisis of control in order to support this assertion, but one could certainly put forward the case that the unique timing of English industrialisation ensured that there was no pressure on industry or government to change the old processes and structures until almost a century after the first industrial developments. This late crisis of control would also explain the low growth in labour force statistics for public administration between 1841 and 1911, and the significantly higher figure of 32 per cent of the labour force employed in public administration in 1998 (Hill, 2001, p. 162). This theory is also supported by the fact that in 1913, England dominated the traditional markets of coal production (52 per cent of world market), and cotton (43 per cent of world market), in which English production and processes had always been dominant, yet in the new sectors of steel and chemicals where European competition was strongest, England held only 23 per cent and 19 per cent of the world market respectively (Walker, 1980, pp. 20-2, Table 2.1).

However, this is not to suggest that there were no changes in the organisation of industry during the nineteenth century. The biggest influence on the rationalisation of commerce was an increase in demand and production. The total UK output of coal more than doubled between 1861 and 1891, from 83.6 million tonnes to 185.5 million tonnes, and the country's total output of iron ore in thousands of tonnes rose by around 77 per cent during the same period (Mitchell and Dean, 1962; Berg, 1994, pp. 115, 129). The rise in production, and redistribution of wealth and population, made the structural inefficiencies more evident, which strengthened the case for reform by the end of the century (Allen, 1933; Walker, 1980; Quinault, 1993; Stevenson, 1993). Where industries did become more centralised, it tended to be in towns such as Liverpool, Manchester and London, where demand and production were higher, and in order to maximise production, some form of centralisation and chain of command was necessary. Mechanisation in factories also helped to increase centralisation by allowing products to be rationalised in quality and cost, and consequently, the factory system saw a rise in emphasis on hierarchy, division of labour and supervision (Von Tunzelman, 1993; Berg, 1994; Mokyr, 1994). In the opening pages of the *Wealth of Nations*, Adam Smith (1976) listed three advantages from the division of labour in this way:

(1) the specialisation of function increases skill;

(2) specialisation saves times and trouble of setting up new tasks (therefore, is a time-saving tool); and

(3) simplification of individual tasks paves the way to new inventions (a dynamic "learning" tool).

A fourth principle was put forward by Charles Babbage, now recognised as the inventor of the computer, in 1832 in his work *On the Economy of Machinery and Manufactures*. He argued that the division of labour allowed tasks to be sub-divided

according to skill, so that masters could divide and rule, therefore introducing the concept of hierarchical management decision-making.

While also in its infancy, a great deal is already known about the introduction of modern bibliographic classification schemes, cataloguing rules, and abstracting and indexing services in the nineteenth century (Beniger, 1986; Taylor, 1999; Bawden and Robinson, 2000). However, accounts are usually restricted to the description and application of these organisational tools, and the reason for their implementation is regarded only as something that became possible when information became more easily duplicated and distributed. If one takes this a step further, it is quite plausible to argue that these systems were in fact a method of controlling the problems caused by unprecedented communication, production and geographical scope of business. By the middle of the century George Augustus Sala was commenting that "subdivision, classification, and elaboration are certainly distinguishing characteristics of the present era of civilisation" (Sala, 1859, pp. 218-19). This terminology was even applied to society, with commentators such as Adna Weber writing that the city was "the spectroscope of society; it analyses and sifts the population, separating and classifying the diverse elements" (Weber, 1899, p. 442). Perkin (1993) attributes the growth of these ideas to the rise of the middle class, who were the new generation of thinkers and administrators better adapted to the changing structures of England. Interestingly, a similar argument has been put forward recently by Drucker (1999) in relation to the new generation of knowledge workers which is emerging as a result of the information revolution.

A related point, discussed in depth by Pearson and Richardson (2001), is the rise of business networking during the nineteenth century. The concept of "networking" is more usually regarded as a fairly recent phenomenon, yet the argument proposed by Pearson and Richardson (2001) is that it became particularly distinct during the industrial revolution due to social and political factors and new market mechanisms. The rise of new social classes (a "working" class, and a "middle" class) with more influence on commerce, increased political intervention and legislation (discussed more fully below), and the restructuring of business and communication networks, all facilitated the development of networking. In fact, networking may be regarded as a way of controlling the risk and financial cost of transactions in the transitional commercial environment of the nineteenth century. It is an accepted fact that information is collected as long as its value exceeds the cost of collection, and in the mid-1800s developing communication infrastructures meant that both the collection and value of information on competitors and market conditions was expensive. Prior to the telegraph and telephone for example, Anglo-American business communication meant two months in each direction to cross the Atlantic by boat messenger, and was therefore four months out of date of market conditions by the time a response was received (Beniger, pp. 169-218). Pearson and Richardson (2001), argue that networking helped to enhance the "natural" efficiency gains of operating in increasingly sophisticated but stretched regional, national and international markets by reducing the cost of information, as commercial news and capital resources were shared across a web of acquaintances. This form of resource pooling not only had implications for developing national and international communication infrastructures, but it can also be regarded as an early stage in global business co-operation and rationalisation – an essential part of the information society.

This form of networking was aided through the wider development of the telegraph. For almost a decade after the initial system of 1837, the telegraph was almost entirely confined to the railways, and the first English company formed to undertake the business of transmitting telegraphs was the English Telegraph Company Inc., established in 1846. The telegraph and the telephone were the first commercially useful electronic technologies, and their introduction to business was crucial in lowering the cost of information relevant to business transactions by speeding up the flow of business information, extending the effective spatial scale of markets, and thereby improving the efficiency of the market economy (Hall and Preston, 1988, pp. 37-54). Between 1857 and 1867 the number of messages transmitted by the English Telegraph Company increased four-fold from 881,000 to 3.35 million, while the average cost per message dropped by 50 per cent. The rising importance of the telegraph to business can be seen by the nationalisation of the industry in February 1870, in response to public pressure over concerns that private companies were exploiting the financial rewards of the industry without due concern for competition. The result was a uniform tariff per message of one shilling per 20 words, with the belief that this would bring in substantial revenue to the state. The prediction was proved correct: gross revenue from the telegraph industry between 1870 and 1871 was £801,262; by 1895 and 1896 this had risen to £2.88 million. This volume of traffic necessitated better resources, and the total number of telegraph offices in England rose from around 2,500 in 1870 to 9,926 in 1896 (Hall and Preston, 1988, pp. 37-54; Standage, 1998). New businesses emerged as a by-product of the emerging telegraph industry, through the development, production and laying of maintenance cables, wires and insulators across land and sea. This was a secondary innovation, but just as important, and led the way for a new cable industry, which contributed to the first information highway of telecommunications and infrastructure. The crisis on the railways had produced a method of control which had significant knock-on effects for commerce and communication, which in themselves acted as controls against the crisis of expanding markets and increased volume of information.

Crisis of government

The crisis of government is intrinsically tied up with the rise of bureaucracy and administrative control. One way of examining this is through the theory of industrial society, which regards bureaucratic surveillance as a rational response to the size and complexity of administrative tasks posed by science and technology. Another is the more Machiavellian idea that links surveillance with political and military power. (We may note that Showalter (2004), quoting Beninger, suggests that the "military revolution" of the nineteenth century was closely linked to information capability.) Both are relevant to the origins of the information society.

In contrast to European industrialising nations, the English government had relatively little financial or organisational input into the country's industrial revolution. The reasons for this are complex and have been discussed more fully by Ashton (1968), Hobsbawm (1969), Fox and Guagnini (1985), Crafts (1994), Floud and McCloskey (1994), Collins (1998), and Ferguson (2001). However, the basic argument consists of two points. First, England industrialised earlier than any other nation, and therefore did not have to play "catch up", as did the rest of Europe. There were no external competing markets, so English goods and machinery could be sold to the rest

of the world. Second, England had a strong banking economy that allowed for private investors to fund industrialisation, machinery and technology. Consequently, there was little need for government intervention in the early stages of industrialisation. A further point is that unlike much of Europe, Britain had had a strong constitutional monarchy for many years, and there was a tradition of *laissez-faire*, rather than intervention, in government policy (Proudhon, 1923; Perkin, 1969; Hobsbawm and Ranger, 1983; Colley, 1992; Finer, 1997).

However, by the middle of the century the significant expansion of commerce and communication had begun to necessitate increased government intervention. In the 1830s when the railways were first being built, all that was needed to allow construction was a private Act of Parliament. An examination of the private Acts passed in any one year between 1825 and 1840 lists pages of local railway legislation, merely granting permission to build. However, by 1840, there was a significant change in government policy. Prior to 1840, there had been no national Acts of Parliament controlling or regulating the railways. Between 1840 and 1880 there were 16[19]. Similarly, the 1840s and 1850s saw a mass of legislation regulating hours of work and factory conditions. Although somewhat ineffective, this was the first time that government had been called upon to intervene in this manner. The nationalisation of the telegraph industry in 1870, and the telephone exchanges in 1911 demonstrate an increasing state interest in business and communication. Weber (1904, pp. 22-5) saw bureaucratic structures as "modern rational organisation of the capitalist enterprise", made possible by the separation of business from the household, and which in turn allowed for civic economy and increased regulation. He argued that the capitalist economy required rational structures of law and administration in order to operate effectively. Robert Owen, famous for his support of early trade unions, wrote in 1815 in *Observations on the Effect of the Manufacturing System* that "the general diffusion of manufacturers throughout a country [...] will produce the most lamentable evils, unless its tendency is counteracted by legislative interference and direction". Government bureaucracy was not a new idea, yet the scale of intervention was radically different. The idea had been around in some form since Greek and Roman times, yet the word itself did not appear in English until the nineteenth century, and due to the tradition of *laissez-faire*, quickly became the topic of much political debate. J.S. Mill wrote of the "vast network of administrative tyranny [...] that system of bureaucracy" in 1837, and in 1850 Thomas Carlyle expressed his wariness for the "Continental nuisance of bureaucracy"[20]. During the nineteenth century, as a direct result of the need for some central regulation and authority, the government took on new characteristics, which increased over time and are still evident today.

The most significant of these with regard to this thesis is that government became unprecedentedly intrusive in people's everyday lives (Giddens, 1985; Habermas, 1989; Dandeker, 1990; Finer, 1997). The main parameters that allowed this increased surveillance were the speed revolution (the speed at which messages and freight could be carried), and increased bureaucracy (Finer, 1997). During this period, the government also became more powerful than the monarch for the first time, and Queen Victoria was the last monarch to have an active role in government policy. The growth of cities due to industrialisation and a more mobile workforce saw a rise in crime rates and social discontent throughout the first half of the nineteenth century, which led to the introduction of a police force for the first time through the Rural Constabulary Act

of 1829. The police could use the railways and telegraph systems to mobilise themselves against the threat of social crisis, using the technology of surveillance and bureaucracy to control the civil unrest caused by industrialisation. This is not to suggest a control in the form of dictatorship, but in terms of organisation and the processing of information. The police became a more rationalised profession, and after 1850 there was an emergence of a criminal investigation department, and application of scientific techniques to detection, surveillance and storage of information (Jones, 1982, pp. 2-7, 117-42; Emsley, 1987, pp. 18-47; Finer, 1997, pp. 88-122). However, here we see the paradox of the crisis of government. While this sort of bureaucratic and surveillance control was becoming increasingly necessary in order to allow the new social and commercial structures to operate effectively, the unprecedented intrusion into people's lives and businesses was regarded with suspicion and hostility. As one contemporary French observer saw it:

> to be GOVERNED is to be watched, inspected, spied-upon, directed, law-driven, regulated, enrolled, indoctrinated, preached at, controlled, checked, estimated, valued, censured, commended, by creatures who have neither the right nor the wisdom nor the virtue to do so (Popper, 1972).

This type of fear of government intervention was common, and it bears a striking resemblance to current debates and fears over the issues of data protection and personal privacy. Debates on whether employers or the authorities should be allowed to intercept and monitor e-mails are prevalent in British society in 2005, as is the increasing significance of data protection and the freedom of information. Webster (1995, pp. 52-73) has stressed that routine surveillance is a prerequisite of an effective social organisation, and that organisation and observation have grown together in the modern world. However, there is a darker element to the increase in government power since the nineteenth century, which has been discussed by Giddens (1985) and Dandeker (1990). What is particularly interesting about their arguments is that they stress the role of warfare and military organisation in the rise of bureaucracy. In other words, the surveillance capabilities of the modern state and business were initially, and have continued to be, influenced by the importance of "knowing your enemy". It is no coincidence, perhaps, that the real growth in computer technology and the early development of the worldwide web in the 1960s was largely due to the influence of the Cold War and the space race. The connections between bureaucratic control and public perceptions of government power have continued to be dominant themes in England from the mid-1800s through to the information society of the twenty-first century.

Implications for the information society

By this point, it should be evident that the crisis of control experienced by the railways had profound secondary effects for commerce. By expanding the geographic scope over which goods could be distributed and traded, increasing the mobility of the workforce, and facilitating faster communication, the control technologies from the railway crisis forced a crisis of control in business. Traditional localised structures and processing methods were unsuitable for this new environment, and by the 1860s one can see the development of business communication through the telegraph, national and international resource pooling and networking (made possible by better communication technologies), and the introduction of basic cataloguing and classification schemes in order to control the increased flow of information and

business documentation. However, while a basic commercial infrastructure was developing through the mid-1800s, the real crisis of commerce did not occur until after the turn of the century. From 1880 onwards the emergence of trade unions, the suffragettes, changes in the franchise, a national welfare policy, and state education were all symptoms of increasing links between industrial and civic society. The rise in organisation was the symptom of a more complex and interdependent society, and consequently it was not until after 1900 that significant changes in the bureaucratic structure and organisation of industry begin to be seen.

The crisis of government, however, was different to that of the railways or of commercial bureaucracy. The crisis lay both in the need for central regulation in a rapidly expanding economy, and in the social perceptions of the very bureaucratic control that was implemented. The technologies of speed and communication, and of commercial information processing, forced government to take a more interventionalist role, resulting in the increased power of the state, and organised surveillance in domestic law and order, and foreign security became more commonplace and routine than ever before. The intervention and intrusion of government into the lives and businesses of people was unprecedented and irreversible, inadvertently producing a social crisis of a fear of tyranny and loss of personal privacy. Unlike the crises of control discussed previously, this has still not been entirely reconciled in 2005, as it is impossible to have bureaucratic control and regulation without some form of surveillance. While the sophistication of the techniques and processes has improved, the basis of them has remained remarkably similar. As a recent article in *The Guardian* observes, "the information age has created a paradox: we do not trust government with details of our private lives, but we have let the commercial world intrude all over our personal space"[21]. The origins of this paradox can clearly be traced back to the nineteenth century.

Concluding thoughts

The purpose of this research was to assess the validity of Beniger's control revolution theory when applied to England, and to see if it would be a legitimate general theory for the origins of the information society. Although this work has necessarily been selective in its coverage, it does establish that several crises of control occurred in England during the nineteenth century, and that the methods introduced to manage and organise the new technologies do form part of the structural, although not technological, origins of the information society. The "control revolution" may indeed be applied to countries other than America, although as this research has suggested, the speed and scope of methods of control may vary depending on the context in which industrialisation took place. Consequently, the control revolution may not be as applicable in some other parts of the world as it is in the UK or the USA.

It should be evident that there was no single "crisis", but rather an interrelated series of factors that formed the basic infrastructures, networks and social and commercial structures that supported the development of the IT revolution during the twentieth century. National communication infrastructures, and the beginnings of rapid global communication for the first time; the development of information as an increasingly important commodity in business; the augmented role and power of the state; and the gradual trend towards bureaucratic, efficient organisation, are all just as vital to the information society in the twenty-first century, as they were during the

control revolution of the 1800s. In introducing this research, it was acknowledged that many information scientists view the information society as a development of the last 50 years (Bell, 1973; Haywood, 1995; Oppenheim, 1996; Castells, 2000). This work has taken a step towards demonstrating that this is not the case, and that the origins of the information society in England can be traced back to the societal, structural and organisational implications of the control revolution of the nineteenth century, although there is clearly much more work that needs to be done on this substantial topic.

The control revolution and the information society

It has been argued here that in nineteenth century England technologies were established without the power to harness, control or manipulate them effectively. These crises led to developments of control in three broad areas:

(1) communication techniques and technologies;

(2) organisation and administration; and

(3) the importance of information as a commercial commodity.

Significantly, these areas parallel recent developments in the information society:

- new forms of global communication through e-mail and video conferencing;
- new forms of organisation by digital distribution, intranets and extranets; and
- new uses of information and technology in business through e-commerce, and the rise of the dotcom industries.

These recent technological advances have precipitated many social, economic, and political concerns, which the information society is now facing. These include huge issues with digital divides, digital literacy, and threats to the established economic structures by ventures such as Napster, and apprehensions over personal, commercial and national securities. These concerns suggest that the information society is currently lacking the methods needed to resolve and regulate these issues, and if we look to the nineteenth century crises of control, it seems the most significant developments of the information society may be yet to come.

Notes

1. For the British industrial revolution see Toynbee (1884), Hobsbawm (1962, 1969), Jewkes *et al.* (1969), Henderson (1972), Floud and McCloskey (1994), Ferguson (2001), and Floud and Johnson (2004). For the information age refer to Bell (1973), Giddens (1985), Webster (1995), Feather (1998), Drucker (1999), Evans and Leder (1999), Castells (2000).
2. For further discussion on this topic, refer to Fleck (1958, pp. 814-16), Ashton (1968), Hobsbawm (1969), Mokyr (1994), Schofield (1994), Castells (2000, pp. 30-5). There has also been some recent discussion which puts forward the idea that the process of industrialisation is still under way. Greenwood (1997), Drucker (1999) and Evans and Leder (1999) argue that the rise of computers in the 1960s and 1970s was a phase on from the mechanical and chemical industrialisation of the nineteenth century, and the internet and rise of digital technologies is the stage currently under way.
3. Literature on the definition of "information" and "information society" is vast. Refer to Popper (1972), Giddens (1985), Webster (1995), Oppenheim (1996), and Feather (1998).

4. Although James Watt patented (but did not build) the steam engine in 1769, it was not adapted for practical use in locomotives until 1804, and not for passenger trains until George Stephenson's *Rocket* in 1829. Experiments in electro-magnetism began in 1810, but Wheatstone and Fothergill Cooke patented the first practical electric telegraph in 1837. The first public demonstration of the telephone in England was at the British Association in 1876 (Routledge, 1900, pp. 4, 14, 549, 588).
5. Much has been written on the subject of technological determinism. See Bell (1973), Martin (1988), Smith and Marx (1994), Webster(1995) and Castells (2000).
6. All population figures have been taken from Mitchell and Dean (1962) unless otherwise stated. Table and page numbers refer to this volume. There is a huge selection of statistics relating to this period, each of them varying to some degree. While it is recognised that the sources used within this work may not be absolute, due to time constraints it has been necessary to select one source over others. Mitchell and Dean's work is recognised as one of the most valid resources by scholars, as they have done much of the necessary groundwork analysis on contemporary data.
7. Figures taken from Mitchell and Dean (1962, p. 60, table 1B). Data have been compiled from census returns, based on the categories of the 1911 census. Admittedly there will be differences between categories of 1841 and 1911, making it hard to construct fair comparisons. These differences are unavoidable, although Mitchell and Dean have done much to balance out any irregularities.
8. With thanks to a referee for pointing out the differences between such railway organisations.
9. *The Albion*, 16 September 1830.
10. Samuel Smiles, quoted in *The Times*, 20 September 1830.
11. It would give an unbalanced picture to fail to note that fatalities occurred in sectors other than transportation. In coalmines for example, accidents through uncontrolled technology and safety resources often lead to serious accidents. Hobsbawm (1969, p. 94) lists only a selection of these accidents, including: High Blantyre in 1877, 200 dead; Haydock in 1878, 189 dead; Ebbw Vale in 1878, 268 dead; and Seaham in 1880, 164 dead.
12. The importance and rapid growth of the coffee houses as arenas for information exchange and business is discussed in Brewer (1997, pp. 34-40), Wilkes (2002, pp. 36-7), *The Economist* (2003, pp. 48-50).
13. An example of this can be found in Routledge (1900), which chronologically lists the main inventions of the century, starting with steam, iron production, and railways, and concluding with the phonograph, anaesthetics and chemical explosives.
14. *The Times*, 8 May 1881.
15. *London Illustrated News*, 24 August 1861.
16. The original idea was credited to Dr William Hyde Wollaston, and was popularised by Abraham Follet Osler.
17. Although it is interesting that France still does not concede Greenwich as the Prime Meridian, and continues to observe the "Paris Meridian", French measurements are quoted as x degrees East or West of this line.
18. For more on the role of the government and monarchy, refer to Hobsbawm and Ranger (1983), Richards (1991), Colley (1992), Finer (1997), and Cannadine (2001). Useful reading on the organisation of British industry prior to 1830 includes Berg (1994), Crafts (1994), and Boot (1999).
19. *Statutes of England and Wales*, 1800-1900.

20. Bureaucracy and its impact upon government were the subjects of a great deal of nineteenth-century debate. See J.S. Mill (1861), *Representative Government*, London; Walter Bagehot (1867), *The English Constitution*, London; and James Bryce (1888), *The American Commonwealth*, London, esp. Vol. I, pp. 111-58, 263-9.
21. *The Guardian*, 7 September 2002, p. 21.

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