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Patents and the first industrial revolution in the US, France and Britain, 1700-1850

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Abstract

This paper surveys the recent historiography of three national patent systems during the period of the first industrial revolution – the United States, France and, in particular detail, Britain. The purpose of the paper is two-fold. First, to show in a comparative framework how the institutional parameters of a patent system influence inventive activity. Second, to show that patents can, under certain circumstances, provide a net benefit to society.

1 Introduction

In essence, a patent constitutes the (temporary) right to exclude others from employing a particular technology or invention. Certain requirements must be fulfilled before a patent can be obtained, though. For example, the invention cannot have been known to the public before the patent is applied for, otherwise they would be prevented from using technology that had been previously free to use. With the exception of the United States, it was usual in the nineteenth century for this novelty requirement to be defined in terms of what had been previously used within the same jurisdiction as that of the prospective patent, i.e. you may patent in Britain anything that was in use in France, or indeed wherever else, so long that it was novel within Britain. Now, though, novelty requirements are defined in global terms.

Further, patents can only be obtained by those responsible for developing the invention (although in Europe, the inventor may transfer the right to obtain the patent before the application is filed) and it is precisely their efforts to invent, that patents are designed to encourage. In particular, by awarding an inventor the right to exclude prospective competitors from using their technology, they can appropriate a return above the market rate and recoup their costs of invention as well as their costs of production. This would not be possible in a perfectly competitive market. Of course, perfectly competitive markets rarely occur and indeed, they are especially unlikely to occur in regard to new technology, as large costs are often involved with acquiring the relevant knowledge, violating the assumption of perfect information.[i] Still, some empirical studies support the inference that patent protection subsidises research and development (R&D). One study on French patent renewal data from between 1970-1987, estimated that patents provided a 25 percent subsidy to company funded R&D (Schankerman, 1998). In a similar study of Japanese corporations, it was estimated that the cessation of patent protection would result in a 60 percent decline in R&D expenditure by chemical firms

(Granstrand, 1999). There was, however, a wide degree of sectoral variation. In mechanical firms, the cessation of patent protection would have resulted in only a 5 percent decline in R&D expenditure, and firm surveys consistently show that that the importance of patents varies considerably between different sectors. In their 2000 paper, Wesley Cohen, Richard Nelson and John Walsh surveyed the appropriation methods of American firms, delineating three broad strategies: exploitation of complementary capabilities and lead time, secret working and legal mechanisms, including patenting. Although these strategies are not mutually exclusive, they concluded that in the majority of sectors exploiting lead time and protecting secrecy were more important appropriation strategies than patenting and other legal mechanisms.[ii] Patenting, however, was found to be important in a minority of industries, particularly pharmaceuticals and certain classes of machinery and computing. Pronounced sectoral differences in appropriation strategies also existed in the nineteenth century. At the 1851 Great Exhibition, approximately 30 percent of manufacturing machinery exhibits and 25 percent of engine exhibits had been patented. In contrast, the equivalent figure for chemicals was only 5 percent (Moser, 2012). Historical evidence suggests that at least some of this variation can be attributed to the difficulty and costs involved with acquiring knowledge of new technology that competitors are determined to keep secret. Over the course of the second half of the nineteenth-century, as the tools of chemical analysis improved (the introduction of the Periodic Table was particularly important), so it became much easier to reverse-engineer chemicals. The corresponding response by inventors was to eschew secret working, which had once been widely practised, and to rely instead on patent protection (Moser, 2012).

Thus, the incentive provided by patents to inventive activities is not of equal importance in every industrial sector. Rather, it is largely confined to those sectors where the costs of imitating new technology are comparatively low. A second strand of literature goes further, arguing that not only have the benefits of patent protection been overstated, but that the associated societal costs have been hitherto understated. It is well established that because patent protection leads to an increase in price above the marginal cost of the product, this in turn reduces output, creating a static dead-weight loss. From a neo-classical perspective, this is the principal disadvantage with awarding patents (Rosenberg, 1972), but there is now a more nuanced and extensive understanding of the problems involved with awarding inventors patent rights. Technological development is inherently cumulative, but while an invention is still protected by a patent, any new technology which makes use of the invention can only be commercialised with the permission of the patent holder. This may be given, but usually in return for some form of royalty. Even when there is an active and well functioning market in patent rights, the transactions costs involved with these exchanges still act to hinder sequential innovation. One study has compared the amount of R&D undertaken on those genes which were sequenced by the publicly

funded Human Genome Project, with those sequenced by the private Celera Corporation.[iii] It found that when a gene was first sequenced by Celera, this led to a reduction in subsequent R&D of between 20-30 percent (Williams, 2013). Moreover, this case study involves a willing licensor. Often licences are refused, or patents are used strategically to block new developments coming to the market.

Patent rights are also fragmentary. The ever increasing complexity of technology means that to produce a new product can involve obtaining access rights to hundreds of patents, held by a variety of entities whose interests may not coincide. With so many interested parties with the capacity to block each-other, scarce resources may be underused – 'the tragedy of the anticommons' (Heller and Eisenberg, 1998). The problem is exacerbated when these patents are broadly defined and/or overlap with one another and such a scenario appears to have arisen in nanotechnology, where the U.S. patent office (USPTO) has awarded more than 1,600 patents that make reference to carbon nanotubes, dozens of which claim essentially the same thing (Pearce, 2012). For the researcher or inventor venturing into this 'patent thicket', an enormous range of licences have to be obtained before even the most basic work can be undertaken. Ideally, this problem could be meliorated with a proper examination procedure, which either curtailed and delineated the claims of applications or rejected outright the unoriginal. Unfortunately, examination procedures are flawed and overburdened. It is, for example, the avowed intent of the USPTO to reject patents for inventions which – if actually practicable – would break the laws of physics. This has failed to stem the flow of the incredible and the application procedure is now regarded by many as simply one of registration in all but name (Jaffe and Lerner, 2005).

Another legal requirement for obtaining a patent is to enter a detailed written description of the invention (the 'specification') and recent theoretical work indicates that the best-designed IPR systems are those that over the long-run, augment the pool of technology that is freely available for commercial use (Stiglitz, 2014). In practice, however, it is unclear whether patents really are inducing the circulation of technical information. In the United States, frequent enforcement of Wilful Infringement Rules, (that if an infringer can be shown to have had notice of a patent they were alleged to be infringing, they can be liable for three times damages) has forced many inventors to stop using patent specifications as sources of information. Moreover, it is doubtful whether specifications would actually provide access to useful technical information anyway. Patentees are advised ***not*** to provide a single concise description of the invention as otherwise that can be interpreted as narrowing the scope of the patent, but to instead provide as many conceivable variations of the invention as possible. Engineers reportedly find patents to be 'unreasonably repetitive and in parts almost incomprehensible' (quoted in Roin, 2007, p. 2026).

There are a number of well documented failings with the administration and law of the United

States patent system: ineffective examination of applications has led to the development of patent thickets, there are too many incentives for incumbents with the power to exclude newcomers to stymie sequential technological progress and specifications have been rendered otiose. Although matters are better within the jurisdiction of the Japanese and European Patent Offices (the other members of the global patent triumvirate), for some, the solution is simply to dispense with patents altogether. This has been argued most forcefully by Michele Boldrin and David Levine. They start with the premise that most inventive ideas occur by chance, usually when carrying out a routine production activity (2008, p. 4), and that 'fierce' competition is sufficient for their commercialisation (2008, p. 10). As such, they suggest that there is little evidence that IPR encourages inventive activity and that patents represent an 'extraordinary' and monopolistic imposition, blocking sequential technological development (2008, p. 128).

'Exhibit A' in this argument, which is discussed over the first five pages of their 2008 book, is James Watt's patent for the separate condenser. Watt's condenser was the most important invention in steam engineering in the second half of the eighteenth century and, by radically improving the fuel efficiency of steam engines, it was instrumental to the adaptation and adoption of the steam engine as a source of power to a plethora of new industrial activities, such as cotton spinning and iron smelting. However, according to Boldrin and Levine, Watt and his business partner, Matthew Boulton, were apparently uninterested in manufacturing steam engines themselves, and 'few steam engines were built during the period of Watt's legal monopoly'. Instead, 'their activity consisted primarily of extracting hefty monopolistic royalties through licensing' and, to this end, they 'used the patent system as a legal cudgel with which to smash competition' (2008, p. 2). This, claim Boldrin and Levine, stymied the adoption of the steam engine by potential users and arrested the development of steam-engineering technology: 'Boulton and Watt's steam engine patent most likely delayed the industrial revolution by a couple of decades' (2013, p. 38).

This betrays a naïvely reductionist view of the industrial revolution: it was a much more complex and variegated event than simply the development of the steam engine (as important as that was). Also, as we will see later, matters concerning Watt's patent were far more complicated than Boldrin and Levine suggest. It is also misleading to suggest that there empirical evidence in support of patents is sparse. One study has found that the introduction of pharmaceutical patents in developed countries led to a statistically significant increase in domestic R&D expenditure and pharmaceutical patents obtained by nationals in the United States (Qian, 2007). However, patents had no such effect in less developed countries without the potential to innovate: not a single pharmaceutical patent originating from French West Africa was awarded in Europe or the United States during the period of study (1978-1999). A more wide ranging study up to 54 manufacturing industries in up to 72 countries

between 1981-2000, has found strikingly similar results. Patent rights were found to be associated with faster growth – especially in patent-intensive industries such as chemicals – but again, the effect was greatest in high income countries with the endogenous ability to innovate (Hu and Png, 2013). Firm level studies confirm the same picture. One study of 236 large British firms between 1968 and 1996, demonstrated that the size of a firm's patent stock has an economically and statistically significant impact on productivity (Bloom and Van Reenen, 2002).

Although the terms of the 'patent' debate have become more sophisticated, there is surprisingly little that is substantially new. The first political economists were comfortable with the idea that awarding exclusive rights to inventors encouraged their efforts and that this was a superior policy to offering rewards. Adam Smith, for example, observed that:

> the inventor of a new machine or any other invention has the exclusive priviledge of making and vending that invention for the space of 14 years by the law of this country, as a reward for his ingenuity, and it is probable that this is as equall an one as could be fallen upon. For if the legislature should appoint pecuniary rewards for the inventors of new machines, etc., they would hardly ever be so precisely proportiond to the merit of the invention as this is. For here, if the invention be good and such as is profitable to mankind, he will probably make a fortune by it; but if it be of no value he also will reap no benefit (Meek, 1982, p. 116).

Across the Channel in France, Britain's industrial success was often attributed to the provision of patent rights. In 1803, Jean-Baptiste Say wrote:

> En Angleterre, quand un particulier invente un produit nouveau, ou bien découvre un procédé inconnu, il obtient un privilége exclusif de fabriquer ce produit, ou de se servier de ce procédé. Comme il n'a point de concurrens dans cette production, il peut en porter le prix fort au-dessus de ce qui serait nécessaire pour le rembourser de ses avances avec intérêts, er pour payer les profits … et dans un pays aussi prodigieusement productif que l'Angleterre … cette récompense est souvent très-considérable.[iv]

Even the prototype anarchist, Pierre-Joseph Proudhon ("*La propriété, c'est le vol*!"), thought temporary protection for inventors was a social 'necessity' (Machlup, 1950, p. 9). By the mid-nineteenth century, however, with the ascendancy of the free trade movement and repudiation of monopoly, patents became an obvious target for reform. In England, the standard bearer for abolition was the classical liberal *The Economist* and it anticipated many of the objections made about patents today. One 1851 edition complained that patents stymmied the sequential development of technology: 'On all inventors it is especially a prohibition to exercise their faculties; and in proportion as they are more numerous

than one, it is an impediment to the general advancement, with which it is the duty of the Legislature not to interfere' (*The Economist*, 1851, p. 113). Later, when under the editorship of Walter Bagehot, a rudimentary form of the 'patent thicket' idea appeared, referring to how 'trade is crippled by all sorts of patents for useless, trivial, or "old" inventions' (*The Economist*, 1871, p. 285). Although patent abolitionists were unsuccessful in England, they successfully lobbied for the abolition of the Dutch patent system in 1869 and they were able to delay the introduction of patents in Swtizerland until 1888 (where in 1863, the Federal Assembly had resolved that patents were '*verderblich und verwerflich*' ('pernicious and reprehensible'); Machlup, 1950, p. 5).

Historical evidence has often informed the debate on the social utility of patents and this paper adopts a similar approach with a comparative survey of three national patent systems during the first industrial revolution, in order: Britain, the United States and France. The purpose is two-fold. First, to show in a comparative framework, how the institutional design of the patent system effects inventive activity. Second, to show that patents can, under certain circumstances, provide a net benefit to society.

2 Great Britain

As the first country to industrialise, the example of Britain (specifically England) has a particular significance for this paper. In the early modern period, England was a relatively successful organic economy. Although population almost trebled between 1500 and 1700, it was still able to sustain an increase in GDP per capita of almost 50 percent (Broadberry *et al.*, 2014). As with previous episodes of prosperity, much of this growth was Smithian in nature, based on expanding access to markets and so allowing for greater division of labour over larger areas – although without further technological development, the returns to increasing market size would have begun to diminish. The industrial revolution, which is traditionally thought to have begun in the late eighteenth century, was the harbinger of a very different economic regime, where growth was now largely Schumpeterian in nature, derived from an unceasing flow of new, ever more productive, technology, replacing the obsolete and outmoded.

Broadly speaking, there are two competing explanations for this technological transformation. The first can be seen as a 'demand-side' explanation. This starts from the premise that inventive activity in the eighteenth and early nineteenth centuries was principally motivated by material gain: 'the decision to incur costs to operationalise a technical idea was an economic one' (Allen, 2009, p. 12). What was unique about England, was that it was profitable to incur these costs and to invent the technology of the industrial revolution. This was due in large part to the underlying structure of the economy and Bob Allen has emphasised the role of factor prices (2009). But the availability of patent protection was

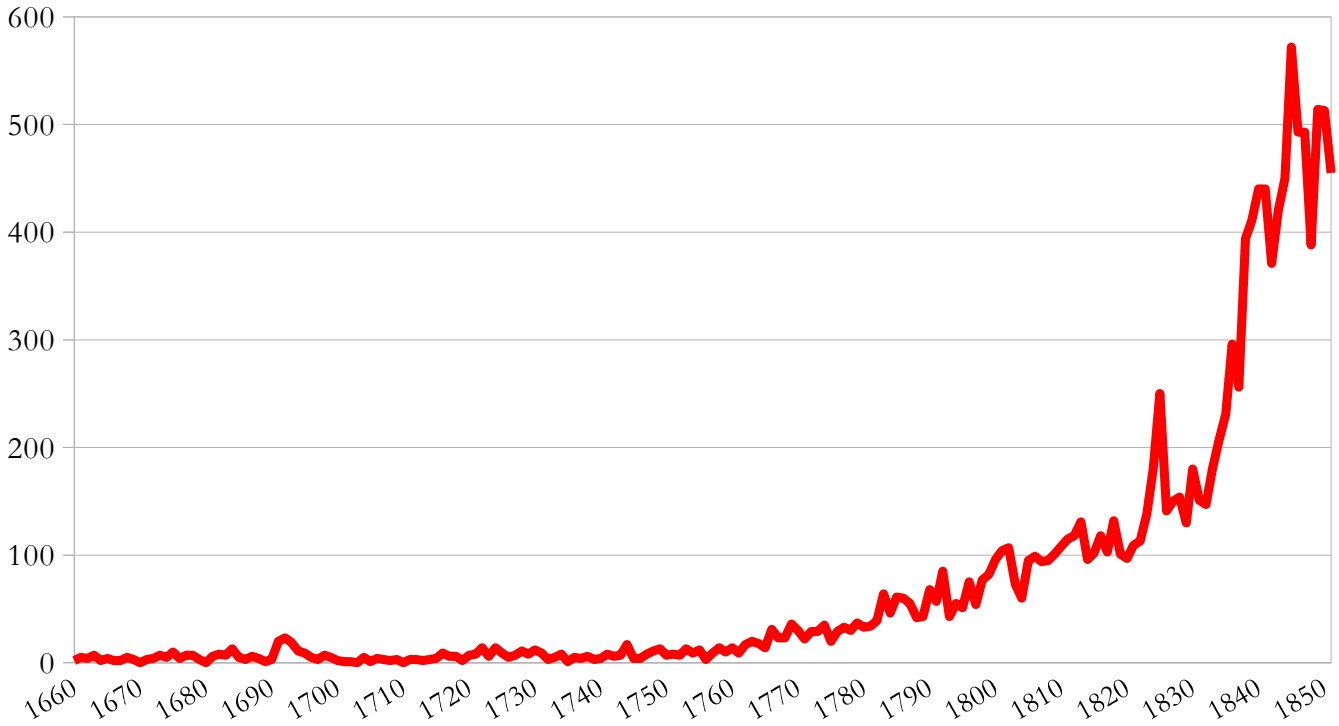
also important, as it meant that 'an inventor with an enforceable patent could recoup the development costs' (2011, p. 368). In a similar vein Stephen Broadberry *et al* argue that high wage rates in Britain induced the adoption of capital-intensive methods of production (2009). Such methods were more susceptible to technological improvement than those based on traditional handiwork. In the textile industry, the transition to machinery had already occurred by 1770 and thereafter, inventive activities were 'strengthened in the institutional context of the patent system in England, which provided a stronger incentive to search for improvements in machine-intensive processes' (2009, pp. 295-7).

It should be little surprise that those economic historians who have favoured demand-side explanations have been attracted to patents as a contributory factor to industrialisation. Just as demand-side explanations assume that inventors were commercially motivated and responded to market signals, so the same logic underpins the granting of patent rights. In contrast, 'supply-side' interpretations of the industrial revolution emphasise exogenous developments in ideas as causative factors, rather than economic pre-conditions. Deirdre McCloskey, for example, argues that perceptions of entrepreneurial activity and the bourgeoisie began to change in north-west Europe during the eighteenth century: 'ordinary conversation about innovation and markets became more approving', allowing both to flourish (2010, p. 7). McCloskey argues that it was these new ways of thinking about business and creativity that led to the industrial revolution. Because the industrial revolution had little, if anything, to do with economic incentives, McCloskey regards patents as an irrelevance; indeed, by obstructing knowledge 'spillover', patents are supposed to have impeded the circulation of these new ideas and the technology that embodied them (2010, p. 337). Joel Mokyr also attributes a causative role in the industrial revolution to new ideas percolating throughout Europe. Beginning in the late seventeenth and eighteenth centuries, there was a growing belief that the material condition of man could be improved by increasing the stock of knowledge and by making it widely available; an intellectual development Mokyr labels the 'Industrial Enlightenment' (2005). He is, however, careful not to entirely discount more traditional economic and institutional explanations for the industrial revolution and although he regards 'the British patent system [as] deeply flawed' he does consider patenting to have incentivised inventive activity via a demonstration effect (2009, p. 409). As long as there were a few lucky patentees who were seen to profit from their endeavours, it would provide a strong signal to other potential inventors.

There are three initial reasons for supposing that patents made at least some contribution to inventive activity. First, patenting became far more common after 1760, when England began to industrialise. Figure 1 plots the annual number of patents awarded in England between 1660 and 1851 (the last full year before the system was reformed). Between 1660-1760, few patents were awarded in England; it was unusual for more than a dozen to be granted in any one year. Thereafter, however, the

number of patents increases rapidly so that in 1800, 96 patents were awarded and in 1850, 513.

Figure 1.1
English patents, 1660-1851



Second, very few important inventions or inventors of the industrial revolution bypassed the patent system entirely. In one exercise, Ralf Meisenzahl and Mokyr (2012) examine some of the characteristics of 72 'superstar' inventors born between 1660 and 1830. Of these superstars, 81 percent obtained at least one patent in the course of their careers, 21 percent 10 or more. In a larger dataset, including an additional 687 'tweakers' or 'implementers' (or rather, less significant inventors), Meisenzahl and Mokyr find a lower propensity to patent - 40 percent of their sample never obtained a patent over the course of their career and only 35 percent 2 or more. Meisenzahl and Mokyr consider these to be modest figures, noting that 'a full 25 percent of the superstars did not patent all of their inventions' (p. 473). Compared to what would likely be patenting rates today, these figures are indeed modest. However, it also suggests that 75 percent of important inventors *did* patent the majority of their important inventions: a scenario that is unlikely to have occurred at any previous point in time, anywhere in the world. Moreover, these figures understate the proportion of inventive output that was patented. First, multiple inventions could be included in the same patent, and this was a frequent occurrence. Second, these figures exclude those inventors who did obtain patents, but used the name of their patent agent instead: one London agent, Moses Poole, was named on 105 different patents

(Woodcroft, 1969). Finally, it excludes those inventors, such as Thomas Newcomen, who worked their inventions under the patent of another party, often a business partner.

Third, in a related point, until patent laws were passed in France and the United States in the 1790s, no other country in the world had a patent system which was used so frequently by inventors – with the partial exception of the Venetian Republic, which had instituted the world's first patent law in 1474 (Berverglieri, 1995). Alas, empirical work on the British patent system depicts a system wherein patents were often prohibitively difficult to obtain and rarely enforceable at law (Dutton, 1984, MacLeod, 1988, 1991). Prior to reform in 1852, the British patent system was not administered by a single, centralised authority but rather, a slew of government offices, departments and law courts, through which every patent petition had to pass. The inventor was responsible for physically transmitting their petition through every step, requiring personal attendance in London. This would not have been so burdensome, if the petition had not taken six months to negotiate and few inventors could afford to abandon their business affairs for so long. Moreover, this 'tortuous labyrinth' (Dutton, 1984, p. 76) had to be negotiated twice more, if an inventor sought protection in Scotland and Ireland. Inevitably, patents were expensive to solicit – all told, an English patent cost about £145 during the first half of the nineteenth century. As a multiple of average earnings, the 1800 value would equate to around £150,000 today; for 1850, around £105,000. Even with 'statutory reforms in 1852 and 1883, it [the patent system] remained barely fit for purpose' (MacLeod and Nuvolari, 2010, p. 4).

Having paid their money, what was the inventor left with? Well, despite its convolution, the petition procedure was entirely pro forma and patents issued as a matter of course (MacLeod, 1988). Without any examination of the proposed patent, the legal cachet of the eventual grant was necessarily undermined and 'the market value of a patent depended upon a successful case at law' (Dutton, 1984, p. 179). Unfortunately for patentees, this was supposed to be exceedingly difficult to obtain, especially before 1830. The judiciary were apparently hostile towards patentees and Dutton cites one instance where Chief Justice Kenyon pronounced himself, 'not one of those who greatly favour patents'. Although vague on how he defined 'hostility' or 'prejudice', Dutton is clear on how it manifested itself – as an infeasibly strict interpretation of the law, 'allowing no error, however immaterial' (1984, p. 77). Under such circumstances, patentees were naturally loath to venture their patent rights in court. Dutton estimates that between 1770 and 1799 only sixteen patents (compared with 1,418 awarded over the same period) were litigated and in the absence of any statutory law besides the antiquated Statute of Monopolies (1624), there was almost no legal guidance for inventors. Such were the difficulties involved with enforcing patents, they were rarely 'worth the parchment [they were] written on' (MacLeod, 1988, p. 69). It was only around 1830, when there was an apparent 'sea-change' in attitudes, that judicial hostility was replaced by a growing appreciation of patenting's role in encouraging invention. The law

courts eventually began to develop a coherent body of law, placing patent rights on a more secure footing. It was, for example, eventually confirmed in *Crane* v. *Price* (1842), that processes and methods of manufacture were patentable.

Recent work, however, suggests that the British patent system – decrepit as it might ostensibly appear – was adaptable, and that important changes did occur to improve the accessibility and enforceability of patent rights during the eighteenth and early nineteenth centuries (Cornish, 2010; Gubby, 2012; Bottomley, 2014 (a, b)). One development of particular importance was the appearance of patent agents in the third quarter of the eighteenth century. By employing an agent, it was no longer necessary for an inventor to transmit his petition through the various offices in person, and there was actually very little they needed to do. In 1829, one agent testified before Parliament that '[T]he only acts the inventor is obliged to perform himself, are the making of an affidavit of his having invented the object for which he applies for the patent; paying his money; and afterwards, making out, acknowledging and signing the specification of that invention; all the rest may be done by his attorney, or patent agent' (quoted in Bottomley (a), p. 66). This could be done by post and by relieving inventors of the burden of travelling to London, agents offered an extremely valuable service; by 1849, virtually all inventors employed an agent (even if they resided in the capital).

Agents also provided a variety of ancillary services. First, they maintained extensive contacts throughout Europe, helping inventors acquire protection abroad. The notebook of one agent, Moses Poole, shows that by the 1820s, he had representatives as far afield as Sweden and Russia (Bottomley, 2014 (a)). Inventors regularly availed themselves of this service. In the 1820s, Britons obtained, at the very least, 170 patents in France (6.3 percent of the total awarded) and in the 1830s, 415 (7 percent of the total awarded).[v] International patents were usually obtained with the intention of selling the rights on to locals. A noteworthy example was Henry Bessemer, who was able to sell an exclusive licence to the Spanish patent for his steel converter, for £5,000 (Paetal and Saiz, 2012).

Second, agents also maintained domestic contacts with investors and manufacturers for the benefit of their clients. Investors were able to help inventors with the expense of obtaining patents (with a view to obtaining a share for themselves) and the engineer Samuel Clegg (famous for his self-activating meter, used to measure gas) claimed that 'if a workman has discovered anything … likely to be beneficial, there is no difficulty in procuring anyone to join him in the expense of taking out a patent for it' (quoted in Bottomley, 2014 (a), p. 70). Instances where important inventions went unpatented for lack of funds (such as happened to Samuel Crompton and his spinning mule in 1779) were more unusual in the nineteenth century. As we will see, it was also common for manufacturers to come to longer term arrangements with inventors, to work the patent in partnership. Third, because of their familiarity with extant patents, agents often provided inventors with technical advice, especially on

the practicability and patentability of new inventions. The appearance of patent agents made it much easier for inventors to obtain patents (by 1849, the time taken to obtain a patent had fallen to one month) and their importance has been hitherto understated.

Neither was the administration of patents ossified – in response to the growing number of petitions, the law officers, the officials primarily responsible for administering patents, increased the number of clerks they employed. The law officers also administered the system of caveats. A caveat was a form submitted with a law officer, requesting that the caveat holder be given notice of any patent petition which pertained to a particular area of interest, as defined by the caveat. Upon receipt of notice, the holder could choose to oppose the petition at a hearing, if he believed it conflicted with one of his own inventions. In the absence of systematic examination of petitions, the caveat system was important because it provided the only means by which the claims of the petitioner might be investigated. From 1838 to 1847, the law officers held 1,687 caveat hearings, as a result of which, 181 petitions were refused (equivalent to 3 percent of the 5,993 petitions received over the same period) and 203 petitions had to be amended (3.4 percent). For comparison, when systematic examination was introduced in America in 1836, between 20 and 50 percent of applications were refused, much higher than the 6.4 percent of English petitions which were refused or amended. Still, contemporaries thought that caveats worked well and that they acted as a preventative check to illegal grants. One witness in a select committee investigating patents observed that 'the knowledge that a person may be stopped before the Attorney-General, prevents persons trying to play tricks which would otherwise be attempted' (quoted in Bottomley, 2014 (a), p. 57). Caveat opposition was also thought to endow at least some legal cachet to the eventual grant. In an 1849 Select Committee, on being asked 'what part of the present system is that which you think gives such an efficient protection to the patentee?' the patent agent Frederick Campin replied, 'I think these stages, the [law officers'] report, the bill and the Great Seal, where we could have opposition' (quoted in Bottomley, 2014 (a), p. 58).

The pre-reform patent system was by no means 'perfect'. High fees in particular, excluded many from obtaining patent rights. But neither, however, was it as ineffective as has been suggested – the problem with high fees, for example, was alleviated to some extent by the good offices of patent agents. Moreover, the enforceability of patents has also been underestimated. First of all, the notion that the judiciary were implacably opposed to patents has been repudiated (Gubby, 2012). Rather, it is clear that the large majority of judges understood the rationale behind awarding patents. In *Hornblower* v. *Boulton & Watt* (1799), Justice Grose observed that 'the aim of the Legislature is obvious … it was to encourage ingenious artificers and able and studious men to invent and bring forward for the use of the public new manufactures, the produce of their ingenuity, by holding out to them the reward of the 14 years' monopoly' (1 HPC 391). Earlier, in *Arkwright* v. *Nightingale* (1785), Lord Loughborough stated,

'[T]he law has established the right of patents for new inventions; that law is extremely wise and just' (1 HPC 239).

Consequently, patentees *were* willing to take legal action to enforce their rights. Work on patent cases in the Court of Chancery between 1714 and 1758, shows that there were, at the very least, forty-one cases instigated by patentees (Bottomley, 2014, (b)). The Court of Chancery offered patentees a variety of legal remedies – most importantly, injunctions. An injunction was a court order restraining the defendant from infringing the patent, or risk being found in contempt of court and potentially imprisoned. For inventors who had been working their patent for several years, injunctions were relatively easy to obtain (except when Lord Cottenham was Lord Chancellor, between 1836-1841 and 1846-1850) and they provided the most effectual means by which patentees could directly enforce their right to exclusive use of an invention. Moreover, if patents could not have been enforced in the law courts, then more informal enforcement mechanisms would have broken down – patentees could not have credibly threatened interlopers. The ready availability of injunctive relief in the Court of Chancery meant patents could be enforced against infringements without always resorting to legal action.

One final point needs to be made concerning the substantive development of patent law. Dutton suggested that it was only in 1842, that the judiciary were able to decide that methods and processes of manufacture could be patented and that they were therefore dilatory in developing a body of legal precedent that was applicable to the rapidly changing economic and technological landscape of the period. However, the patentability of methods and processes does not appear to have exercised contemporaries – it was generally understood that they could be patented. In *Boulton & Watt* v. *Bull* (1795), for example, defence counsel did not try to dispute the admissibility of methods as patents, acknowledging that 'the word manufacture is descriptive either of the practice of making a thing by art, or of the thing when made'. Similarly in *Huddart* v. *Grimshaw* (1803), Lord Ellenborough made reference to his prior experience as Attorney-General and agreed that different methods and 'modes' of manufacture were patentable even if they all produced the same generic product:

> It does not follow, that because the ends are materially the same, it is thereon open to the public. It has happened to me in the same morning to give, as far as I was concerned, my consent to the granting of three different patents for the same thing; but the mode of attaining it were all different, and I thought I was entitled to receive them.

In theory, by allowing them to exclude other parties from using their invention, patents help inventors appropriate returns and so incentivise the development of new technology. During the industrial revolution, inventors were able to enforce this exclusion on potential competitors – and this resurrects the possibility that the patent system did indeed encourage the development and diffusion of

technology. The crux of the matter lies in whether inventors could actually use patents to appropriate returns from inventive activities and if so, how. It is especially important that inventors were able to transact patent rights, for three principal reasons:

1. Many inventors were unable to commercialise their inventions themselves. Instead, by selling or licensing their patent, inventors could realise returns without incurring the risk of going into business.
2. By selling a portion of the patent as part of a partnership agreement, inventors could obtain access to manufacturing plant and/or capital. Without sufficient capital, it is difficult to turn an invention to profit.
3. Licensing allows other parties to use patented technology, facilitating the physical dissemination and sequential development of new technology.

Contemporaries often commented upon the frequency of these transactions and quantitative work confirms this. Between 1770 and 1845, around 30 percent of English patents were assigned in full (with little variation over the whole period) and another 25 percent were either assigned in part and/or licensed as well.[vi]

It is more difficult to demonstrate that these transactions were commensurate with the value of the technology involved or suitably lucrative for the inventors concerned, (although such a judgement will be somewhat subjective). Certainly though, there were many inventors during the industrial revolution who failed to reap any rewards from their endeavours and ended their days in poverty – John Kay, James Hargreaves and Richard Trevithick to name but three. Moreover, Kay, Hargreaves and Trevithick all chose to patent their most important inventions (respectively, the flying shuttle, the spinning jenny and the first high-pressure steam locomotive), but to no avail. Understandably, cases such as these have led many to query whether patents ever helped inventors appropriate returns from inventive activity; in the words of Greg Clark: 'the empirical difficulty with the appropriability argument is the appallingly weak evidence that there was any great gain in the returns to innovators in England in the 1760s and later … the Industrial Revolution economy was spectacularly bad at rewarding innovation' (2003, p. 20).

This, however, overlooks two important points. First, possessing a patent for an invention, even one that posterity might recognise as 'revolutionary' or 'ground-breaking', does not mean that profits will automatically ensue. Inventors needed to possess at least some degree of business acumen (or if they did not, to find a business partner who did) if they wanted to introduce and commercialise new technology in what was, relative to today, still a technologically conservative society. Second, and more important still, it overlooks what was unique about England in the eighteenth and early nineteenth

centuries. It is not that inventors sometimes failed to profit from patenting their inventions but that others were able to do so at all: this was the first time and place where inventors were frequently able to appropriate large returns from new technology via patenting. An early example is provided by Thomas Newcomen who introduced his atmospheric engine (the first commercially viable steam engine) under the auspices of a pre-existing patent, along with the co-founders of the "Proprietors of the Invention for Raising Water by Fire". Newcomen earned, at the very least, £5,100 from dividends and share sales, in addition to what he was able to earn when directly employed by engine users (Bottomley, 2014 (a)). Even more profitable was the silk-winding machinery patented by Thomas Lombe in 1718 and worked in partnership with his half-brother John and his cousin William. Over the course of the patent term (1718-1732, the standard fourteen years), Thomas made £80,000, and when he died in 1739, he was able to leave his family £120,000, a colossal fortune by the standards of the day (Prosser, 2004).

If we move on to the period of the industrial revolution proper (usually dated *c.*1760-1830), then there was a multitude on inventors who made their fortune with patented technology, often worked in partnership. Perhaps the most famous example was the partnership between James Watt (a steam engineer who left over £60,000 in his will) and Matthew Boulton, although there were many others such as Strutt, Need & Arkwright (cotton spinners); Marshall, Benyon & Murray (flax spinners) and Neilson, MacIntosh & Wilson (iron founders; Dutton, 1984). These men often came from humble backgrounds. Thomas Newcomen was an ironmonger from Dartmouth, Richard Arkwright began working life as a barber's apprentice. Thomas Lombe's father has been a worsted weaver from Norwich; his daughters married into the aristocracy. It is difficult to envisage how Lombe *et al.* could have accumulated such wealth over the course of their lifetimes without proprietary rights over the technology they developed. This re-establishes the point that it was possible for inventors – with luck – to make their fortunes with patented technology.

The active market in patent rights also reduced the likelihood that patents would frustrate the sequential development of technology. Indeed, the 'pyramidal conception' of patents – where if an inventor developed an improvement to a product or process for which a patent was in force, the improvement could be used under licence – was of extremely long standing (Cornish, 2010). In 1764, for example, John Morris patented an improvement to Jedediah Strutt's stocking frame (used for knitting ribbed stockings and itself patented in 1759), which he was able to work under licence from Strutt.

As was discussed in the introduction though, James Watt's enforcement of his patent for the separate condenser is thought to have frustrated the development of steam engineering and to have 'delayed the industrial revolution by a couple of decades' (Boldrin and Levine, 2013, p. 38). The argument, however, is founded on three mistaken premises. First, Boldrin and Levine suggest that Watt

wielded a virtual monopoly over the construction of steam engines during the course of his patent term (1769-1800). However, Watt and his business partner Matthew Boulton were responsible for less than a quarter of steam engines erections during this period (Kanefsky and Robey, 1980). Consequently, there was no change in the growth trend of steam engine installation during Watt's patent term – it did not confer that degree of market power. Second, Boldrin and Levine assert that 'it is only after their patents expired that Boulton & Watt really started to manufacture steam engines' (2008, p. 2). Their accounts suggest otherwise. By the last full year of their patent term (October 1799 to September 1800), Boulton & Watt were manufacturing goods to the value of almost £30,000 per annum (Bottomley, 2014 (a)).

Finally, Boldrin and Levine argue that Watt used his patent 'as a legal cudgel with which to smash competition' (2008, p. 2). In particular, Watt was supposed to have used his patent against those (in particular, Jonathan Hornblower) who were beginning to use steam at high pressures to actively 'push' against the piston, rather than using the pressure exerted by the atmosphere to 'pull' the piston down. This would be significant because high-pressure compound engines became the predominant engine design for stationary steam engines during the nineteenth century. However, during the 1780s, Hornblower's engines worked poorly. They cost nearly three times what he had originally budgeted and by 1785, Hornblower's 'engine man' at Radstock colliery was feeding information to Watt in the hope of gaining employment with him instead. As long as Hornblower's engines remained uncompetitive, the partnership decided to take a relaxed attitude to his endeavours: 'As to the trumpeting [Watt's occasional expression for Hornblower] if anybody is wicked enough to erect one of their Engines let them, and when we can do no better lett us try the law' (quoted in Bottomley, 2014, (a) p. 260).

Yet when the Hornblower engine did become a viable alternative in the 1790s, Boulton & Watt refrained from taking legal action until 1799. There are two reasons for their apparent restraint. First, the *threat* of legal action proved to be sufficient for extracting royalties from those mine owners who were using Hornblower's engines. Ambrose Weston, Boulton & Watt's lawyer, believed that over the course of the patent term, mine owners had been intimidated into paying around £40,000 (although this figure is probably an exaggeration; Hills, 2006). This explains why the partnership was able to wait until 1799 to enjoin the use of a Hornblower engine: they had no cause to. Second, Hornblower never used the compound engine at high enough pressures for it to become fully competitive with Watt's own design; after the expiration of Watt's patent in 1800, not a single engine was erected on Hornblower's design. Instead, the opportunities presented by high-pressure compound steam engines would be first exploited by Arthur Woolf, who patented his engines in 1804 and 1805.

This calls for a more nuanced interpretation of the Watt patent and how it might have impeded the sequential development of steam engineering – it was possible to use a Hornblower engine

unmolested, as long as royalties were paid to Boulton & Watt as well. Of course, the payment of these royalties would have increased the price of a Hornblower engine and this would have disincentivised its adoption by potential users, some of whom may have been in a position to realise the benefits of using the it at higher pressures. Perhaps with more business, Hornblower would have come to realise this for himself. But the argument is now more speculative, and one that is unlikely to be proven.

Instead, a much stronger, positive, argument can be made that the patent system encouraged sequential technological development by enabling the diffusion of technical information. After 1734, inventors had to submit a detailed written description of their invention at the Court of Chancery – the 'specification'. This requirement formed the jurisprudential basis of the English patent which was conceived as a contract. In 1789, for example, Justice Buller observed that 'the consideration which the patentee gives for his monopoly, is the benefit which the public are to derive from his invention after the patent is expired; that benefit is secured to them by means of a specification of the invention' (1 HPC 327). If the description was found to be inadequate, the patent was annulled, and inventors spent up to £200 hiring technical and legal assistance for preparing their specifications. Moreover, specifications were not encumbered with legalise – it was a specific criterion, that they were to be intelligible to a mechanic or workman, albeit one who had some familiarity with the relevant area of technology (see, for example, *Boulton & Watt* v. *Bull* (1795), 1 HPC 380).

Anyone could visit Chancery to consult a specification, and during a period when technical information was not always readily available and/or verifiable, patent specifications came to form a uniquely reliable and up-to-date source of industrial technology. Inventors and manufacturers frequently consulted specifications at the Court of Chancery and it was observed that the availability of specifications entirely undermined the prohibition on the export of machinery then in force. In 1824 Bryan Donkin observed that 'a foreigner, or any person, for a few shillings, can go to our record offices, and examine a specification, containing a description of the best machines we have, because for all the most valuable machines patents are obtained; specifications are by law registered there, and the offices are open to any man, and copies may be obtained at a small expense' (quoted in Bottomley 2014 (a), p. 198). Moreover, specifications were frequently published in contemporary technical journals (for example, *The Repertory of Arts* or *Mechanics Magazine*) and, indeed most of the material carried by these publications was derived from patents. These publications enjoyed large circulations (the *Mechanics Magazine* sold 16,000 copies a week at 3d.) and by publishing patent specifications, they offered a significantly cheaper way of obtaining the latest technical information than if it had remained in tacit form/worked in secret – a likely scenario in the absence of patent protection. The ready availability of patent specification should also have reduced the wasteful duplication of inventive activity.

The British patent system was by no means perfect, their expense certainly limited access to its

provisions. It has been suggested that high fees were retained to 'deliberately generate disincentives for inventors from humble backgrounds' (Khan, 2011, p. 28) and that there was a pervasive belief in Europe 'that only a very narrow group of the population was capable of truly important contributions to technological knowledge' (Khan and Sokoloff, 2008, p. 140). This is an unfair assessment of 'elite' views (as evidenced by the parliamentary select committees on patents) and of 'popular' views; literary evidence shows that inventors were often represented sympathetically and/or romantically as geniuses of humble stock, toiling alone in their workshop (Pettit, 2004). Instead, high fees, along with caveat opposition, was used as a filtering mechanism, limiting the number of patents that were awarded and reducing the chances of a patent thicket developing in the absence of systematic examination. In addition, consistent with the jurisprudential emphasis on the specification, sufficiency requirements were strictly enforced (see, for example, *Turner* v *Winter* (1789), 1 HPC 321), reducing the likelihood of overlapping patents. It has also been established that patents were enforceable, and the Court of Chancery was a particularly important and effective tribunal for patentees seeking to enforce their rights to exclusivity. Consequently, many inventors were able to appropriate returns from inventive activities and without the provision of patent rights, research projects where the resultant technology could not have been commercialised in secret – such as was often the case in steam engineering and manufacturing machinery (sectors that were integral to the industrial revolution) – would rarely have been privately profitable.

3 The United States

Prior to independence, patents for the American colonies were obtainable in London and they could even be litigated there.[vii] Similarly, individual states granted patents, the first such award occurring in Massachusetts in 1646 (Khan, 2010). Drawing on British practice, the founders of the new Republic were determined to offer protection to new inventions (although they consciously diverged in some important respects, e.g. American patents were much cheaper at $35). In the first Article of the United States Constitution, Congress was mandated to 'promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries' (Art. 1, § 8, cl. 8). A year after the Constitution came into force, the first patent legislation was passed by Congress. Initially, it required patent applications to be examined by the Attorney-General (Edmund Randolph), the Secretary of War (Henry Knox) and the Secretary of State (Thomas Jefferson). Thorough as this was, it consumed the valuable time of senior political figures and the examination of patent applications was abandoned in 1793. In its place, a system of straightforward registration was instituted, which made no provision for the examination of applications and even

obvious copies could be patented (Thomson, 2009).

Non-examination appears to have produced the worst of both worlds. Many specious patents were awarded which were used to harass manufacturers and businessmen. One noteworthy example was Michael Withers, who in 1827 was able to obtain a patent for bevelling gudgeons, an important component in water mills – even though bevelled gudgeons were already available. Withers's strategy was to wait until a water mill had been erected before pursuing the owner for royalties. Few had the resources to resist Withers and paid up. If Withers was challenged, he would abandon the contest and find another, more amenable, target (Jaffe and Lerner, 2005). Without any examination of applications, the responsibility for divining the legality of patents was devolved entirely to the law courts – and with patents such as Withers's being awarded, few were able to stand up in court. In the 1820s, only a quarter of verdicts went in favour of patent holders (Khan, 2005). Khan has rightly observed that such bald figures cannot be interpreted as evidence of anti-patent bias on the part of the judiciary, but the knowledge that the courts rarely found patents valid must have offered succour and encouragement to (well-resourced) infringers, undermining the returns to invention for bona fide inventors. By the 1830s, many were unhappy. One judge thundered that the system was 'producing evils of great magnitude' (quoted in Jaffe and Lerner, 2005, p. 127). Such problems were increasing in step with the number of patents being awarded (752 in 1835), and the 'costs of enforcing these property rights were approaching levels that threatened the viability of the system, and inhibited inventive activity' (Sokoloff, 1988, p. 818). Neither was the early patent system an effective agent for diffusing technology – the first superintendent of the USPTO, William Thornton, did not believe that patent specifications should be publicised until after the patent had expired, a practice that only ended in 1825 (Thomson, 2009).

Consequently, in 1836, the American patent system was completely overhauled. The patent fee was maintained at the modest sum of $30, but in a reform that would (eventually) provide the template for changes abroad, an intensive examination of applications by technically qualified examiners was instituted. They were charged with assessing the novelty and legality of every prospective patent and many of these early examiners were very distinguished: the Patent Office at this time was 'truly remarkable for its concentration of scientific expertise' (quoted in Thomson, 2009, p. 193). They were also scrupulous and as was noted in section 2, up to half of all applications were rejected. Technical examination provided reassurance to potential investors of the patents legality (in the 1840s, nearly 60 percent of verdicts were in favour of patentees; Khan, 2005) and the practicability of their invention. Before 1836, the transfer of patent rights had often been hindered by their insecurity, but the mid-nineteenth century saw a rapid growth and development in the market for technology (Lamoreaux and Sokoloff, 2001). By the 1870s, some 70-80 percent of US patents were being assigned. Unlike in Britain (which is obviously much smaller), many patent assignments were geographically restricted –

accounting for 71.4 percent of all assignment contracts registered at the patent office in 1851. However, with improvements in communications, especially the growth of the railways, this figure fell to 22.8 percent in 1871 and 4.6 percent in 1891 (Lamoreaux *et al.*, 2013).

The discussion on British patents emphasised the importance of the market in patent rights in expediting the sequential development of technology and as a means by which inventors could appropriate returns and obtain capital to work new inventions. In the United States, this very high propensity to trade in patents also contributed to the professionalisation of invention. Now it was possible for talented inventors to concentrate on research while leaving the commercialisation of their ideas to others. A survey of 'great inventors' born between 1846-65, shows that 66 percent derived their main source of income from selling and/or licensing their patents – although the numbers of great inventors pursuing this strategy had always been relatively high (Khan and Sokoloff, 2004). In a similar vein, the proportion of patents which were awarded to individuals who received ten or more patents over their careers increased from 4.4 percent in 1830-42, to 28.9 percent by 1870-71

The market spawned a range of intermediaries. Patentees could hire specialist agents in different parts of the country to hawk their inventions to locals – although the reliability of these agents was occasionally impeached. Sometimes, they were accused of exaggerating the value of the invention and unfrotunately for buyers, the courts are reported to have 'followed a rule of caveat emptor', and money could only be reclaimed if the patent vendor had acted fraudulently (Lamoreaux *et al.*, 2013, p. 11). A more trustworthy source of agency services were the large national firms. They often published their own magazines which could be used to advertise their cleints inventions. *Scientific American*, which was owned by the patent agency Munn & Co., printed lists of patents that had been awarded and detailed descriptions of inventions. Favourable coverage of their clients' invention encouraged business (Lamoreaux *et al.*, 2013). In Britain, the largest technical magazines such as *The Repertory of Arts* and *The Mechanics' Magazine* were edited by patent agents as well.

After 1836, the United States probably boasted the most sophisticated patent system in the world; the introduction of professional examiners, working in a specialised patent office would in time form the template for all future Patent Offices. Khan concludes that patent 'policies helped to propel the United States to the first rank among developed countries' (2005, p. 309). Despite this 'democratic' patent system, however, Petra Moser still reports a low propensity to patent. Of the 550 American exhibits at the Great Exhibition of 1851, only 15.3 percent had been patented. The figure for Britain was lower still at 11.1 percent (Moser, 2012). These figures, though, understate the propensity to patent new inventions. In particular, exhibiting an unpatented invention would have constituted an act of publication, invalidating any subsequent patent that might be obtained. As such, inventors intending to obtain a patent would refrain from entering such an Exhibition. Moreover, many of these exhibits were

not patentable – examples of high quality workmanship abound at these fairs, for instance – and when they are excluded from exhibition data, the propensity to patent *patentable* exhibits is shown to be much higher (Khan, 2013 (a)).[viii] Because those inventions which are truly novel products and/or methods of manufacture (and which are therefore patentable) lead to the most dramatic changes in producivity then, from an economic standpoint, one can still argue that patents are important.

Great efforts were also made to diffuse the mass of technical material that passed through the Patent Office which was published promptly and freely distributed to libraries throughout the country. In 1849, one examiner did complain of 'the almost boundless and ill arranged masses of information to be found in the books, the shops and in the archives of the patent office' (quoted in Thomson, 2009, p. 214) but this seems to be more a symptom of success. There was a growing range of both general magazines and more specialised publications such as *The Journal of the Society of Glass Technology* and *The American Journal of Photography* which digested this material and informed inventors of the latest developments in areas of interest (Lamoreaux and Sokoloff, 1999). A recent spatial autocorrelation analysis demonstrates that the American patent system was exceptionally conducive to the diffusion of new technology – if patenting doubled in one county, then patents in neighbouring counties would increase by 29 percent and this effect was significant even when controlling for manufacturing labour force and urban amenities. By contrast, no similar knowledge spillovers can be isolated for unpatented exhibits from the industrial fairs of the American Institute of New York between 1835 and 1870.[ix]

4 France

As with the English patent, the French *privilège* awarded to inventors during the *ancien régime* had initially developed within a much larger apparatus of monarchical grants. There were many types of *privilège* awarded, perhaps the most important being fiscal in nature, which excused the holder from paying certain types of tax. Similarly, since the medieval period, certain groups of merchants and manufacturers had been afforded state protection via the *privilège*, and these form the closest institutional precursor to the inventors' *privilège*. *Privilèges* for inventors could take two forms. The first type were 'ordinary', and usually they only excused the inventor from working within the remit of a manufacturing guild (Hilaire-Pérez, 1991). The second group were 'exclusive' *privilèges*, and these were more alike modern patents, granting exclusive rights to inventors, (although they were often limited to a particular locality). Also, to be eligible for a *privilège*, the invention needed to be 'politic': it could not conflict with government policy.

Petitions were usually first submitted to the Paris *Académie des Sciences* which was charged with appraising the technical aspects of the invention. After this, the petition was passed to the *Bureau de*

Commerce and then the *Contrôleur Général des Finances*, who were responsible for deciding whether the interests of the state would be met by providing the inventor with a *privilège*. The *privilège* could then issue as an *arrêt du conseil* (royal council decree) – although such a decree needed to be registered with the *Parlement de Paris* (a judicial rather than legislative body). The *Parlement* would take the opportunity to examine the propspective *privilège* of its own accord and to hear opposition from those opposed to the *privilège (*usually the guilds). Few inventors were able to negotiate such a convoluted and politicised petition process; between 1715 and 1760, only 48 exclusive *privilèges* were awarded (Plasseraud and Savignon, 1986). A royal decree of 1762 clarified and delineated the terms on which the inventors' *privilège* would be granted. Now, the term was set for fifteen years and the invention needed to be worked within one year, or otherwise the *privilège* was annulled (Hilaire-Pérez, 1991). Administrators, though, were still reluctant to award exclusive *privilèges* to inventors. Instead, financial awards became the preferred means of encouraging inventive efforts and from 1740 to 1780, the French state doled out some 7 million livres to reward various inventions. The large majority of these inventions proved to be useless (Rosen, 2010), and on the eve of Revolution, many regarded state policy to encourage invention as a failure. In 1788, the *députés du commerce* warned that until reform occurred, French inventors 'would continue to seek patents in the United Kingdom and not work their invention in France' (quoted in Duncan, 1997, p. 38). Accordingly, the English patent system was viewed as a model for reform. One proponent was Jean-François de Tolozan, head of the *Bureau du commerce* from 1787 to 1791: '*Je fond mon avis sur l'expérience constante des anglais, qui n'ont acquis sur nous dans les arts une si grande supériorité qu'en accordant des privilèges à tous ceux qui en demandent*'.[x]

The entire system of *privilèges* was swept away by the French Revolution, providing the opportunity to institute new state policies for encouraging invention; a delegation of artisans and inventors was soon assembled to petition the new government for '*l'établissement en France d'une législation comparable à celle des patentes anglaises*' (quoted in Galvez-Behar, 2008 (a), p. 23). However, in the revolutionary ferment of the time, many were leery of awarding any new rights of protection. To appease opponents, Stanislas de Boufflers, the nobleman charged with drafting the new patent law, appealed to the inalienable rights of man: '*s'il existe une véritable propriété pour un homme, c'est sa pensée*' (quoted in Galvez-Behar, 2008 (a), p. 23). The preamble to the law of 9 January 1791 re-affirmed that 'it would be to attack the rights of man in their essence, not to regard a discovery in industry as the property of its author'. These rights were perceived to exist independently of this legislation and the system it instituted. As such, it was possible for an 1801 decree to state that the *brevet d'invention* represented a 'mere recognition of property' and accordingly, the French *Bureau des brevets* did not concern itself with examining applications, instead awarding *brevets* as a matter of right and confining itself to 'a recording function' (Hilaire-Pérez, 1991, p. 931). Even if the prospective patent was known

to cover a pre-existing invention, the *Bureau* could not block the application (Perpigna, 1832, p. 52). Despite several reforms of the French patent system (most notably in 1844, which formed the bedrock of French patent law until 1968), examination of patent applications was never introduced during the nineteenth-century.

These idealised notions of the natural rights of inventors proved to be influential and several countries such as Brazil in 1809, Russia in 1812 and Spain in 1820 adopted French legislation wholesale, along with its unequivocal reference to the natural rights of inventors.[xi] However, De Boufflers' emphasis on the natural rights of inventors – although sincere – had been exaggerated for 'tactical' reasons and some provisions of the 1791 law were clearly inconsistent with the idealised notion of the inventors' natural rights. For example, novelty was only decided relative to domestic use, allowing for technology to be imported and patented by someone other than the inventor (a provision based on English practice; Duncan, 1997). Similarly, working requirements meant that the inventor had to have commercialised the invention within two years, otherwise the patent was forfeit. Finally, *le brevet* was expensive to obtain. Until 1844, a fifteen year patent cost 1500Fr or around £60, excluding the additional costs of an agent and technical assistance with the specification.

Moreover, French patents were often difficult to enforce at law. Louis-Benjamin Francœur, professor at the *Faculté des sciences de Paris*, bemoaned the indulgence shown by the courts towards infringers and lauded the severity with which they were treated in England (Galvez-Behar, 2008 (a)). The law was also applied inconsistently by the courts: in 1850, Jean-Baptiste Dumas, the Minister of Commerce, complained that 'a patent, valid in a jurisdictional court, is void in the neighbouring one; such an act of counterfeiting in Paris, elsewhere escapes any repression' (Galvez-Behar, 2008 (b) p. 8). Indeed, if it was decided that a patentee's legal action had been vexatious, they could be fined up to 6000Fr (Perpigna, 1832, p. 128). The difficulties involved with enforcing patents, dissuaded many inventors from obtaining patents, especially those living in the provinces. For example, during the nineteenth-century, the Nord department (bordering Belgium) was the most heavy industrialised in France. In 1860, (for when there are the earliest available figures), Nord was second only to the Seine department (which contained Paris) in terms of the value of its manufacturing output (Combes *et al.*, 2008). Yet in the 1830s, Nord accounted for only 2 percent of all patents awarded in France and in the 1840s 2.4 percent. These figures are roughly in line with the proportion of the French population who lived there (3 percent in 1836) but entirely divorced from the proportion of French industry located there.[xii]

That so few patents originated from the industrial heartland of France, implies that *brevets* gave little encouragement to inventive activity. It also seems that the problems involved with enforcing French patents precluded the development of an active market in patent rights. Between 1844 and

1846, the number of patents assigned in full, as a percentage of the number of patents awarded over the same period, was only 7.7 percent. From 1859 to 1861, this figure was even lower, at just 3.5 percent.[xiii] Without a well functioning market in patent rights, the commercial opportunities available to inventors in France were obviously curtailed. It would also have stymied the sequential development of technology and some of the specific provisions of French patent law aggravated this problem. For example, if a product was protected by a patent and a better method for its production appeared, use of this new method would still be regarded as an infringement of the original product patent. For a long time, this was regarded as '*un frein au progrès*' (Galvez-Behar, 2008 (a), p. 42).

Neither does it appear that the French patent system expedited the circulation of technical information. In his initial 1790 report on the patent system, De Boufflers had also stressed how the patent could be conceived as a social contract, and the law of 9 January 1791 allowed for the free consultation of specifications (although only for *'tout citoyen domicilé*'). This contractual conceptualisation of the patent came to form a longer lasting jurisprudential base for the French *brevet* than natural rights; the patent agent Antoine Perpigna observed that a patent 'is a contract made between the nation on the one side, represented by the government, and the inventor' and in return for their patent, the inventor had to meet certain conditions 'among which is the express one of giving up at once his secret, which at the expiration of his privilege is to become public property' (1832, p. 17). However, inventors complained bitterly about the availability of specifications and from 1811, they could only be accessed with permission of the Ministre *du Commerce*. This permission was not forthcoming and unless patentees chose to publicise their invention themselves, specifications were effectively unobtainable until the patent expired (Galvez-Behar, 2008 (a)). When the patent system was reformed in 1844, it was decided that *Le Conservatoire national des arts et métiers* should be entrusted with the publication of specifications **during** the patent term. Unfortunately, publication of *La Description des machines et procédés* by *Le Conservatoire* proved to be partial and much delayed. Specifications entered in 1854 were only published in 1859, and those entered in 1860 appeared in 1870 and learned socities such as *La Société d'encouragement pour l'industrie nationale* wanted the British system of immediate publication to be adopted (Galvez-Behar (a), 2008).

Ostensibly, the French law of 1791 upheld the natural rights of inventors. The incipient French patent office was limited to a mere recording function and there was no examination of the patent application. However, several provisions of the new law contradicted such high-flown notions, viz., the strict working requirements. Natural rights only formed an organising principle of the French *brevet* when it was convenient to do so. Instead, a contractual notion of the patent came to pre-dominate. But again, this was usurped and from 1811 onwards specifications of extant patents could only be accessed with great difficulty.

It is difficult to make the case that French specifications did anything to assist with the diffusion of technology. Neither does it appear that they did much to incentivise technological development. As easy as they were to obtain, the French *brevet* was as difficult to enforce against infringers. Uncertainty over their enforceability largely precluded the development of a market in patent rights. We can take the example of Henry Fox Talbot, an early pioneer of photography and inventor of the 'Calotype' the first form of photography where unlimited copies of the image could be made. To profit from his invention, Talbot obtained patent rights in Britain, France and the United States. In France, Talbot entered into an agreement with a Marquis de Bassano to found a *Compagnie Calotype* in 1843. The *Compagnie* collapsed when Talbot discovered that Bassano was usurping his rights by patenting a near identical process in his own name. Talbot could neither challenge Bassano's patent application nor enforce his own against it and his French venture failed. In the United States, by contrast, Talbot was able to sell his patent for £1,000 to Wilhelm and Friedrich Langenheim (although only after protracted negotiations; Bottomley, 2012).

5 Conclusion

Because the propensity for British and American exhibits to be patented at the Great Exhibition in 1851 were similar, Petra Moser suggests that 'patenting decisions were unresponsive to differences in patent law' (2012 p. 43). As section 2 showed, however, recent historiographical work on the British patent system has produced a more favourable assessment of its efficacy and now the similarity in the propensity to patent between the United States and Britain can be explained in a simpler way – it was because the efficacy of protection offered in the two countries was broadly the same. Interestingly, the propensity to patent French exhibits was, at 7.4 percent, less than half that of America (Royal Commission, 1851).

What this paper has shown is that differences in the institutional parameters of the patent system ***do*** matter. The patent represents the right to exclude others from using a protected technology. Where the means of enforcing this exclusivity are seldom available, such as was the case in France, patents will be of marginal importance. In a related point, the transaction costs involved with transferring insecure property rights are often prohibitive and a market in patent rights – an important way in which inventors can appropriate returns – can only develop where patents are clearly defined and secure. It is telling that the proportion of patents which were exchanged in the United States (post 1836) and Britain was considerably higher than in France.

The legality and security of patent rights is derived in part from the criteria by which applications for them are assessed. Where the criteria are fluid and malleable, as when patents need to

be deemed politically or economically expedient, they will also be inherently insecure. Such was the case in *ancien régime* France, where inventors needed to negotiate with multiple bureaucracies. Indeed, many inventors were effectively cut off from *privilèges* altogether. Similarly, when there is no examination at all, many spurious patents will issue and unless courts adjudicate patents strictly, manufacturers will be harassed by speculative attacks.

When, however, applications are decided by consistent legal criteria, those patents that are passed will be more secure and well defined: once America introduced systematic examination, there was considerable growth in the market for technology. Regression analysis on international patenting between 1840 and 1920 confirms that patent assignments were more frequent in systems involving examination (Khan, 2013 (b)). Britain provides a more complicated example. Political actors had refrained from interfering in patents from the middle of the eighteenth century onwards but there was also an aversion to systematically investigating the legality of prospective patents. Instead, very high fees and frequent private oppositions were preferred mechanisms for filtering out 'undesirable' patents and judging from the high proportion of patents which were transferred, this worked tolerably well. Charging higher application fees today would discourage the patenting of lower value inventions, reducing the burden of examination at Patent Offices and the social costs of patent thickets. Examination also forces the inventor to clearly describe their invention, usually in the specification. When these specifications were made publicly available and their sufficiency assessed by appropriate standards, they made a significant contribution to the circulation of technical information and this in turn facilitated the sequential development of technology.

There is one final area concerning institutional design that has yet to be broached – the patent term. In the United States and Britain, patents lasted for fourteen years; in France, for a maximum of fifteen (extensions could, with difficulty, be obtained in each country). In Britain, the patent term had been settled by the mid-seventeenth century, when it was decided that patents of twenty one years should no longer be awarded as it took too long 'before the Commonwealth should be partaker thereof' (Coke, 1669, vol.3, p. 184). Product cycles are now much shorter today than they were 350 years ago. One, this was a period where novelty and invention was not always greeted with the same abandon as they are today; it took a long time for a new product or process to establish itself. Two, reliable communications were much slower. Not only did this stymie the diffusion of technical information, it made it more difficult for prospective adopters to verify its practicability without costly experimentation. Yet today, we have seen fit to revert to a patent term that lasts twenty years. This allows holders to rights in obsolete technology to continue to hold out for licence fees and royalties and for many large companies, enforcement activities on obsolete patents have become an important revenue stream. Patent terms can probably be reduced dramatically, without radically undermining the

incentive to invent, while clearing away much of the patent thicket.

Finally, it is important that the institutional parameters of the patent system are carefully calibrated: the paper has also endeavoured to show that a well designed patent system does encourage inventive activity. In the British case, patent rights allowed some inventors to become extremely wealthy and the returns appropriable with a patent did encourage the development of technology. However, the British case also confirms Qian's observation that the provision of patent rights will be of no consequence in countries that do not already have inventive potential. Ireland possessed a patent system that was derived directly from the one in England, yet it saw very little inventive activity in the eighteenth and nineteenth centuries (Bottomley, 2014 (c)) and remained an extremely poor and agrarian society – tragically evidenced by the Great Famine of 1845-49. This shows that the patent system was not in itself a sufficient cause for industrialisation, i.e. it does not alter the 'background' economic conditions that determine whether an invention can ever be commercially feasible. Rather, the provision of patent rights reduced the threshold at which it became privately efficient to develop new technology. It also seems that patents contributed to technological development in America, where a thriving market in technology rights offered inventors the opportunity to sell their ideas without incurring the risk of commercialising them and facilitating the professionalisation of invention later in the nineteenth century.

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i In a study of thirty patented inventions that had been imitated by competitors, it was found that the ratio between the full costs of imitation to the costs of invention was around 0.65, although there was wide variation around this figure. (Mansfield *et al.*, 1981).

ii Although in an identical Japanese survey, patenting was shown to be the most important of the three appropriation strategies and secrecy the least important. (Cohen *et al.*, 2002).

iii In the end, Celera was only occasionally successful in patenting their gene applications, although uncertainty at the time over whether they would be granted gave Celera a stronger bargaining position.

iv 'In England, when a private individual invents a new product, or discovers an unknown process, he obtains an exclusive privilege for making this product or to use this process. As he has no competition in this production, he can raise prices above what would be necessary to repay his advances with interest, and to pay profits … and in a country as prodigiously productive as England … this reward is often very considerable'. (Say, 1803, p. 262).

v These numbers were obtained by searching the *Institut national de la propriété industrielle* database for patentees whose address contained 'Angleterre', 'Ecosse' or 'Irlande'. http://bases-brevets19e.inpi.fr/, accessed 3 October 2014 (while omitting those inventors who lived on rue d'angleterre in Lille). This exercise, though will also omit the (many) British patentees who, for the purposes of obtaining the *brevet*, provided a French address and so the figures in the text are really lower bound estimates.

vi These figures are derived from Bottomley, 2014 (a). Using the annual Report of the Commissioners of Patents, Zorina Khan estimates that approximately 35 percent of British patents were assigned and/or licensed between 1870 and 1883 (Khan, 2005, p. 62). However, many assignments and licences were unregistered, so the 'true' proportion of patents so transacted, is likely to be higher (Bottomley, 2014 (a)).

vii In 1750, for example, Robert Turlington entered a bill at the Court of Chancery in London, complaining that the defendants had infringed his American patent and seeking an injunction to restrain them. Tellingly, the defendants did not dispute the court's jurisdiction in American patents (which they could have done so by entering a demurral). *Turlington* v. *Kidby* (1750), Chancery Pleadings 1714–58, C11/581/43, National Archives.

viii An analysis of exhibits from fairs organised by the Massachusetts Charitable Mechanics Association between 1837 and 1874, show that even with most relaxed criteria, less than half of the exhibits were patentable (Khan, 2013 (a)). Although exhibits at the Great Exhibition have not been appraised in the same way, a perusal of the catalogue shows that many exhibits were also examples of skilled handicraft or new patterns and designs, rather than patentable inventions (Royal Commission, 1851).

ix Khan 2014. One recent study, however, found that patent disclosures have almost no impact on information flows between U.S. firms 'and therefore no measurable effect on R&D productivity'. (Arora *et al.*, 2003, p. 19)

x 'I base my opinion on the constant experience of the English, who have acquired over us a large superiority in the arts by awarding privileges to all those who seek them' (quoted in Hilaire-Pérez, 2000, p. 262).

xi It is striking how many of the specific clauses of the French patent law were adopted by other countries – in 1845, for example, almost every continental patent system had a maximum term limit of fifteen years and the Netherlands, Belgium, Austria-Hungary, Russia and Spain all offered the same choice between five, ten and fifteen year patent terms as existed in France (Urling, 1845). The English adopted a more hard-headed approach to the rights of inventors; the liberal *Westminster Review* observed that 'to talk of the natural rights of an inventor is to talk nonsense' (Dutton, 1984, p. 18).

xii Derived from http://bases-brevets19e.inpi.fr/, accessed 3 October 2014. London also accounted for a large proportion of British patentees, although this reflects the large proportion of the (urban) population which lived there and the fact that patent agents (who often obtained patents on behalf of clients) invariably lived there. On a per capita basis, there were more patents in Birmingham than London (approx. one patent per 1010 residents over the 1830s, compared with one patent per 1360 residents in London) and Manchester was not far behind (one patent per 1550 residents). Derived from Woodcroft 1969 and Census 1831, p. 13.

xiii These figures are derived from Galvez-Behar, 2008 and Federico, 1964.