QUCEH WORKING PAPER SERIES
http://www.quceh.org.uk/working-papers

PATENT COSTS AND THE VALUE OF INVENTIONS: EXPLAINING PATENTING BEHAVIOUR BETWEEN ENGLAND, IRELAND AND SCOTLAND, 1617-1852

Stephen D. Billington (Queen's University Belfast)

Working Paper 2018-10

QUEEN'S UNIVERSITY CENTRE FOR ECONOMIC HISTORY
Queen's University Belfast
185 Stranmillis Road
Belfast BT9 5EE

October 2018

Patent Costs and the Value of Inventions: Explaining Patenting Behaviour between England, Ireland and Scotland, 1617-1852[†]

Stephen D. Billington[‡]

October 2018

Abstract

Ascertaining whether patents encourage invention necessitates understanding the incentives inventors respond to. The British patent system prior to its reform in 1852 was cumbersome and expensive. Whether it facilitated or delayed the Industrial Revolution is hotly debated. This paper's contribution is to examine the incentives to patent, and the characteristics of patentees, by observing the entire population of British patents granted up to the patent reforms of 1852. I find inventors patented widely because they had valuable inventions. Their value was positively associated with the skills and wealth of patentees. Inventors responded to demand-side conditions, and the system's expense did not hinder invention.

Keywords: Incentives, Innovation, Patents, Patent Quality, Industrial Revolution

JEL Codes: N74, 031, 034.

[†]I thank Matthias Blum, Sean Bottomley, Alan de Bromhead, Graham Brownlow, David Clayton, Chris Colvin, Christopher Coyle, Norma Dawson, David Jordan, Ruben Peeters, Steve Rigby, John Turner, Homer Wagenaar, and Harm Zwarts for useful comments and encouragement. Thanks especially to Alessandro Nuvolari for hosting me at Sant'Anna School of Advanced Studies, Pisa (March 2018). Thanks also to seminar and conference participants at Queen's University Belfast (November 2017), the Economic History Society Residential Conference (Manchester, December 2017), Scuola Superiore Sant'Anna (March 2018), the Irish Economic Association (Dublin, May 2018), and the Lancaster PhD Summer School on Applied Microeconomics (September 2018) for suggestions on how to improve this paper.

[‡]Queen's Management School, Queen's University Belfast. Email: sbillington01@qub.ac.uk.

1 Introduction

Most explanations for the Industrial Revolution place technological change at the centre of the story (Landes, 2003; Allen, 2009; Mokyr, 2009). One aspect of this narrative which remains widely debated is the role of Britain's patent system. Some argue the system was too cumbersome and too expensive to have actively encouraged anyone to invent, and anyway note that many important innovations bypassed the system all together (MacLeod, 2002; Nuvolari, 2004). Yet, others argue the system was crucial in getting Britain's Industrial Revolution off the ground. North (1990) contends that the patent system was part of a package of institutions which together had a positive effect. Meanwhile, Dutton (1984) highlights the role patenting played in combating secrecy and encouraging follow-on innovation. Bottomley (2014b) concludes most of the key inventions of the Industrial Revolution are found within Britain's patent records. Fully explaining the role of the patent system, however, requires an understanding of why individual inventors would choose to obtain patents in the first place. I examine this decision by exploiting the unique institutional setup of the British patent system in the late eighteenth and early nineteenth centuries.

Britain's patent system was characterised by two key features: its separate regional offices, and its high cost. Until 1852, England and Wales, Ireland, and Scotland existed as separate patent jurisdictions. An inventor could obtain any combination of these national patent rights for a single invention, provided they stated their intent to do so in their initial application. Inventors were unable to acquire a patent in one jurisdiction, test the market for their invention, and then later extend the patent right to elsewhere in the UK; once the patent was granted, it became public knowledge and no further extension to new geographic markets was permitted (Bottomley, 2014b). British patents were also very expensive. Fees were known to be as high as £380 in 1850 for the whole UK (Dutton, 1984; Bottomley, 2014b), or £293,000 in today's money, compared to the equivalent of £10 for a US patent for a US citizen.

At present, the prevailing arguments concerning the incentives to invent and patent can be summarised as either "demand-side" or "supply-side" explanations.

Demand-side arguments view invention as a response to profitable market conditions; we invent and patent because it pays to do so, and sometimes only if the invention is protected from imitators (Schmookler, 1966; Allen, 2009). The supply-side school, however, rejects this thesis. Instead, it contends that skilled individuals drove inventive activity. Here, invention is akin to Smithian specialisation; we invent because we are good at it (Mokyr, 2009; Kelly et al., 2014), meaning that patenting does not provide the necessary incentive to invent. This specialisation is the likely result of: the pursuit of science (McCloskey, 2011); access to scientific knowledge and knowledge-sharing institutions (Dowey, 2017); and/or a superior British mentality toward science and innovation (Howes, 2017). However, both demand and supply-side arguments are not necessarily mutually exclusive (Crafts, 2011); inventors may supply their skills to areas with a high degree of profitability. Ultimately, any explanation of patenting is underpinned by whichever argument best explains the decision to invent. This is an empirical question.

I exploit the patent application process to understand why inventors obtained patents under this expensive and cumbersome system, which in turn provides an explanation for their decision to invent. My analysis makes the reasonable presupposition that inventors had a rational motivation to obtain patents, because the patent application fees were very high. Inventors had to decide *ex ante* where to seek protection. But, inventors did not always patent their invention in multiple regions. Observing those jurisdictions in which an inventor obtained protection allows me to ascertain why they wanted patents in the first place, and why they chose to "extend" protection.[1] I hypothesize the probability of patent extension is likely conditional upon the potential value of a patentable invention, the costs of geographic protection, and the wealth of inventors.

This study also examines the determinants of the value of patented inventions. Any insights into patenting behaviour benefit from understanding who those patentees were. Patentee characteristics, like wealth, may influence what types of inventions were being patented, and, subsequently, whether they were valuable. Expensive patent systems are

[1] Here, extension is defined as obtaining additional patents for a single invention within Great Britain and Ireland, assuming inventors sought patents in England first (Bottomley, 2014a).

thought to produce negative welfare effects, as costly patent fees restrict the population of potential patentees to society's wealthiest (MacLeod et al., 2003). Poor inventors cannot afford the high fees, denying them access to patents. But, poor inventors can make valuable contributions to technological progress (Khan, 2005). Should poor inventors require patent protection, they may be discouraged from innovating, or instead keep their inventions secret; both actions potentially harm the rate of innovation. By contrast, wealthy inventors are documented to have engaged in "vanity patenting", whereby they patent trivial ideas (MacLeod et al., 2003; MacLeod and Nuvolari, 2016). Wealthier, "gentlemen" inventors are thought to have engaged in invention as a hobby, rather than for any profit motives (Mokyr, 2009). For them, patenting was a tool to enhance their prestige, to signal themselves as inventors, rather than for the exploitation of any economic opportunities. Britain's high patent fees could have harmed innovation, by excluding valuable inventions produced by the lower classes while including less valuable ones made by the upper classes.

My paper observes the entire population of British patents for the period 1617 to 1852. The data identify which jurisdictions each patent is protected in. The dataset is then matched up with the Woodcroft Reference Index (WRI), a popular proxy for patent quality that measures patent citations in the technical literature, pioneered by Nuvolari and Tartari (2011). Next, occupations are matched up to the Historical International Social Class Scheme (HISCLASS). Social status is likely to capture the potential wealth, human capital, or the influence that patentees may have had over those journal editors within the technical literature. Highly skilled, knowledgeable, or *ex post* successful inventors are further identified using the Oxford Dictionary of National Biography (DNB). Such individuals are considered by scientific experts to have produced inventions of historical and technological significance, and are thus counted as being "great inventors" (Khan and Sokoloff, 2004; MacLeod, 2007; Khan, 2008; Nuvolari and Tartari, 2011). This metric intends to capture those inventors most likely to have been motivated by supply-side factors. Finally, the patent dataset is classified according to the Billington and Hanna (2018) patent classification schema, by using their defined machine learning methodology for assigning patents to multiple classes, in a systematic and transparent way.

To understand why inventors chose to extend patent protection, I use ordered probit regression models to examine the probability of a patent being protected in multiple British regions. My results suggest much more valuable inventions were more likely to be protected throughout Great Britain and Ireland. Furthermore, inventors with wealthier occupations, as captured by social status, were more likely to protect their inventions in all jurisdictions – as were great inventors. Individual probit models are then used to contrast inventions extended to either Scotland or Ireland. Those patents extended to Scotland were of a higher value than those extended to Ireland. Patents found in single jurisdictions (England or Scotland) were of the lowest value. Overall, the evidence suggests inventors likely obtained patents because they expected they had more valuable inventions.

I examine whether an inventor's occupation affected the value of their patented inventions using a negative binomial model. This model accounts for the skewed distribution of patent citation data. Inventors with higher social status occupations held more valuable patents. This is most probably a wealth effect, since individuals with higher social status occupations tended to patent their inventions widely across Britain. Furthermore, great inventors produced the most valuable inventions found in the patent series, suggesting that skills and human capital mattered. My results are inconsistent with the vanity patenting narrative; potentially wealthier inventors were not patenting trivial things. Instead, higher social status inventors were patenting capital-intensive inventions, such as steam engines, which transpired to be more economically useful inventions during the Industrial Revolution. Such capital-intensive inventions are costly to produce (Khan, 2005), and more susceptible to reverse-engineering (Moser, 2005). Patents were consequently much more attractive for protecting these types of inventions (MacLeod, 2002). Since contemporaries thought the British patent system was more effective than secrecy to protect inventions (Dutton, 1984), the existence of the patent system may have actively encouraged individuals to invent.

My findings contribute to the debate concerning inventors' incentives during the Industrial Revolution (Allen, 2009; Mokyr, 2009; Crafts, 2011). I show that demand-side and supply-side arguments are complimentary. Inventors appeared to be patenting more valuable inventions, and they also patented these inventions more widely across Great Britain and Ireland. The wealth and skills associated with inventors is shown to be positively related to the value of their patents. Inventors were motivated by demand-side conditions, but were also more capable of producing better inventions due to supply-side factors.

My study also contributes to the patenting literature in the context of the Industrial Revolution (Dutton, 1984; MacLeod, 2002; MacLeod et al., 2003; Nuvolari, 2004; Khan, 2005; Nicholas, 2011; Bottomley, 2014a; MacLeod and Nuvolari, 2016). Because inventors likely obtained patent protection to secure potential market returns, inventors may have perceived the patent system to have been useful for introducing their inventions into the different regions of Great Britain and Ireland, to ensure that their potential returns are not expropriated by free-riders, or to remain competitive. In either case, the system may consequently have encouraged individuals to invent. Similarly, since wealth and skills played an important role in patenting behaviour in Britain, it is less probable the expense of the British system was harmful: many key inventions of the Industrial Revolution were capital-intensive, and are found in the patent records.

This paper is closely related to Bottomley (2014a). Bottomley argues that patenting behaviour is driven by demand-side factors. His conclusions are based principally on comparing the average value of patents in different British jurisdictions for the period 1775 to 1841. This present study differs in the following ways. First, by assuming that all valuable inventions could be patented, Bottomley does not fully consider the selective effects of patent fees. By contrast, I include occupations in the narrative, and show their relationship with patent extension and value. Second, I derive my findings from econometric analysis, rather than relying on summary statistics. Bottomley's method cannot account for other factors which could influence patenting behaviour (such as, for example, patentee's previous patenting experience or the relevant technology group of the invention), whereas my method does. Third, I extend the period of analysis by examining the entire population of British patents granted until 1852. In order to do this, I extend the WRI metric to cover a unique series of Scottish patents not found elsewhere in Britain, and previously unexamined in the literature. Fourth, I use a new automated, machine learning methodology to classify patents. This method simplifies the process of classification, thus minimising the degree of subjectivity, leading to more consistent classifications, and also accounts for the spillover effects of inventions by assigning two classes per patent. Overall, my findings strengthen Bottomley's initial argument, but also augment his conclusions to provide stronger support for the British patent system as a potentially useful institution for encouraging invention.

This study is broken down into the following sections. Section 2 discusses the history of the British system and outlines the important institutional details. Section 3 provides an overview of the patent series used, how it has been compiled, and the construction of variables of interest. Section 4 then investigates patenting behaviour. Section 5 examines the determinants of patent quality. Section 6 provides a discussion of the results in relation to the Industrial Revolution debate. Finally, Section 7 concludes.

2 Historical Background

2.1 Patent Law

The Statute Of Monopolies (1624) gave legislative confirmation to a system which the Crown had pursued intermittently over several centuries. It arose out of the Crown's abuse of royal privilege, as parliament attempted to curtail the monopoly-granting powers of the King (Dutton, 1984; MacLeod, 2002). The statute transferred the right to grant monopolies away from the monarch and into the hands of parliament (Boldrin and Levine, 2013). The legislation distinguished letters patent for inventions as separate to regular monopolies, like the East India Company.

The 1624 act birthed the first modern patent system, which intended to encourage useful invention to benefit the public and the Crown. The system was defined by its cumbersome administration and high nominal fees, both of which remained substantially unchanged until the reform of 1852. This is not to say the system never underwent change; there were minor alterations to the system (see Dutton (1984) and Bottomley (2014b) for a complete discussion of these). The majority of changes to patent law, however, derived from cases brought to English courts rather than through legislation (MacLeod, 2002; Bottomley, 2014b).

Prior to 1800, few patent cases had been brought to trial, which MacLeod (2002) attributes to the uncertainties associated with the relatively new patent law. Inventors were unsure what constituted a patent, and likely settled their disputes outside the courts through fear of losing their monopoly rights. The later period, however, saw a growing number of patents contested in court. Dutton (1984) initially interpreted the results of these cases as biased against the patentee. Dutton's evidence showed patentees more often lost their case in the eighteenth century, resulting in void patents, which he suggested might have acted as a deterrent for future inventors to secure patents. Bottomley (2014b) recently contested this argument using a larger sample of patent cases. Instead, he shows patentees were more likely to win their cases in court after 1800, while the earlier period showed no evidence of judicial bias against patentees.

Of the cases brought to trial, two stand out in particular for their effect on the application procedure. The first case, *Roebuck v. Stirling, 1774*, set the rules governing the acquisition of patents in England and Scotland. The 1707 Act of Union led to the extension of the Statute of Monopolies to Scotland. However, there was no clear guidance for patenting an invention in both jurisdictions. Consequently, Roebuck had obtained a patent for a chemical process in Scotland, but the invention was previously used in England. The case went against the plaintiff, and Roebuck lost his Scottish patent. The courts ruled that, as England and Scotland constituted a single Kingdom, prior usage in either could void patents in both. Subsequently, the petition procedure was altered to allow inventors additional time to seal their Scottish patents before entering their specification in England (Bottomley, 2014b). The 1801 Act of Union then extended these rules to Ireland, further increasing the amount of time granted to seal

Scottish and Irish patents.

England, Ireland, and Scotland existed as separate systems of judicature. Variations in patent law could have influenced the decision to patent in that particular polity, although evidence from Bottomley (2014b) suggests this was not the case. English courts set the precedent for patent law throughout Britain, as judges in Scottish and Irish courts routinely referred to English cases to guide their decisions. Similarly, relatively fewer cases were brought before Scottish and Irish courts compared with English ones. Less than 0.5 per cent of Scottish patents and 0.2 per cent of Irish patents went to court. By comparison, approximately three per cent of all English patents were legally challenged (Bottomley, 2014b). Litigation was an expensive affair, as legal fees for both plaintiff and defendant could amount to £600 in England (Bottomley, 2014b), which was approximately 17 times the annual average wage of a British worker in 1850. Only valuable patents would have been worthwhile to challenge legally. Since English cases guided patent law throughout Britain, and since most Irish and Scottish patents were also found in England, English courts were the preferred destination for legal action.

The second notable case brought to trial in England, *Liardet v. Johnson, 1778*, reflected a legal change which had been developing over the course of the mid-eighteenth century: the specification requirement (Bottomley, 2014b). The specification was the detailed written description outlining the workings of a patented invention. Law officers initially introduced the specification in the late-seventeenth century. However, specifications were sparsely submitted until 1734, when it became a standard practice (MacLeod, 2002). The 1778 case led to the specification being recognised as consideration for a patent (Murfitt, 2017): inventors had to provide the knowledge embodied in their invention in exchange for their patent. It was to be 'sufficiently full and detailed to enable anyone, skilled in the art or trade to which the invention pertained, to understand and apply' (MacLeod, 2002: p. 49).

At first, inventors were unsure how to draft a specification; the law required their enrolment, but did not stipulate what should be contained within them (MacLeod, 2002). The fact patents could be easily voided based on simple mistakes or omissions in the specification compounded this uncertainty. Consequently, a professional body of patent agents began to develop in the late eighteenth-century. Patent agents began as employees in the patent office, and saw the opportunity to provide their knowledge and experience of the patent system as a service (Bottomley, 2014b). Patent agents would initially guide petitions through the patent office, and would later begin to patent inventions in their own name, but on behalf of a client (Bottomley, 2014b). As a result, the uncertainties associated with patenting diminished, and the demand for patent agents increased.

2.2 Patent Costs

Britain's patent fees were notoriously high. Indeed, many scholars have pointed to the great expense of the system as a significant defect which was potentially harmful to inventive behaviour. The high fees initially resulted from the 1536 Clerks Act, which intended to provide income to unsalaried Crown officers (Dutton, 1984). However, the fees remained unchanged until the 1852 reform of the law, which has lead to different arguments to explain this inertia.

Khan (2005) argues the high fees were an important source of revenue for the Crown, and that it was in the Crown's interest not to alter them. Figure 1, however, does not support this conclusion. As the figure shows, the fees were a minuscule share of the Crown's receipts. This share peaked in the 1640s at approximately 0.4 per cent, and remained at less than 0.1 per cent for the duration of the eighteenth century. Even during the increase in patenting activity in the nineteenth century, the contribution of patents to the Crown's finances remained extremely low. Therefore, it is reasonable to suggest the fees did not remain high to serve the government's fiscal needs.

Instead, Dutton (1984) notes many contemporaries were in favour of high fees (and some advocated for a further increase) to reduce the amount of trivial patents. Cheap patents, it was believed, would 'lead to an increase in the number of costly lawsuits' (Dutton, 1984: p. 45). This interpretation suggests the fees remained high to act as a barrier to entry against poorer inventors.

Patent costs can be split into two categories: opportunity costs and fees. The

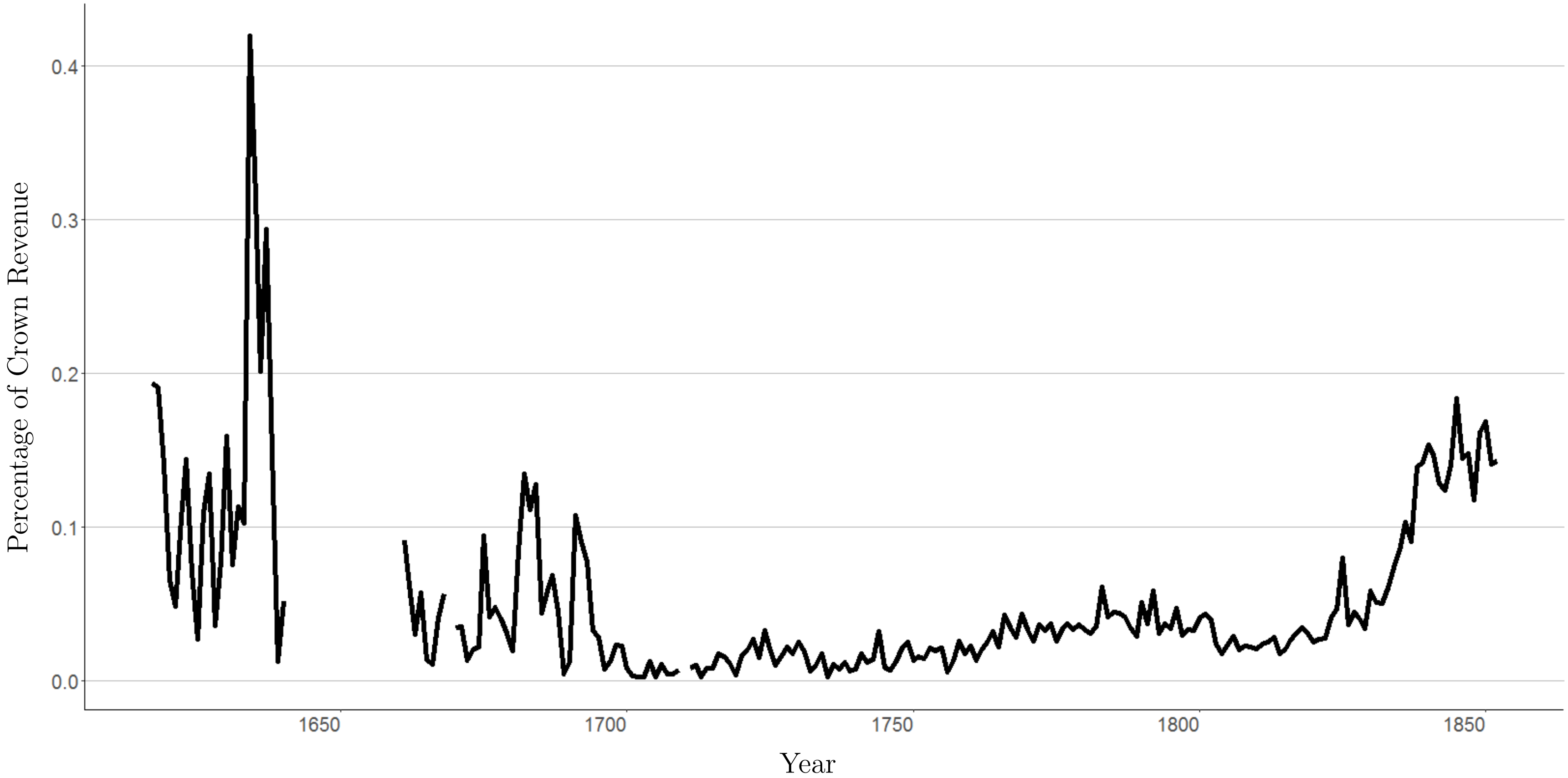

Figure 1: *Share of Patent Fees in Crown Revenue, 1617-1852*

Notes: The figure shows the share of Crown Revenue attributable to patent fees.

Source: The figure plots the revenue derived from patent fees as a percentage of the Crown's fiscal revenue for the period 1617-1852. The fiscal data are collected from Mitchell (1998) and O'Brien and Hunt (1999), and patent revenue is calculated by multiplying the number of patents granted by their average cost (listed in Table 2).

Table 1: *Breakdown of English Patent Fees, 1842*

Item	Ordinary Fees			Extra Fees		
	£	*s.*	*d.*	*£*	*s.*	*d.*
Preparing Title of Invention, Petition, and Declaration				1	5	6
Secretary of State's Reference	2	2	6			
Secretary of State's Warrant	*7	13	6			
Secretary of State's Bill	*7	13	6			
Mr. Attorney or Mr. Solicitor-General's						
Report	4	4	0			
Bill	* † ‡15	16	0			
Signet Office fees				† ‡ 4	7	0
Privy Seal fees				† ‡ 4	7	0
Great Seal Office Fees	5	17	8			
Great Seal Office Stamps	30	2	0			
Great Seal Office Boxes	0	9	6			
Great Seal Office Gratuity	2	2	0			
Great Seal Office Hanaper	7	13	6			
Great Seal Office Deputy	0	10	6			
Great Seal Office Recipi	1	11	6			
Great Seal Office Sealers	0	10	6			
Great Seal Office Office keeper	0	5	0			
Passing the Patent				10	10	0
Letters, &c				1	1	0
**Specification £———				**108**	**2**	**2**

Notes: Text in bold represents the sum total of all fees, not the cost for the specification. * If the patent include the colonies or the islands, the cost will be increased by 7l. 7s. 6d.; and if there be two or more persons in the patent the fees are further increased. † In the event of the patent being opposed there will be additional charges. ‡ If there be private seals and extra dispatch or journeys, these fees will be increased in amount depending on the circumstances. ** The cost of the specification to each Patent depends on its length, also on the difficulties of drawing that document, and the drawings necessary.

Source: Carpmael (1842).

opportunity costs were associated with the cumbersome administration of the system. For an inventor to secure a patent, they were required to navigate their petition through the offices in Chancery, and obtain the signatures of multiple officials – including the Monarch (Bottomley, 2014a). In 1720, for example, an English patent could take up to five months to be sealed. By 1849, the procedure took approximately one month. Scottish and Irish patents had a similar process, and took an additional six to eight weeks each during the 1840s (Bottomley, 2014b). Prior to the advent of the patent agent, the petitioner was responsible for guiding their own petition through each

Table 2: *Costs of Contemporary Patents for an average British worker in 1850 prices and 2016 prices*

Country	Patent Length	£ (1850)	£ (2016)	C/W (1850)
Belgium	15 years	70	54,000	2.06
Holland	15 years	70	54,000	2.06
France	15 years	73	56,000	2.14
Austria	15 years	75	58,000	2.20
Scotland	14 years	**75**	**58,000**	**2.20**
England	14 years	**110**	**84,000**	**3.23**
USA	14 years (British)	120	93,000	3.53
Ireland	14 years	**135**	**104,000**	**3.97**
UK (inc. Colonies)	14 years	**376**	**293,000**	**11.07**

Notes: 'C/W' represents the nominal cost of a patent in terms of the average nominal British wage in 1850. This is calculated using the nominal wage of £34 in 1850, from Clark (2017).

Sources: Hancock (1850) and Clark (2017).

of these stages. Prospective patentees would have to travel to, and reside in, London/Edinburgh/Dublin until their patent was sealed. This resulted in foregone earnings, as well as travel and accommodation costs. However, the advent of patent agency meant inventors could conduct their petition through agents by post. While this reduced the opportunity cost, it constituted additional fees for the service of these agents. The British system was also expensive in terms of fees. Table 1 provides a breakdown of fees in England.[2] The table lists two types of fee: Ordinary (fixed) and Extra (variable). In nominal terms, an English patent cost approximately £110 until 1852.[3] The fees varied based upon how many named inventors were on the patent, and the length of the specification. English patents for inventions were much more expensive compared to their European and US counterparts. Table 2 compares the fees, in 1850 British pounds, for contemporary patent systems. In real terms, British fees were exceptionally high for British workers. 'C/W' represents the nominal fee for different patent jurisdictions as a fraction of the earnings of the average British worker in 1850. Full British protection could cost up to 1,100 per cent of an average British worker's wage, while a patent for a single British jurisdiction ranged between 220 to 400 per cent.

[2] Appendix A provides a cost breakdown for Scotland and Ireland separately.

[3] An English patent also included the colonies. However, there is little evidence to suggest this made English patents more attractive.

3 Patent Series

My data contain the entire population of British patents granted until 1852. The series represents the digitised version of the 'Titles of Patents of Inventions' compiled by Woodcroft (1854). The data were collected from Nuvolari and Tartari (2011), Bottomley (2014a) and *A Cradle of Inventions: British Patents from 1617 to 1894* (2009) (henceforth referred to as COI). The information contained in the final dataset includes the name of the patentee(s), their listed occupation, their residence (at county level), and the title of their patent. Scottish patents are provided by COI (2009), while the Irish data come from Bottomley (2014a).

Of particular note are a series of Scottish patents which have no English or Irish counterpart. Such patents are termed "only-Scottish". The data also come from the COI (2009), and contains the same degree of richness as the English patent data, meaning they can be analysed in comparison. Additionally, a small set of "only-Irish" patents exist, but are not used because they are too few and lacking in sufficient detail.

Figure 2 shows the time series of patents granted, in each jurisdiction, from 1760 to 1852.[4] The English series displays a marked increase in the number of patents granted after 1760, reflecting the onset of the Industrial Revolution (Sullivan, 1989). Scottish and Irish trends lagged behind their English counterparts until the late eighteenth century. Patenting outside of England remained relatively uncommon throughout the early 1800s. The number of patents granted in all regions increased dramatically in 1825, which coincides with a bubble in the stock exchange in 1824 (Turner, 2014). Following this bubble, patenting rates increased rapidly throughout Britain. However, the Irish series exhibits a decline in the 1840s, reflecting the outbreak of the Great Famine.

[4] For the period 1617 to 1760, the patenting rate is relatively constant and so is excluded from this figure

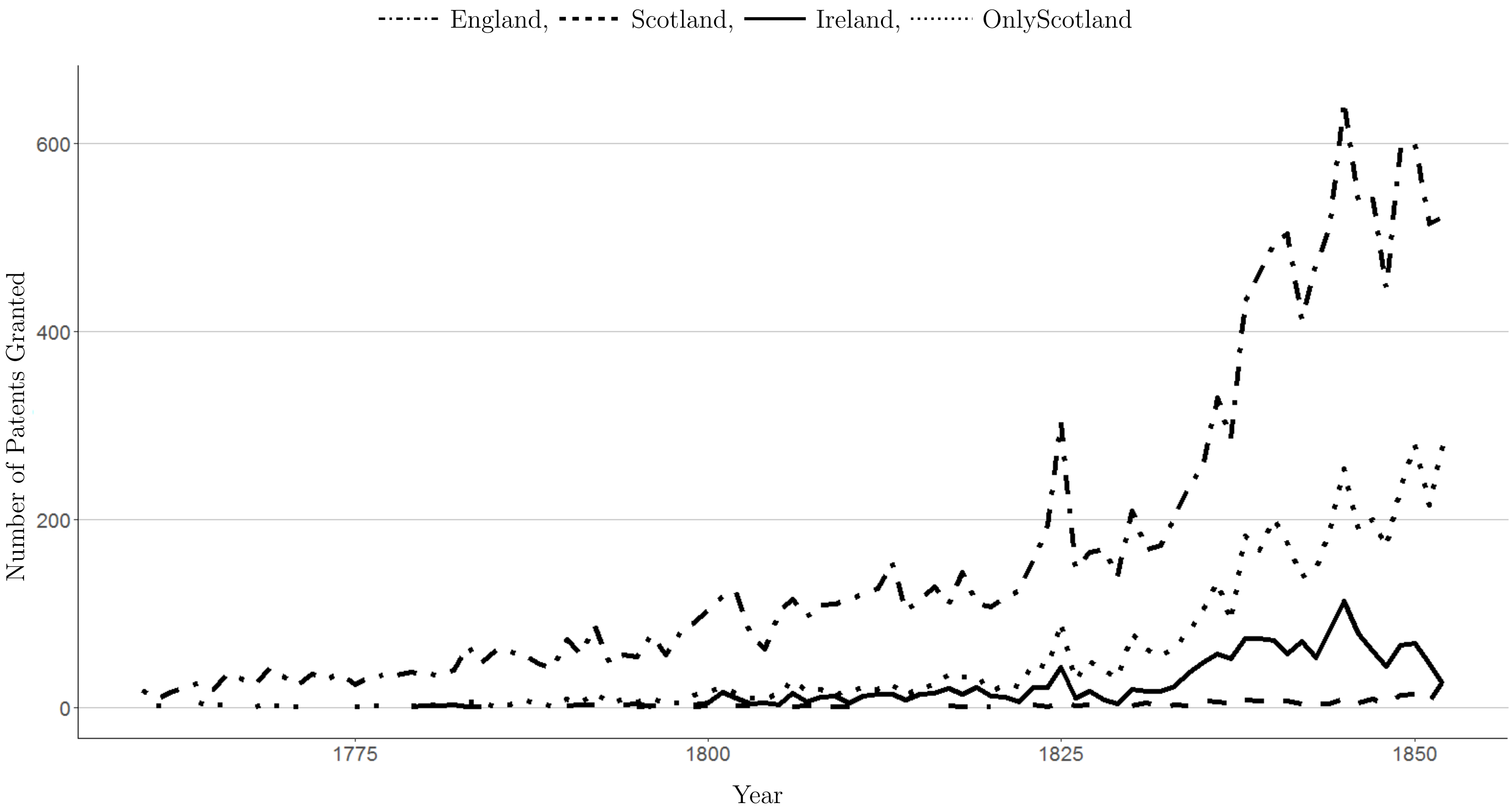

Figure 2: *Time Series of Patents by Jurisdiction, 1760-1852*

Notes: The figure shows the number of patents granted in each patent jurisdiction by year from 1760. Prior to 1760, the trends show little variation.

Source: Author's calculations using Woodcroft (1854) and Bottomley (2014a).

3.1 Patent Value

Most criticisms of patent statistics focus on their inability to differentiate economically valuable inventions from entirely useless ones (Dutton, 1984; Griliches, 1990). One widely popular method to account for the variation in patent value is to observe the number of forward citations on a particular patent (Hall et al., 2001; Hall et al., 2005; Lach and Schankerman, 2008; Bernstein, 2015; Kogan et al., 2017). Patent examiners assign citations during their investigation of a patent application. Hall et al. (2005: p. 18) argue 'if patent B cites patent A, it implies that patent A represents a piece of previously existing knowledge upon which patent B builds'. In this respect, citations capture the effect of knowledge spillovers from old technologies onto new ones. Highly influential technologies are likely to be cited more frequently in new patent applications, reflecting their affect upon the direction of innovation. In this way, an influential technology can be considered economically valuable, and therefore a strong proxy for patent quality or value.[5]

For the British patent data, the Woodcroft Reference Index (WRI) is the commonly used proxy for patent value, as pioneered by Nuvolari and Tartari (2011). This dataset is similar to patent citations, except it counts the number of references to a patent in the contemporary trade and scientific literature, rather than in other patents. Only journals which published complete patent specifications constitute a reference. The references indicate the relative "visibility" of a particular patent (Nuvolari and Tartari, 2011). This visibility captures the economic importance and technical nature of the cited patent.[6] Therefore, counting the number of references acts as a useful proxy to discern *ex post* realised value.[7]

[5] These terms are used interchangeably to mean the same thing: a patent likely to earn profits.

[6] This is either because patents that were important from a technical standpoint are more heavily cited in the technical literature, or because valuable inventions are more often brought to legal action, leading to more references concerning the trial itself (Nuvolari and Tartari, 2011).

[7] While it is possible "failed patents" may be overly cited, this is not the case. References are only assigned after the patent is granted, as journal and magazine editors (who are commonly patent agents) inspect the patent offices for new patents. They then decide which patents, and specifications, to publish in their literature. The specification is printed, including drawings, and sometimes accompanied by a more detailed discussion about the invention, and what is new or novel about it. Because different publications specialised in different technology sectors, editors would then likely only publish novel, valuable patents within that field.

I match each patent with its respective WRI score. However, Woodcroft only documented references to English patents. For patents not found in England, such as the only-Scottish series, references are unavailable. Instead, I assign references to these patents in the spirit of Woodcroft. My method is to search digitised historical journals and magazines for the listed title, inventor, and year.

However, no journals published the specifications of any only-Scottish patents. Nevertheless, most journals did provide a "basic" reference to these patents, defined as a journal entry which lists the patentee's name, the title of their patent, and when it was sealed. This is in contrast to a "complete" reference, which publishes the specification and is the criteria used in Woodcroft. To ensure the basic reference method is comparable to Woodcroft, I draw a random sample of Scottish patents which have an English counterpart and search through the digitised literature for both a complete reference and a basic one. This method lets me check: the correlation between complete and basic references, whether both types of references are similarly distributed, and whether the digitised journals are representative of the literature surveyed in Woodcroft.

The absolute count of basic references is greater than the complete references, but they are similarly distributed. Basic references are therefore suitable in place of the complete ones. However, for patents brought to court, the number of basic references are fewer than the number of complete references. This is less serious, as Scottish patents infrequently went to trial: less than 0.5 per cent were litigated (Bottomley, 2014b). Finally, Table 3 compares the sources of my basic references with those in Woodcroft. I list only the top six frequently appearing journals, as they represent the majority all references across both datasets. Half of the journals in my investigation match those in Woodcroft, while the relative frequency of the top journals is very similar in both cases. Consequently, the Scottish references are reasonably comparable to the English ones.

3.2 Occupations

In the data, the vast majority of patentees documented their occupation at the time of filing. Accordingly, I can use their occupational data to control, approximately, for

Table 3: *Comparison of Reference Sources*

This Study			Woodcroft		
Sources	Total	%	Sources	Total	%
The Edinburgh Philosophical Journal	78	23.64	Repertory of Arts and Manufactures	3,392	25.33
Repertory of Arts and Manufactures	77	23.33	London Journal of Arts and Sciences	3,085	23.04
Mechanic's Magazine	52	15.76	Rolls Chapel Reports	2,311	17.26
London Journal of Arts and Sciences	37	11.21	Mechanic's Magazine	1,138	8.50
Iron: An Illustrated Weekly Journal	23	6.97	Inventors' Advocate and Patentees' Recorder	939	7.01
The Practical Mechanic and Engineers Magazine	20	6.06	Register of Arts and Sciences	873	6.52

Notes: I included only the top 6 most frequently appearing articles, as these accounts for more than 50 per cent of all citations.

Source: Author's calculations, in addition to Nuvolari and Tartari (2011).

their potential wealth and human capital. Occupations are matched to their five-digit HISCO code (Van Leeuwen et al., 2002). HISCO represents a classification schema for comparing occupations across time and space (Van Leeuwen et al., 2004). Using HISCO, I then attach HISCLASS codes. HISCLASS represents a social class schema, which groups occupations into one of 12 categories, based on skill, the supervision required of the occupation, and whether the work is non-manual (Van Leeuwen and Maas, 2011). The major difference between these metrics is that HISCO groups similar occupations over the long-run, while HISCLASS stratifies them on a social class scale. The breakdown of HISCLASS codes is presented in Appendix B. Using the HISCLASS scores, occupations are divided using two different methods. The first, following Klemp and Weisdorf (2012) splits occupations into manual versus non-manual labour, where HISCLASS scores of 1-5 reflect manual occupations. The second method divides the 12 HISCLASS scores into six groups: high-skilled non-manual, low-skilled non-manual, high-skilled manual, farmers, low-skilled manual, and unskilled (in line with Meier zu Selhausen et al., 2017). High-skilled non-manual occupations I assume to be the wealthiest, while unskilled occupations reflect the poorest.

Social class schemas are useful for capturing the potential wealth and skills of occupational groups, but they cannot disentangle these factors. As such, I construct an additional variable to capture highly skilled or knowledgeable inventors. This is a dummy variable, indicating whether an inventor is listed in the Oxford Dictionary of National Biography (DNB). This metric is commonly used to account for individuals who, in hindsight, made valuable contributions to technological progress – also known as "great inventors" (Khan and Sokoloff, 2004; Khan, 2018). Great inventors – such as, for example, Edmund Cartwright, David Napier, James Watt, and George Fergusson Wilson – are synonymous with the knowledge elite, who are argued as drivers of the Industrial Revolution (Mokyr, 2009). However, this method has well documented downsides (MacLeod and Nuvolari, 2006). Biographical dictionaries often tend to over-represent patentees and engineering type inventions, while simultaneously neglect the contribution of female inventors. Still, the metric acts as a reasonable, but noisy, approximation for great inventors.

Both occupational measures capture, to varying degrees, the wealth, skills, or "power" inventors may have had. Wealthier inventors can engage in costlier innovation, or can engage in more extensive R&D to produce more valuable inventions. A wealthier inventor may even have better opportunities to attract external financing. Similarly, skilled inventors probably have better ideas for inventions, which translate into patents which are more valuable. "Power", which I define as the potential influence an inventor has over the actions of their contemporaries, could have led to artificially valuable patents. In this case, the number of references their patent receives could be a result of their influence over magazine and journal editors: they could have convinced editors to publish their specification as a means of advertising.[8] Social class metrics capture all three factors, while knowledge elite accounts predominately for skills.

Patentees were, however, not representative of the British population. The 1851 Census for England and Wales provides a detailed breakdown of the occupations of subjects.[9] British patentees tended to be drawn from the higher social strata of society. For example, higher professionals and managers accounted for approximately one per cent of the male population, but these occupations are associated with at least 40 per cent of all patents granted in 1851. Conversely, medium-to-lower-skilled occupations held 23 per cent of patents granted in 1851, but accounted for 20 per cent of the British

[8] However, if they convinced editors using money then power effects will also capture wealth.

[9] Obtained from Southall et al. (2004) as deposited in the UK Data Service. SN: 4559, which contains complete occupational statistics from the 1851 Census of England and Wales.

male population. Britain's patent system was then over-represented by potentially wealthier, higher social class individuals.

3.3 Patent Classes

The propensity to patent is heterogeneous across industries. In a comparison of patented inventions against those exhibited in prize-giving institutions, Moser (2005) shows machine inventions had a higher propensity to be patented compared to chemical inventions. Moser attributes this to the ease of reverse engineering. Dismantling machine inventions is relatively straightforward when compared to chemical processes, for example. Inventors of machines rely more heavily on patent protection as a result, while secrecy is more effective in protecting chemical inventions. As such, these varying propensities to patent need to be accurately controlled for. However, conclusions drawn from patent statistics have been shown to depend upon how the patent data have been classified (Billington and Hanna, 2018). Investigators are prone to subjective errors and inconsistencies when manually classifying patents.

To overcome this problem, I adopt the machine learning methodology and patent taxonomy developed in Billington and Hanna (2018). Their method classifies patent data based on their titles, by deriving sets of common word associations, or "topics", to cluster patents of a similar nature. For example, patent titles containing words such as 'weaving, looms, carding, cleaning, washing' indicate Textile inventions, and would be grouped as a single topic. As topics are generated, patents are simultaneously classified by them. This means each patent receives a score for each topic, where a higher score suggests that patent is most strongly identified by that particular association of terms.

Each topic is then assigned to one of the 19 patent classes described in Billington and Hanna (2018). Topics present a set of vocabulary which identifies the types of invention it covers. This makes it relatively simple to identify which patent class a topic relates to. In this method, patent classes are transitively assigned through the associated topic score. Patents also receive multiple topic scores, resulting in multiple classes assigned per patent. I use only the two highest topic scores, denoted as "TopicOne"

Table 4: *Patent Classes by Patent Polity (%)*

TopicOne	England	Ireland	Scotland	OnlyScotland	All
Power	13.70	15.38	16.24	16.22	14.92
Textiles	12.77	7.69	15.25	13.96	12.87
Machinery	11.08	11.74	13.52	18.92	12.19
Manufacturing	10.09	12.55	10.48	9.01	12.33
Hardware	7.37	4.45	4.99	4.05	1.77
Transportation	6.98	9.72	6.79	3.15	7.70
Construction	6.30	8.91	5.27	6.31	4.70
Instruments	5.42	5.26	3.35	5.86	2.66
Chemicals	4.97	3.64	5.52	9.46	6.75
Utility	4.78	2.83	5.11	2.25	4.97
Agriculture	4.53	5.26	4.06	4.50	3.81
Metal	4.52	5.26	4.22	3.15	5.72
Health	2.19	1.62	1.15	0.00	1.70
Mining	1.67	1.21	1.05	0.45	0.75
Paper	1.62	2.02	1.70	1.35	1.84
Commodities	1.27	1.62	0.87	0.00	1.02
Food	0.41	0.81	0.28	0.45	0.54
Communications	0.15	0.00	0.06	0.00	0.41
Electricity	0.15	0.00	0.09	0.90	0.34

Notes: The table shows the percentage of all patents granted in each polity by their highest scoring patent class for the period 1617-1852. These are listed from highest to lowest by England.

and "TopicTwo". Both topics are controlled for individually and then simultaneously, following the recommendations of Billington and Hanna (2018).

Descriptive statistics of TopicOne patent assignments, by patent jurisdiction, are shown in Table 4. In England, the most common technologies were in 'Machinery', 'Power', and 'Textiles', which is consistent with the types of inventions associated with the Industrial Revolution. In Ireland, 'Agriculture' and 'Construction' type patents were relatively more common, possibly reflecting the stage of Ireland's development at the time (Mokyr, 1983). Scotland attracted similar inventions to England, supporting the idea Scotland was also an industrialising nation (Devine, 2004).

3.4 Summary

Table 5 displays select descriptive statistics for English, Irish, Scottish, All, and only-Scottish patents. First, 'Great Inventor' is a dummy variable indicating whether a patentee appeared in the DNB. Great inventors tended to have a greater share of patents protected in multiple jurisdictions (Ireland, Scotland, All) compared to patents in single jurisdictions (England, only-Scotland). Second, 'Non-manual Occupations' indicates whether an occupation is classed as non-manual labour. The assumption is that non-manual occupations are associated with greater levels of wealth or superior skills, compared to their manual counterparts. Like 'Great Inventor', non-manual occupations are more common amongst patents protected more widely in Great Britain and Ireland. Finally, 'References' indicates the WRI scores for patents. On average, patents protected in multiple jurisdictions had higher scores, suggesting their potential value. This would appear to support the results posited in Bottomley (2014a): higher cited patents were extended because they had higher potential returns. The remaining control variables used in my ensuing regression analysis are described in Table 6.

Table 5: *Comparison of Descriptive Statistics*

	Number	Mean	Std. Dev.	Min	Max
Great Inventors					
England	11,438	0.049	0.22	0	1
Ireland	247	0.072	0.26	0	1
Only Scotland	222	0.036	0.19	0	1
Scotland	3,226	0.075	0.26	0	1
All	1,468	0.074	0.26	0	1
Non-manual Occupations					
England	10,725	0.76	0.44	0	1
Ireland	238	0.86	0.34	0	1
Only Scotland	183	0.77	0.42	0	1
Scotland	2,886	0.78	0.41	0	1
All	1,431	0.81	0.39	0	1
References					
England	11,438	2.50	1.47	1	19
Ireland	247	2.99	2.02	1	14
Only Scotland	225	2.36	1.66	1	7
Scotland	3,004	3.07	1.63	1	21
All	1,468	3.22	2.01	1	23

Notes: 'Great Inventors' represent a dummy variable indicating whether an inventor appears in the Oxford Dictionary of National Biography. 'Non-manual Occupations' shows the percentage of non-manual occupations associated with patents in each jurisdiction. 'References' shows the *ex post* average number of citations.

Source: Author's calculations using data from Table 6 for the period 1617-1852.

Table 6: *Definitions of Dependent and Independent Variables*

	Unit	Definition	Description
Dependent Variable			
Quality	Continuous	number of citations per patent weighted by average citations of a given time interval	measure of patent quality
Only-Scottish	Dummy	1 if patent was granted only in Scotland	captures patents which were not filed anywhere but Scotland
Scotland	Dummy	1 if patent was granted in both England and Scotland but not Ireland	captures patents which received additional protection
Ireland	Dummy	1 if patent was granted in both England and Ireland but not Scotland	captures patents which received additional protection
All	Dummy	1 if patent was granted in England, Ireland and Scotland	captures patents which received additional protection
Family	Ordinal	1 if a patent is protected in one polity, 2 if protected in two polities, and 3 if protected in all polities	captures patents which received additional protection
Inventor Variables			
Great Inventor	Discrete	1 if inventor is listed in the Oxford Dictionary of National Biography	captures whether the inventor produced an invention of historical significance; intended to account for potential knowledge elite
HISCAM	Continuous	0-100 representing Social Status	measures potential wealth, education, and status of a patentee; a higher score indicates a higher social status
HISCLASS	Categorical	1-12 representing Social Status	measures potential wealth, education, and status of a patentee; a lower score indicates higher social status
Inventor Dummies			
Non-manual	Dummy	1 if HISCLASS score <6	captures effect of manual vs non-manual occupations
Higher Skilled Non-manual	Dummy	1 if HISCLASS score is 1-2	captures effect of higher status occupations
Lower Skilled Non-manual	Dummy	1 if HISCLASS score is 3-5	captures effect of upper skilled occupations
Higher Skilled Manual	Dummy	1 if HISCLASS score is 6-7	captures effect of lower skilled occupations
Farmer	Dummy	1 if HISCLASS score is 8	captures effect of farmer occupations
Lower Skilled Manual	Dummy	1 if HISCLASS score is 9	captures effect of low skilled occupations
Unskilled Manual	Dummy	1 if HISCLASS score is 10-12	captures effect of unskilled occupations
Patentee Variables			
Another Patent	Dummy	1 if patentee has at least one prior patent	captures potential experience upon future patents
Difference in Social Status	Numeric	the difference between the maximum and minimum HISCAM scores associated with a particular patent	captures inventors from the lower classes who obtained a wealthy business partner to finance their patent
Distance to Dublin	km (000s)	distance from centroid of a historic county to Dublin	captures transport costs for extending patent protection
Distance to Edinburgh	km (000s)	distance from centroid of a historic county to Edinburgh	captures transport costs for extending patent protection
Distance to London	km (000s)	distance from centroid of a historic county to London	captures transport costs for extending patent protection
For Inventor Use	Dummy	1 if patent occupation matches patent classification	captures whether patentee was a true inventor or a tinkerer
Patent Variables			
Topic One	Factor	first related patent technology class	control for related patent characteristics
Topic Two	Factor	second related patent technology class	control for related patent characteristics
Foreign Communication	Dummy	1 if patent was filed on behalf of a foreign communicator	control for additional cost of patenting
Number of Inventors	Count	number of inventors per patent	control for cost or quality of having an additional inventor
Patent Agent	Dummy	1 if patentee occupation is a patent agent	control for additional cost of patenting
Other Variables			
Inflation	Index	captures changes in the price level (2013=100)	controls for changes in the real costs of patenting
Population	1,000,000s	size of the population of each patent jurisdiction over time	control for potential market size

Source: Patent data (Woodcroft, 1854; Bottomley, 2014a); Patent citation data (Nuvolari and Tartari, 2011); Historic county coordinates from Great British Historical GIS Project www.VisionofBritain.org.uk; Population data (Mitchell, 1971); Inflation data (Clark, 2017); and author's own calculations.

4 Why Extend Patent Protection?

Inventors who possess inventions of economic value may be more likely to rely on patent rights to protect them. Inventors could obtain patents either to work their inventions themselves, license them to others, or sell the rights entirely. In any case, secrecy is less capable of effectively protecting these inventions (MacLeod, 2002). Competitors could either reverse engineer an invention, or they would eventually produce a similar invention on their own. Furthermore, licensing and selling inventions are practically impossible under secrecy. Patents, though risky, provided a more secure and legally enforceable method of protection (Dutton, 1984). However, Britain's fees created a selection mechanism. Protection was only feasible for the wealthy, regardless of an invention's potential value (MacLeod et al., 2003).

Patent acquisition depended on two conditions. First, whether inventors perceived it to be beneficial: either due to profitability (Bottomley, 2014a), greater security (Dutton, 1984), or to enhance their own prestige (MacLeod and Nuvolari, 2016). Second, inventors had to possess the requisite capital to cover any fees associated with patenting. Although wealthier individuals appear more frequently in the patent statistics, there is also evidence of inventors from the lower classes obtaining patents. These inventors either were wealthy outliers within their occupational class, or had access to external financing. Dutton (1984) argues against the prevalence of external funding. Invention, by definition, is an uncertain endeavour as there is no guarantee any new invention is economically valuable. However, the possession of a patent acted like a signal to investors: once granted, patent rights were legally enforceable. One famous example is in the partnership of Boulton and Watt. Matthew Boulton, James Watt's long-term financial partner, would only support manufacturing Watt's inventions once he had patented them (Dutton, 1984: p. 151). Indeed, Watt was only able to secure his famous patent because of financial assistance from John Roebuck, who believed in the value of Watt's invention (MacLeod, 2002; Bottomley, 2014b). For most poorer inventors, however, external finance for obtaining patents would probably have been under-supplied.

By observing where inventors patented their inventions within Britain, I can infer why an inventor opted for patent protection in the first place. Inventors had to decide *ex ante* where to patent before realising their inventions *ex post* value. My hypothesis is akin to the demand-side argument: inventors patented in multiple jurisdictions because they held valuable inventions.

To test this, I use an ordered probit regression model, outlined in equation 1. Here, the dependent variable, "Family", is an ordinal variable, where the values reflect the number of jurisdictions a patent was protected in. The explanatory variables are *ex post* patent value, and occupation as proxied by the three different occupational methods discussed in the previous section. I weight the WRI by the average number of references in a given time period, since the number of references artificially increases over time. The time periods are identical to those in Nuvolari and Tartari (2011).

$$Family_{it} = \alpha_{it} + \beta_1 Quality_{it} + \beta_2 Occupation_{it} + \beta X_{it} + \mu_{it} \tag{1}$$

The control variables constitute: whether the inventor possessed at least one prior patent; the distance of the inventors listed residence to the relevant patent office; whether the invention matches the occupation of the inventor; the technology class of the invention; the inventor's nationality; the level of inflation across the last year at the time of filing; the population of the jurisdiction the patent was extended to; the difference between social status scores for patents with more than one inventor; and whether the invention was communicated by a foreigner.

Table 7 reports the results for the ordered probit model. Coefficients are interpreted as marginal effects at the means. Columns 1-3 control for non-manual occupations, following the approach of Klemp and Weisdorf (2012). Columns 4-6 use the HISCLASS breakdown of Meier zu Selhausen et al. (2017). Columns 7-9 control for great inventors, who made important technological advancements during the Industrial Revolution.

My results support the demand-side hypothesis. Inventors, who held patents that turned out to be valuable, were more likely to protect their inventions throughout Britain. A standard deviation increase in the *ex post* number of references on a patent corresponds to a 7-8 per cent increase in the probability that patent was protected in all jurisdictions.

Table 7: *Ordered Probit Results: Dependent Variable is the Number of Jurisdictions in which a Patent is Protected*

VARIABLES	(1) Family	(2) Family	(3) Family	(4) Family	(5) Family	(6) Family	(7) Family	(8) Family	(9) Family
Quality	0.038***	0.040***	0.039***	0.038***	0.040***	0.039***	0.038***	0.039***	0.038***
	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)
Non-manual	0.027***	0.027***	0.026***						
	(0.005)	(0.005)	(0.005)						
Higher Skilled Non-manual				-	-	-			
				-	-	-			
Low-Skilled Non-manual				-0.012**	-0.014**	-0.014**			
				(0.006)	(0.006)	(0.006)			
High-Skilled Manual				-0.037***	-0.039***	-0.037***			
				(0.006)	(0.006)	(0.006)			
Farmer				-0.024	-0.028	-0.018			
				(0.024)	(0.023)	(0.024)			
Low-Skilled Manual				-0.012*	-0.009	-0.012*			
				(0.007)	(0.007)	(0.007)			
Unskilled				-0.054	-0.051	-0.054			
				(0.038)	(0.039)	(0.038)			
Great Inventors							0.037***	0.038***	0.036***
							(0.008)	(0.008)	(0.008)
Time	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Topic One	Y	N	Y	Y	N	Y	Y	N	Y
Topic Two	N	Y	Y	N	Y	Y	N	Y	Y
Observations	12,909	12,909	12,909	12,909	12,909	12,909	12,909	12,909	12,909
Pseudo R-Squared	0.0637	0.0610	0.0681	0.0643	0.0618	0.0687	0.0633	0.0606	0.0677

Notes: Coefficients are marginal effects at the means for the highest expected outcome (a patent protected in all polities). The coefficients are interpreted as a percentage point increase in the probability of being protected in all regions. For example, one unit increase in Quality is associated with a 3.8 percentage point increase in the probability of a patent being protected throughout the British Isles, in column 1. For a categorical variable, belonging to a Non-Manual occupation increases the probability of being protected throughout the British Isles by 2.7 percentage points for the same column. Columns 1, 2, and 3 break HISCLASS into 'manual' against 'non-manual' occupations. Columns 4, 5, and 6 breakdown HISCLASS into 6 groups, where the omitted category is 'Higher Skilled Non-manual'. Columns 7, 8, and 9 identify Elite Inventors using the Dictionary of National Biography. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 6 for the period 1617-1852.

Potential wealth also plays a significant role in patenting behaviour. Insofar as social status accurately reflects patentee wealth, wealthier inventors were more likely to have protected their inventions throughout Britain. Non-manual workers, for example, were 2.7 per cent more likely to patent their inventions Britain-wide. Expanding occupations into six groups further supports this association. Compared to high-skilled non-manual workers, occupations associated with lower wealth were less likely to have patented in all jurisdictions. Low-skilled non-manual workers were 1.2 per cent less likely, while unskilled workers were 5.4 per cent less likely to patent widely, although the latter results are not significant. In this instance, social status is strongly indicative of wealth.

Great inventors were also patenting widely. Arguments in favour of supply-side mechanisms downplay the role of economic incentives for encouraging these individuals to invent. However, the evidence found here suggests otherwise. Compared to all other inventors, great inventors were 3.7 per cent more likely to extend their patent protection to all jurisdictions. As such, great inventors' incentives were also consistent with the demand-side hypothesis. The results also suggest great inventors were likely wealthy, as they could afford to patent widely.

Inventions that were more valuable had their patent protection extended to multiple jurisdictions in Britain, while wealth played a role in determining the how far patents could be extended. Therefore, not all inventors patented in all jurisdictions. Many inventors chose to extend their English patent to only one additional region. To understand why, I use probit models. Here, the dependent variable is a dummy variable, indicating which regions inventors obtained patents for. Table 8 reports the results. Columns 1-3 examine patents extended to Scotland. Columns 4-6 examine patents extended to Ireland. Columns 7-9 contrast inventions patented only in England against those patented only in Scotland.

The results continue to support the demand-side hypothesis. Patents extended to Scotland are found to have been more valuable than those patents extended to Ireland. For example, a standard deviation increase in the *ex post* number of references corresponds with an 8-10 per cent increase in the probability an invention received additional Scottish

Table 8: *Probit Results by Jurisdiction of Protection*

VARIABLES	Scotland			Ireland			Only Scotland		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Quality	0.052***	0.052***	0.050***	0.006**	0.006**	0.006**	-0.008***	-0.008***	-0.008***
	(0.008)	(0.008)	(0.008)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Non-manual	0.030***			0.005			0.000		
	(0.010)			(0.004)			(0.002)		
High-Skilled Non-manual		-			-			-	
		-			-			-	
Low-Skilled Non-manual		-0.006			-0.004			-0.001	
		(0.013)			(0.004)			(0.003)	
High-Skilled Manual		-0.060***			-0.002			0.000	
		(0.012)			(0.004)			(0.002)	
Farmer		-0.007			0.007			0.000	
		(0.056)			(0.019)			(0.012)	
Low-Skilled Manual		0.024			-0.022***			-0.002	
		(0.016)			(0.008)			(0.003)	
Unskilled		-0.063							
		(0.083)							
Great Inventors			0.089***			0.004			0.001
			(0.017)			(0.005)			(0.004)
Time	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Topic One	Y	N	Y	Y	N	Y	Y	N	Y
Topic Two	N	Y	Y	N	Y	Y	N	Y	Y
Observations	11,123	11,123	11,123	8,595	8,564	8,595	7,760	7,732	7,783
Pseudo R-Squared	0.118	0.119	0.119	0.109	0.112	0.108	0.275	0.275	0.277

Notes: Probit results for patents protected in one or two polities. Columns 1-6 show results for patents extended either only to Scotland or Ireland. Columns 7-9 examine patents protected only in Scotland and not in England or Ireland. Coefficients are interpreted as marginal effects at the means. Columns only control for TopicOne as results show no difference when controlling for TopicTwo, and both Topics together. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 6 for the period 1617-1852.

protection. By contrast, a corresponding increase in references is associated with a 1-2 per cent increase in the likelihood an inventor sought Irish protection. The Industrial Revolution transformed Scotland into an industrialised nation alongside England (Devine, 2004), while Ireland remained predominately agrarian and substantially less developed by comparison (Mokyr, 1983). Indeed, patenting in Ireland declined following the onset of the Great Famine, suggesting inventors were responding to market conditions. Similarly, inventors who chose to patent in only a single British jurisdiction patented their more valuable inventions in England instead of Scotland. This is despite the lower Scottish fees: England was the largest market in the British Isles, and probably attracted inventions which were more valuable.

5 What Determines the Value of Inventions?

Wealth matters for patent extension and presumably for obtaining patents altogether. However, wealth, skills and power could also matter for determining how valuable a particular invention really is. The literature considers skills and wealth to produce somewhat contrasting effects regarding the value of inventions: wealthy inventors made trivial inventions of little value, while skilled inventors invented the technology of the Industrial Revolution. Yet, wealth can afford superior schooling or skills, while skills can increase earned incomes (North, 1991; Becker, 1994). Wealthier inventors may have been capable of producing better inventions because they had the requisite skills to do so.

To test this, I use a negative binomial regression model, as outlined in equation 2. This follows the approach set out in Hall et al. (2005), Nicholas (2010), and Brunt et al. (2012). Patent citation datasets have skewed distributions. Many patents receive few references, and few patents receive many references. Negative binomial models account for this skewness.

$$PatentValue_{it} = \alpha_{it} + \beta_1 Occupation_{it} + \beta X_{it} + \mu_{it} \tag{2}$$

Table 9: *Negative Binomial Results for Entire Patent Series*

VARIABLES	(1) Quality	(2) Quality	(3) Quality	(4) Quality	(5) Quality	(6) Quality	(7) Quality	(8) Quality	(9) Quality
Non-Manual	0.046***	0.054***	0.044***						
	(0.011)	(0.011)	(0.011)						
High-Skilled Non-manual				-	-	-			
				-	-	-			
Low-Skilled Non-manual				-0.001	0.001	0.002			
				(0.014)	(0.014)	(0.014)			
High-Skilled Manual				-0.042***	-0.052***	-0.041***			
				(0.013)	(0.013)	(0.013)			
Farmer				-0.022	-0.040	-0.019			
				(0.057)	(0.057)	(0.057)			
Low-Skilled Manual				-0.056***	-0.059***	-0.049***			
				(0.019)	(0.019)	(0.019)			
Unskilled				-0.069	-0.072	-0.060			
				(0.053)	(0.052)	(0.052)			
Great Inventors							0.175***	0.180***	0.176***
							(0.024)	(0.024)	(0.024)
Constant	0.151**	0.119**	0.148**	0.198***	0.174***	0.193***	0.201***	0.176***	0.198***
	(0.059)	(0.060)	(0.061)	(0.057)	(0.058)	(0.060)	(0.057)	(0.058)	(0.060)
Time	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Topic One	Y	N	Y	Y	N	Y	Y	N	Y
Topic Two	N	Y	Y	N	Y	Y	N	Y	Y
Observations	15,283	15,283	15,283	15,283	15,283	15,283	15,283	15,283	15,283
Pseudo R-Squared	0.00340	0.00302	0.00377	0.00340	0.00302	0.00377	0.00411	0.00371	0.00450

Notes: The dependent variable is the weighted WRI metric. The coefficients are interpreted as the difference in the logs of expected counts of the predictor variable. To translate this into a unit change, the coefficients need to be exponentiated. For example, a coefficient value of 0.046 (Column 1) can be interpreted as follows: a one unit change in a variable leads to a 1-exp(0.046)=0.047, or a 4.7 per cent increase in the dependent variable. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 6 for the period 1617-1852.

The dependent variable is the weighted number of references on a given patent in a given period. The model explains the number of references as a function of occupations. I use the same occupational metrics as I used in the probit regressions. Here, the control variables constitute: the number of inventors named per patent; whether the patentee had at least one prior patent; whether the invention matches the inventor's occupation; the nationality of the inventor; whether the inventor employed a patent agent; the level of inflation; the difference between social status scores for patents with multiple inventors; and whether the invention was communicated by a foreigner. The results are reported in Table 9.

My results are inconsistent with the argument that wealthy inventors predominantly patented trivial inventions, while simultaneously supporting the supply-side hypothesis. In all specifications, potentially wealthier occupations are associated with a greater number of *ex post* references. On average, non-manual occupations are associated with five per cent more references per patent than their manual counterparts. Furthermore, breaking HISCLASS groups into six categories also shows a positive association between social status and patent value. Compared to high-skilled non-manual occupations, high-skilled manual workers had 4-5 per cent fewer references, while unskilled workers received 6-7 per cent fewer references per patent. As stated, the probit results suggest social status metrics reasonably capture wealth. As such, it is reasonable to interpret the results presented here as wealth rather than power effects.

The Great Inventors dummy is much more likely to capture skills or knowledge effects. The DNB does not seem to include individuals purely based on their wealth, but rather on their contributions to science and technology. The results suggest great inventors did produce much more valuable inventions. On average, a great inventor received 17-18 per cent more references per patent. Power, in terms of influence over those editors who published patent specifications, is unlikely to affect the results here. As stated, the DNB identifies great inventors through their inventions, and not through their patents or whether their invention was widely discussed by contemporaries. It is unlikely to be coincidence that the highly valued technologies of the Industrial Revolution had many references. Similarly, these patents were more often contested in English courts: this is only worthwhile if the patent is valuable. Therefore, I interpret the results as a direct skills effect on the value of patented inventions.

6 Patents and the Industrial Revolution

The patent system receives little credit with regard to encouraging the Industrial Revolution (Landes, 2003; Crafts, 2011). The perceived ineffectiveness of the system largely stems from its cumbersome administrative procedure and its great expense, particularly since many inventions are thought to have avoided it entirely (MacLeod, 2002; Nuvolari, 2004). However, a recent re-examination of this institution argues it contributed more positively to the Industrial Revolution (Bottomley, 2014b). My results further add to our collective understanding of patenting during this period. Inventors were patenting to protect their more valuable inventions, which suggests, in some cases, the patent system could have actively encouraged individuals to invent.

Understanding what motivates inventors is the first step toward understanding how best to encourage innovative behaviour. The prevailing arguments centre around whether inventors can be considered "economic men" (Dutton, 1984: pp. 104-117). Economic men seek out profitable market opportunities with their inventions, suggesting patents can be useful to encourage innovation (Schmookler, 1966). However, if patents are too expensive, then credit constraints limit their usefulness for innovation. Similarly, if inventors are not economic men – if they are motivated by scientific pursuits, for example – then patents are also ineffective because they would not encourage these individuals to invent.

I have shown inventor's patenting behaviour was consistent with the demand-side argument: they appeared to behave like economic men. They obtained patents because they had inventions which were subsequently proved to be valuable. The value of their inventions also strongly correlates with their wealth and skills. My evidence is consistent with the arguments of Crafts (2011): we invent because we are good at it, but also because we can earn profits from it. Indeed, James Watt himself strongly believed inventors responded to profitable opportunities and that patents were of great importance. A quotation, taken from his letter to Lord Loughborough, reveals exactly how important profits and patents were to Watt's own incentives (cited in Dutton, 1984: p. 109):

> There seems to be only three motives that can excite a man to make improvements in the arts, the desire of doing good to society, the desire of fame, and the hope of increasing his private fortune [...] when the three motives are united they must prove the strongest stimulus which can act upon the human mind, and they can make it to struggle with anxiety, the unremitting attention and the frequent disappointment and the labour and expense which infallibly attend every attempt at improvement in the arts [...] we have for many years devoted our time and money to the bringing the invention to perfection [...] but if our right to our patent should be taken away, or rendered illusive, we must drop any further pursuits of that scheme and apply ourselves to other businesses where our property can be more effectively guarded.

Whether patentees are representative of inventors remains questionable. Should patentees represent the average inventor, then inventors can be considered economic men. Conversely, if they do not represent all inventors, then only those inventors who seek patents are likely to be economic men. At the very least, patentee inventors respond to economic incentives, and therefore the patent system might have actively encouraged their behaviour.

As stated, inventors did not have to work their patents themselves, as licensing or selling their patent rights were also profitable options. By incurring the additional fees for Scotland or Ireland, a patentee had the right to license or sell their inventions to a wider market. Similarly, inventors may have wanted to pre-empt others from copying their ideas and working them in other British jurisdictions. Once a patent was granted and the specification enrolled, anyone was capable of paying to view it. Imitation would be likely to occur in those regions where an invention had not also been extended, and such imitation may have led to direct competition with the initial patentee. In this manner, patenting becomes a defensive mechanism for protecting profits rather than for earning them. While I cannot discern which mechanisms influenced which patentees, my results suggest patentees were attempting to protect the revenues from their inventions and did so by extending their patents to multiple jurisdictions in Great Britain and Ireland.

Patenting behaviour is also conditional upon the potential wealth of inventors, as well as how skilled they may be. Occupations are positively associated with patent extension, but also with patent value. Prior studies view wealthy inventors as a hindrance to inventive behaviour, because they patent trivial inventions (MacLeod and Nuvolari, 2016). The patent statistics do not support this conclusion. Instead, wealthier inventors appear to patent more economically valuable inventions, and they appear to patent widely throughout Great Britain and Ireland. Similarly, highly skilled inventors are associated with patents that turned out to be more valuable. Although skills and wealth may be endogenous, it is still reasonable to conclude both factors mattered with regard to patenting behaviour.

The efficacy of the patent system depends upon the degree to which it encouraged individuals to invent. In particular, its contribution depends upon whether patents encouraged the invention of the technologies of the Industrial Revolution. Although I cannot conclude from my evidence whether patents caused the Revolution, my evidence is at least consistent with the argument inventors were economically motivated, and therefore they obtained patents to protect valuable inventions. As such, patents may well have encouraged the development of key technologies of the Industrial Revolution.

7 Conclusion

This paper has examined the behaviour of British patentees by exploiting the unique institutional setup of Britain's patent system. I find evidence suggesting inventors opted into patent protection because they held inventions of value. Inventors who possessed valuable inventions patented these throughout Great Britain and Ireland. Furthermore, an examination of patentee characteristics revealed that the value of patented inventions was positively associated with the wealth of inventors and with their skills. Britain's historical patent system is renowned for its high fees, which arguably harmed innovation. Alternatively, the high fees may have actively encouraged invention from the upper classes, thereby contributing more positively to the Industrial Revolution. Based on the evidence presented here, the latter effect is more likely to have occurred.

Jacob Schmookler stated that, 'we have a choice of using patent statistics cautiously and learning what we can from them, or not using them and learning nothing about what they alone can teach us' (Schmookler, 1966: p. 56). While patent indicators cannot possibly explain the whole of inventive behaviour during the Industrial Revolution, they can still shed light on what patentees were doing. Patent statistics represent the only complete time series representation of technological change available for the Industrial Revolution.

8 References

A Cradle of Inventions: British Patents from 1617 to 1894 (2009). Stevenage, UK: Metal Finishing Information Services Ltd.

Allen, R. C. (2009). *The British Industrial Revolution in Global Perspective.* Cambridge: Cambridge University Press.

Becker, G. S. (1994). Human capital revisited. *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (3rd Edition).* The University of Chicago Press, pp. 15–28.

Bernstein, S. (2015). Does Going Public Affect Innovation? *The Journal of Finance* 70(4), pp. 1365–1403.

Billington, S. D. and A. J. Hanna (2018). That's Classified! Inventing a New Patent Taxonomy. *QUCEH Working Paper Series (No. 2018-06).*

Boldrin, M. and D. K. Levine (2013). The Case Against Patents. *Journal of Economic Perspectives* 27(1), pp. 3–22.

Bottomley, S. (2014a). Patenting in England, Scotland and Ireland during the Industrial Revolution, 1700-1852. *Explorations in Economic History* 54, pp. 48–63.

Bottomley, S. (2014b). *The British Patent System During the Industrial Revolution 1700-1852: From Privilege to Property.* Cambridge: Cambridge University Press.

Brunt, L., J. Lerner, and T. Nicholas (2012). Inducement Prizes and Innovation Inducement Prizes and Innovation. *Journal of Industrial Economics* 60(4), pp. 657–696.

Carpmael, W. (1842). *The Law of Patents for Inventions, Familiarly Explained for the use of Inventors and Patentees.* Third Edit. London: Simpkin, Marshall, Co., Stationer's-Hall Court; and Weale, High Holborn.

Clark, G. (2017). What Were the British Earnings and Prices Then? (New Series). *MeasuringWorth.*

Crafts, N. F. R. (2011). Explaining the first Industrial Revolution: Two Views. *European Review of Economic History* 15(1), pp. 153–168.

Devine, T. (2004). Scotland. *The Cambridge Economic History of Britain: Volume I, Industrialisation, 1700-1860.* Ed. by R. Floud and P. Johnson. Cambridge: Cambridge University Press, pp. 388–416.

Dowey, J. (2017). Mind over matter: access to knowledge and the British Industrial Revolution. PhD thesis. The London School of Economics and Political Science.

Dutton, H. I. (1984). *The patent system and inventive activity during the industrial revolution, 1750-1852.* Manchester University Press.

Griliches, Z. (1990). Patent Statistics as Economic Indicators: A Survey. *Journal of Economic Literature* 28(4), pp. 1661–1707.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001). The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools. *National Bureau of Economic Research Working Paper Series* No. 8498.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2005). Market Value and Patent Citations. *The RAND Journal of Economics* 36(1), pp. 16–38.

Hancock, N. W. (1850). On The Cost of Patents of Invention in Different Countries. *Statistical Section of the British Association.*

Howes, A. (2017). The Relevance of Skills to Innovation during the British Industrial Revolution, 1547-1851 (Unpublished, Brown University).

Kelly, M., C. O Grada, and J. Mokyr (2014). Precocious Albion: a New Interpretation of the British Industrial Revolution. *Annual Review of Economics* 6(1), pp. 363–391.

Khan, B. Z. (2005). *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790-1920*. Cambridge University Press.

Khan, B. Z. (2008). Premium Inventions: Patents and Prizes as Incentive Mechanisms in Britain and the United States, 1750-1930. *Understanding Long-Run Economic Growth: Geography, Institutions, and the Knowledge Economy*. University of Chicago Press, pp. 205–234.

Khan, B. Z. (2018). Human capital, knowledge and economic development: evidence from the British Industrial Revolution, 1750–1930. *Cliometrica* 12(2), pp. 313–341.

Khan, B. Z. and K. L. Sokoloff (2004). Institutions and Democratic Invention in 19th-Century America: Evidence from 'Great Inventors,' 1790-1930. *National Bureau of Economic Research Working Paper Series* No. 10966.

Klemp, M. and J. Weisdorf (2012). The lasting damage to mortality of early-life adversity: evidence from the English famine of the late 1720s. *European Review of Economic History* 16(3), pp. 233–246.

Kogan, L. et al. (2017). Technological Innovation, Resource Allocation, and Growth. *The Quarterly Journal of Economics* 132(2), pp. 665–712.

Lach, S. and M. Schankerman (2008). Incentives and invention in universities. *The RAND Journal of Economics* 39(2), pp. 403–433.

Landes, D. S. (2003). *The Unbound Prometheus*. Cambridge University Press.

MacLeod, C. (2002). *Inventing the industrial revolution: The English patent system, 1660-1800*. Cambridge University Press.

MacLeod, C. (2007). *Heroes of invention: technology, liberalism and British identity, 1750-1914*. Cambridge University Press.

MacLeod, C. and A. Nuvolari (2006). The Pitfalls of Prosopography: Inventors in the 'Dictionary of National Biography'. *Technology and Culture* 47(4), pp. 757–776.

MacLeod, C. and A. Nuvolari (2016). Inventive Activities, Patents and Early Industrialization. A Synthesis of Research Issues. *Rivista di storia economica* 32(1), pp. 77–107.

MacLeod, C. et al. (2003). Evaluating inventive activity: the cost of nineteenth-century UK patents and the fallibility of renewal data. *Economic History Review* 56(3), pp. 537–562.

McCloskey, D. (2011). *Bourgeois Dignity*. Chicago: Chicago University Press.

Meier zu Selhausen, F., M. H. D. Van Leeuwen, and J. L. Weisdorf (2017). Social Mobility Among Christian Africans: Evidence from Anglican Marriage Registers in Uganda, 1895-2011. *Economic History Review (forthcoming).*

Mitchell, B. (1998). *International historical statistics: Europe 1750-1993*. Springer.

Mitchell, B. R. (1971). *Abstract of British historical statistics*. CUP Archive.

Mokyr, J. (1983). *Why Ireland Starved: A Quantitative and Analytical History of the Irish Economy, 1800-1851*. London and Boston: George Allen and Urwin.

Mokyr, J. (2009). *The Enlightened Economy: An Economic History of Britain 1700-1850*. Yale University Press.

Moser, P. (2005). How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs. *The American Economic Review* 95(4), pp. 1214–1236.

Murfitt, S. E. (2017). The English Patent System and Early Railway Technology 1800-1852. PhD thesis. University of York.

Nicholas, T. (2010). The Role of Independent Invention in U.S. Technological Development, 1880-1930. *The Journal of Economic History* 70(1), pp. 57–82.

Nicholas, T. (2011). Cheaper patents. *Research Policy* 40(2), pp. 325–339.

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge university press.

North, D. C. (1991). Institutions. *Journal of Economic Perspectives* 5(1), pp. 97–112.

Nuvolari, A. (2004). Collective invention during the British Industrial Revolution: the case of the Cornish pumping engine. *Cambridge Journal of Economics* 28(3), pp. 347–363.

Nuvolari, A. and V. Tartari (2011). Bennet Woodcroft and the value of English patents, 1617-1841. *Explorations in Economic History* 48(1), pp. 97–115.

O'Brien, P. K. and P. A. Hunt (1999). England, 1485-1815. *The Rise of the Fiscal State in Europe c.1200-1815*. Ed. by R. Bonney.

Schmookler, J (1966). *Invention and Economic Growth*. Cambridge: Harvard University Press.

Southall, H. R. et al. (2004). Great Britain Historical Database: Census Data: Occupational Statistics, 1841-1991. *UK Data service* SN: 4559.

Sullivan, R. J. (1989). England's 'Age of Invention': The Acceleration of Patents and Patentable Invention During the Industrial Revolution. *Explorations in Economic History* 26(4), pp. 424–452.

Turner, J. D. (2014). Banking in Crisis. *Cambridge Books*.

Van Leeuwen, M. H. D., I. Maas, and A. Miles (2004). Creating a historical international standard classification of occupations an exercise in multinational interdisciplinary cooperation. *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 37(4), pp. 186–197.

Van Leeuwen, M. H. and I. Maas (2011). *HISCLASS: A Historical International Social Class Scheme*. Leuven: Leuven University Press.

Van Leeuwen, M. H., I. Maas, and A. Miles (2002). *HISCO. Historical International Standard Classification of Occupations*. Leuven: Leuven University Press.

Woodcroft, B. (1854). *Titles of Patents of Invention Chronologically Arranged, 1617-1852*. London: G.E Eyre & W. Spottiswoode.

Appendices

A Patent Fees

Table A1: *Breakdown of Scottish Patent Fees, 1842*

Item	Ordinary Fees			Extra Fees		
	£	*s.*	*d.*	*£*	*s.*	*d.*
Preparing Title of Invention, Petition, and Declaration				1	5	6
Secretary of State's Reference	2	2	6			
Secretary of State's Warrant	15	7	0			
Secretary of State's Stamp	1	10	0			
Lord Advocate's Report				4	4	0
Lord Advocate's Director	15	0	0			
Lord Advocate's Clerk	7	10	0			
Lord Advocate's Translator	1	1	0			
Lord Advocate's Director	1	1	0			
Lord Advocate's Servant	0	2	6			
Lord Advocate's Livery	0	3	7.5			
Lord Advocate's Extra	0	2	6			
				25	**0**	**7.5**
Great Seal Lord Keeper	6	13	4			
Great Seal Lord Deputy	2	10	0			
Great Seal Lord Usher	2	4	5.5			
Great Seal Lord Appendee	2	2	0			
Great Seal Lord Deputy	0	1	0			
Great Seal Lord Wax	0	7	6			
Great Seal Lord Extra	0	2	6			
Great Seal Lord Agency for Scotland	4	4	0			
Passing the Patent				10	10	0
Letters, &c				1	11	6
**Specification ———				***79**	**15**	**11**

Notes: * These fees are increased if the patent be taken in two names. ** The cost of the specification to each Patent depends on its length, also on the difficulties of drawing that document, and the drawings necessary. Text in bold represents the sum total of all fees, not the cost for the specification.

Source: Carpmael (1842).

Table A2: *Breakdown of Irish Patent Fees*

Item	**Ordinary Fees**			**Extra Fees**		
	£	*s.*	*d.*	*£*	*s.*	*d.*
Preparing Title of Invention, Petition, and Declaration				1	5	6
Secretary of State's Reference	2	2	6			
Secretary of State's Warrant	7	13	6			
Secretary of State's Stamp	1	10	0			
Mr. Attorney or Mr. Solicitor-General's Report				31	10	0
Signet Office				3	3	0
Seal Office				2	14	6
Lord Lieutenant's Fiat				5	5	0
Mr. Attorney-General's Clerk for Fiat				11	0	3
Clerk to Hanaper				8	9	2
Stamp to the Grant				21	13	4
Inrolling				1	1	8
Further Fees				21	2	6
Passing the Patent				10	10	0
Letters, &c				1	11	6
**Specification ———				***130**	**12**	**5**

Notes: * These fees are increased if the patent be taken in two names. ** The cost of the specification to each Patent depends on its length, also on the difficulties of drawing that document, and the drawings necessary. Text in bold represents the sum total of all fees, not the cost for the specification.

Source: Carpmael (1842).

B HISCLASS Breakdown

The HISCLASS scores are broken down into the following:

- 1: Higher Skilled Non-Manual: Higher Managers
- 2: Higher Skilled Non-Manual: Higher Professionals
- 3: Medium Skilled Non-Manual: Lower Managers
- 4: Medium Skilled Non-Manual: Lower Professionals
- 5: Lower Skilled Non-Manual
- 6: Medium Skilled Manual: Foremen
- 7: Medium Skilled Manual: Medium Skilled Workers
- 8: Medium Skilled Manual: Farmers
- 9: Lower Skilled Manual: Low Skilled Workers
- 10: Lower Skilled Manual: Low Skilled Farm Workers
- 11: Unskilled Manual: Unskilled Workers
- 12: Unskilled Manual: Unskilled Farm Workers

The Meier zu Selhausen et al. (2017) approach creates the following groupings:

- I (Higher Skilled Non-manual): HISCLASS 1 & 2
- II (Lower Skilled Non-manual): HISCLASS 3-5
- III (Higher Skilled Manual): HISCLASS 6 & 7
- IV (Farmers): HISCLASS 8
- V (Lower Skilled Manual): HISCLASS 9
- VI (Unskilled Manual): HISCLASS 10-12