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

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Abstract

This paper argues that patenting behaviour is responsive to demand-side incentives, and the quality of patents is a function of inventors' occupations. In particular, I examine patenting behaviour under the expensive, fragmented British patent system in the period 1617 to 1852. This system was comprised of separate offices for England and Wales, Ireland, and Scotland, where the cost of complete UK-wide protection could be up to 11 times the annual wage of the average British worker. Patentees had to decide *ex ante* where to patent in the UK; once the patent was sealed in one region, further UK protection could not be obtained. By matching the historical population of patents granted across the UK's three patent jurisdictions, I find that inventors whose patents are of a higher *ex post* quality were more likely to have chosen *ex ante* to protect their invention in multiple regions. Likewise, I show that patenting in multiple jurisdictions is associated with inventors of a higher social status. Inventors of a higher social status are also found to be more closely associated with higher *ex post* patent quality.

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

JEL Codes: N74, 031, 034.

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1 Introduction

Prior to 1852, England, Ireland and Scotland each possessed a separate patent institution. To obtain UK-wide patent protection, an inventor had to submit his application to one of the three polities and specify whether, and where, they wished to obtain additional protection. Inventors could not acquire a patent in one polity, test the market for their invention, and then later patent the same invention in another UK jurisdiction; once the patent was granted, it became public knowledge and no further extension to new geographic markets was permitted. However, the patent process was not cheap. The total cost of obtaining UK-wide protection was £380 in 1845, or £270,000 in today's money.[1] Likewise, it could take up to eight weeks to obtain an individual patent, and as long as 18 weeks to obtain patents in all jurisdictions. Why would inventors obtain patents in such an expensive system?

Patents are defined as temporary monopoly rights over a new invention or process, granted by a governing authority to an individual or firm; it assigns them the sole right to exclude other persons or firms from producing, using, or selling a good in which their innovation is in some way embodied (Scotchmer, 2004). Patents are characterised by their length, breadth, cost, quality threshold, and geographic scope. They specify: how long the entrepreneur can enjoy exclusive monopoly rights over the innovation (length); the industries in which the innovation is protected (breadth); the private cost the entrepreneur must pay to enjoy these rights (cost); A minimum quality, as patent applications have to fulfil certain technical requirements and specify an inventive step (quality threshold); and political boundaries within which the patent can be enforced (geographic scope). In order to understand how patents influence the process of innovation, and whether an optimal patent institution can be designed, each patent characteristic requires investigation.[2]

Patent costs are the most important characteristic to observe, as fees determine whether or not an inventor can afford protection. Observing the period of the Industrial

[1] The cost of patenting in 1845 was approximately 11 times the average annual English wage. By contrast, today a full UK patent, including renewal fees, would cost approximately 0.3-0.5 times the average annual English wage.

[2] A substantial body of literature exists examining the optimal length and breadth of patents. See Gilbert and Shapiro (1990), Klemperer (1990), and Lerner (1994) as a starting point.

Revolution, Bottomley (2014a) argues that high-quality inventions were more likely to be protected in multiple polities within the UK, suggesting that fees were not a hindrance. Inventors invest time and effort into the development of an invention because they perceive it to be profitable. This is the demand-side hypothesis of innovation associated with Schmookler (1966). Indeed, Allen (2009) advances this exact argument regarding the origins of Industrial Revolution, arguing that it paid to invent technologies crucial to the advancement of cotton spinning only in Britain, because of high British wages and cheap energy.[3]

However, MacLeod et al. (2003) have shown that the quality of inventions is irrelevant in the face of a high-cost patent system. Many useful inventions were likely either not invented, or protected outside the patent institution, such as through secrecy. The MacLeod hypothesis would suggest that inventive quality is independent of human capital and wealth. They argue that a significant reduction in patent fees would likely have lead to more valuable inventions entering the patent system.

However, Nicholas (2011) argues otherwise. In an examination of the 1883 *Patent Design and Trade Marks Act*, which cut patent fees by 83 per cent, Nicholas (2011) finds no significant change in the quality of inventions. Instead, he remarks that the number of patents granted increased significantly, but that many new inventions were likely of lower value. This suggests that "elite" inventors are capable of producing more valuable inventions. Wealth is likely correlated with skills, as skilled individuals are capable of obtaining higher earnings (Mincer, 1974; Becker, 1994). Insofar as skills and wealth are positively correlated, it is unlikely that the quality of an invention is entirely independent of the skills or wealth of the inventor. Indeed, Meisenzahl and Mokyr (2012) and Kelly et al. (2014) argue that British innovators were well-educated and highly skilled; it is these elite inventors who drove innovation.

Likewise, Mokyr (2009) argues that the Industrial Revolution was caused by superior British human capital and access to knowledge. By being able to interact with other

[3] This 'high wage' thesis has been challenged in recent years, see Stephenson (2017). This challenge does not, however, downplay the demand-side argument concerning invention; the 'induced innovation' hypothesis was pioneered by Hicks (1963).

like-minded individuals, knowledge access institutions (KAIs) provided the means for knowledge sharing, and thus positive spillover effects of human capital within an economy (Dowey, 2017). Howes (2017) argues that a distinct British "mentality" determined the ability of Britons to produce higher-value inventions. This mentality spread throughout Britain thanks to the socialisation of British inventors. McCloskey (2011) goes so far as to suggest that ideas and rhetoric were the dominant means of encouraging inventive behaviour; inventors were motivated by much deeper incentives than simple profit maximisation.

Ultimately, the prevailing institutional framework governs the incentives to engage in inventive activity. North (1990) argues that the British patent system was a positive institution for encouraging invention. However, this argument has been widely debated. Dutton (1984) concludes that the imperfections of the British system are what made it valuable to the Industrial Revolution; it only had to be of greater use than the alternative mechanism of secrecy. By contrast, MacLeod (2002) argues that the institution was too cumbersome, and fraught with uncertainties, which encouraged inventors to bypass the system entirely. Clark (2008) also disregards the importance of the system, suggesting that inventors were incapable of earning profits from their patents. Landes (2003), likewise, does not agree that the patent system played any active role regarding the Industrial Revolution. Recently, Bottomley (2014b) has provided a complete re-evaluation of the patent system, citing it as a major determinant of innovation and the Industrial Revolution.

This paper seeks to answer two questions: Why did inventors obtain patent protection? And, because high fees restrict patenting to the elite, was the quality of an invention in any way associated with the inventors' occupation? To answer this question, I exploit the structure of the British patent institution, specifically regarding the choice made by inventors on where to obtain patent protection. Inventors were required to denote, in their initial petition for a patent, which UK jurisdictions they wished to obtain patents in. Their decision to obtain a patent is made simultaneously with their decision of where to "extend" their patent protection.[4] As such, the reason an inventor would obtain a patent is akin to his decision of *where* to patent his invention.

Using a probit model to explain the probability of where inventors chose to patent, I find that inventors who produced inventions which subsequently turned out to be valuable, were more likely to protect them in multiple polities. But the propensity to extend protection was also positively associated with the skills and wealth of an occupation. This effect is particularly strong for patents protected in all jurisdictions. Furthermore, valuable inventions are more likely to be protected in Scotland over Ireland. This reflects the different market opportunities available in both countries. Scotland was a valuable market, as it was a nation which industrialised alongside England (Devine, 2004), while Ireland constantly lagged behind the rest of the UK in terms of living standards and economic development (Mokyr, 1983), making it a less attractive market in which to sell their inventions.

Concerning the second question – whether the quality of an invention was associated with the inventors' occupation – I proxy for an inventor's occupation by using two different social status metrics. These metrics capture wealth, human capital and the potential social influence that inventors had over their contemporaries. To test the relationship between occupations and quality, I use the negative binomial model. I find that higher skilled occupations are more likely to produce inventions which were subsequently determined to be more valuable than their lower skilled counterparts.

Throughout the period of observation, the composition of patentees is likely to have changed: nominal fees remained constant, but due to inflation, the real costs of patenting declined. This would likely have made it easier for lower class individuals obtain patent protection. To test for this relationship, I use a fixed-effects setup to examine how changing inflation influenced changes in patent quality, and also changes in the social status scores of patentees. The results suggest that declining real costs did not encourage poorer innovators into the patent system. On the contrary, the number

[4] "Extension", as defined by Bottomley (2014a), indicates that a patent was protected in multiple UK polities. In general, Bottomley assumes inventors filed for their English patents first, and then extended to the rest of the UK. Ultimately, it is not important where the inventor initially filed their patent; it only matters where they obtained patents.

of patents associated with elite inventors *increased* within the patent statistics. I also find weak evidence to suggest that the value of inventions was rising as these real costs declined; elite inventors likely continued to patent their valuable ideas.

This paper contributes to the literature in multiple ways. First, it builds upon the seminal work of Bottomley (2014a,b) by extending the examination of patenting behaviour with additional econometric techniques. Bottomley argues that patenting behaviour is driven by demand-side factors, but restricts his analysis to observing the differences in the average quality of patents in multiple jurisdictions. Furthermore, he is unable to examine the quality of patented inventions alongside the occupation of their inventors. This study is able to observe the decision to extend patent protection with more robust techniques, and also investigates how inventor occupations influences *ex post* patent quality and patenting behaviour. In doing so, I am able to verify and extend Bottomley's conclusions. Second, this study extends the dataset used in Bottomley (2014a) by examining the entire population of British patents granted in the period 1617-1852. This dataset also includes a unique population of Scottish patents not previously examined in the literature; I also extend the patent quality indicator to cover this additional population of patents. These additional data provide further insights into the behaviour of patentees during the period of the Industrial Revolution.

This study is broken down into the following sections. Section 2 discusses the history of the British system and outlines the 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 why patents receive additional protection. 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. Appendix A provide additional patent fees. Appendix B provides a breakdown of our social status metric. Appendix C contains additional summary statistics. Appendix D shows additional probit results. Appendix E provides a robustness check.

2 Historical Background

Founded in 1624, following the *Statute Of Monopolies*, the English patent office constituted the earliest modern patent system. Following the 1707 Act of Union, the English and Scottish Crowns were united, but both polities retained their separate patent offices. The 1801 Act of Union brought Ireland into the United Kingdom, but did not merge the Irish patent office with those of Great Britain. As such, the entire British system constituted three separate patent jurisdictions. Protection was expensive and, depending on the degree of protection, required the navigation of multiple offices .

2.1 Patent Law

The *Statute Of Monopolies* was directly responsible for the foundation of patents as a temporary monopoly right. It arose out of the abuse of royal privilege by the Crown, as parliament attempted to curtail the monopoly-granting powers of the King (MacLeod, 2002). Indeed, Boldrin and Levine (2013) report that the statute transferred the right to grant monopolies away from the monarch and into the hands of parliament. Instead of providing a monopoly over commodities, or trivial things, to the detriment of the country, the statute declared what could be protected.[5]

> "...any manner of new manufactures within this realm (c) to the true and first inventor (d) and inventors of such manufactures, which others at the time of making such letters patents and grants shall not use (e), so as also they be not contrary to the law nor mischievous to the state by raising prices of commodities at home, or hurt of trade, or generally inconvenient (f)"

The 1624 act created the first modern patent system. But, from its inception until 1852, no amendments to the law were made. The nominal costs of the system did not change, nor was there any substantial update to the act itself. Instead, patent cases brought to the courts formulated patent law. MacLeod (2002) points out that, for the early period of the system, few patents were filed. She attributes this to the uncertainty of patent law; inventors were unsure what could be patented, or how to navigate the

[5] *Statute of Monopolies* 21 Jac 1 c 3

patent system itself. However, Bottomley (2014b) paints a more optimistic picture, suggesting that this great uncertainty, while present, was not as detrimental to innovation as previously argued.

As the body of patent cases grew, the risks associated with patenting declined; inventors learned how to navigate the patent system, and what could or could not be protected. Notably, the case of *Roebuck v. Stirling, 1774*, set the rules governing the acquisition of full UK protection. In this instance, the defendant obtained protection for an invention in Scotland, but the invention had already previously been made public in England. The courts ultimately ruled that, following the 1707 Act of Union, both England and Scotland constituted a single Kingdom, and that prior usage in either polity could void patents in both. Subsequent to this ruling, the application procedure required patentees to specify in which additional UK polities they desired protection at the time of their first application (Bottomley, 2014b).[6]

A second notable case, *Liardet v. Johnson, 1778*, produced the requirement of a detailed description of the invention, outlining what is new and novel, such that those skilled in the art could replicate it using only this document: the specification.[7] This requirement became the primary method through which the new knowledge embodied in an invention was to be diffused to the public.[8] Specifications were widely circulated, both through patent office reports and contemporary trade journals (Bottomley, 2014b).

The specification initially created difficulties as inventors had not been previously required to submit such documents, and so were unaware of potential omissions or mistakes which could invalidate their patent. This lead to the development of a body of professional patent agents – persons who had extensive knowledge of the patent law and

[6] In England, there were 10 stages in the application procedure; prospective patentee's had to outline the additional UK polity(s) they wished to obtain patents from in the first stage – when they submitted their initial petition.

[7] Murfitt (2017: p. 38) describes that this was required for "consideration", defined as a 'benefit or value of a contract', and that it is required to 'for the contract binding to be binding between two parties'.

[8] Prior to this, the statute had not required such a submission, and Bottomley points out that the patent granted to John Naismith of 1711 was the first of its kind to contain such detailed documents. From 1733, MacLeod (2002), Bottomley (2014b), and Murfitt (2017) outline that the courts adopted the submission of a specification as being a requirement for potential patentees. While it was required as part of the patent, it was not the *consideration* until 1778; it would not be until 1778 that the specification became the most important aspect of the patent.

the navigation of the patent system – who understood what was to be expected of a specification.[9] These agents sold their services to prospective patentees; they would either patent on behalf of another, or guide an inventor's petition through the multiple stages of the application process – both requiring an additional fee.[10]

The body of patent law has previously been interpreted as biased against patentees e.g. (Dutton, 1984). Those researches suggested that the law was hostile to patentees due to unfavourable, anti-monopolist sentiments of the courts. However, Bottomley (2014b), having reviewed the history of patent cases, suggests that this was not accurate. He shows that Dutton (1984) had under-counted the number of patent cases. Bottomley then presents updated figures, which show that patentees won their case at least half the time, with 59 per cent of cases going in favour of the patentee after 1800. Patentees, then, had stronger, more certain, protection.

As there existed three separate patent offices, each with its own courts, there is a possibility that some UK jurisdictions were more advantageous to patentees in terms of enforcement and interpretation of the law. Bottomley (2014b) notes that Scottish and Irish patent law stringently followed that of English law. Of the 10,364 patents granted between 1770 and 1849 in England, only 313 (3 per cent) of them were litigated. By contrast, of 4,522 the patents granted between 1800 and 1852 in Scotland, only 22 of them can be recorded in patent cases in Scotland (less than 0.5 per cent). Similarly, of the 1,718 patents granted before 1852 in Ireland, only three patent cases can be found in Irish courts (less than 0.2 per cent). Although Bottomley (2014b) points out that a systematic examination of the court records from each jurisdiction would likely yield more patent cases, he suggests that the ratio of court cases (300:30:3, for England, Scotland, and Ireland) would remain largely the same. This would suggest that there was no great advantage, in terms of patent law, in Ireland or Scotland over England. As such, it is unlikely that legal activity was an important determinant of patent extension.

[9] Patent agency originated independently of the patent office. However, these agents normally began their trade under the employment of the patent office, and utilised their specialist knowledge as a service for prospective patentees.

[10] At present, I am unaware of the fees charged by patent agents. Although Bottomley (2014b: p. 66) notes that in 1850 the Privy Seal Office received £2,450 in fees from patent agents, 43 per cent of which came from Poole and Carpmael.

2.2 Patent Fees

The *Statute of Monopolies* provided a rich source of information concerning the fees for the English patent institution. Table 1 provides a breakdown of fees in England.[11] The table lists two types of fees: Ordinary and Extra. The Ordinary fees are the required fixed costs; the Extra fees are variable. For example, each additional named inventor on the patent elicits an extra fee; assuming at least one additional inventor was named on a patent in 1800, the additional cost is likely to have been approximately £19, which translates into £600 in today's money.

The application process was costly and difficult to navigate. Indeed, Bottomley (2014a) discusses the stages of the patent application process. In England, the patentee had to move their petition through ten stages, which required obtaining the signature of multiple officials, some of which were required multiple times. A similar process is observed in Scotland and Ireland. Overall in 1845, a patent took an average of four weeks to be obtained in England, six weeks in Scotland, and six to eight weeks in Ireland (Bottomley, 2014b). In most instances, patentees had to remain in or near the patent office until their application was completed, as it was their responsibility to guide their petition through to completion. For some, this required travelling to London/Edinburgh/Dublin, and residing there until their patent was granted (or until the procedure had ended). Not only were the fees expensive, but the opportunity cost of patenting was extremely high.

Comparatively, the British patent system was, by quite a margin, the most expensive patent system for the period. Table 2 shows the costs for patents, in 1850 pounds sterling, for contemporary patent authorities. These fees are transcribed from Hancock (1850).[12] The cheapest patent belonged to Belgium and Holland for £70, whilst the highest cost found is for Ireland at £135. It is notable that costs in the US range drastically, from £13 for a US citizen to £120 for a British citizen. In terms of wages, British patents

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

[12] Some countries provided patents for 5, 10, or 15 years. British institutions did not supply patents for fewer than 14 years. This is a relic of the legislation; knowledge diffusion was initially intended to work through the training of multiple apprentices, which took 7 years each, before the specification took precedence.

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).

were incredibly expensive to British workers. 'C/W' presents the nominal fee as a ratio of nominal wages for the average British worker in 1850. A US patent for a US citizen would cost approximately 40 per cent of the average British wage. By contrast full UK protection would cost approximately 1,100 per cent of the average British wage. For protection under a single UK jurisdiction, the cost as a percentage of the average wage ranges between 220 to 400. British workers would have had to save their full wage for approximately two to four years just for one patent; they would have had to save upwards of eleven years for full UK-wide protection.

Table 2: *Costs of Patents in 1850 prices and 2016 prices*

Country	**Patent Length**	£ (1850)	£ (2016)	**C/W (1850)**
U.S.A.	14 years (domestic)	13	10,000	0.38
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**
U.S.A.	14 years (foreign)	77	59,000	2.27
England	14 years	**110**	**84,000**	**3.23**
U.S.A.	14 years (British)	120	93,000	3.53
Ireland	14 years	**135**	**104,000**	**3.97**
U.K. (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 wage in 1850. This is calculated using the nominal wage of £34 in 1850, from Clark (2017).

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

3 Patent Series

To conduct an examination of the British patent system, this study employs the entire population of British patents granted between 1617 and 1852. This dataset was acquired from the *Cradle of Invention* (2009) (COI) and Bottomley's (2014a) online appendix; the final dataset represents the digitised version of the detailed 'Titles of Patents of Invention' compiled by Woodcroft (1854).[13] The document outlines the names of the patentee(s), their respective occupations, their address, and the title of their invention. The dataset also includes the population of Scottish and Irish patents. All datasets are assigned a Woodcroft Reference Number (WRN). Using this, patents can be matched between England, Scotland and Ireland. This allows me to observe patents protected in one, two, or three polities.

The COI dataset also contains a small population of 'only-Scottish' patents. These are defined as patents found in Scotland, but not found anywhere else in the UK. Such patents contain the same degree of richness as the remainder of the COI data, allowing them to be analysed in comparison.[14]

[13] Bennet Woodcroft (1803-1879) became Superintendent in the new UK-wide Patent Office after the 1852 Amendment Act. He pioneered the efforts of the Patent Office to document, in greater detail, all patents granted under the previous iteration of the system.

[14] There is also a small population of 'only-Irish' patents; however, these are too few in number, and

Figure 1 shows the time-series of patents granted, by each polity, from 1617 to 1852. The English series shows a marked increase in the number of patents granted after 1750, which Sullivan (1989) regards as the beginning of the Industrial Revolution. By contrast, patents in additional polities remained relatively stagnant until 1825, when all series exhibit a spike in their trends.[15] Furthermore, the patent trend of Scotland begins to follow that of England more closely, whilst Ireland exhibits a more depressed trend toward the end of the period, which reflects the onset of the Great Famine.

3.1 Patent Citations

One strong criticism of patent indicators is that they treat all patents as being of equal value. Clearly, this is not the case. Some inventions are more valuable than others. One popular method to proxy for *ex post* patent quality is to observe the number of forward citations a particular patent receives (Hall et al., 2001; 2005; Lach and Schankerman, 2008; Bernstein, 2015; Kogan et al., 2017). Patent citations reflect the degree to which a previous patent influences the direction of current technology. Citations are assigned by patent examiners, and are intended to reflect prior art. As such, a particular patent which is commonly cited is considered to have been influential in the development of those technologies, as these firms or individuals have invested heavily in R&D to improve upon this initial technology. An influential technology is then considered economically valuable, making citations a suitable proxy for patent quality.

However, for the period 1617-1852 in British patent history, citations are unavailable. Instead, the literature has made use of a similar proxy for citations. The data employed in this study is compiled 'Reference Index of English Patents of Invention, 1617-1852' (Woodcroft, 1862). The index lists every publication which makes an explicit reference to a patent which has been granted. Nuvolari and Tartari (2011) have pioneered the usage of this index in the economic history literature. Contemporary journals and magazines which cite patents simply provide a list of recently granted patents, alongside the details

lacking in detail, to be used in this analysis.

[15] Turner (2014) notes that there was a bubble in the stock exchange in 1824 and early 1825, which subsequently burst in 1825. The spike in the patent series could reflect this event.

of their specification. The number of references indicates the relative 'visibility' of a particular patent in the literature. Nuvolari and Tartari (2011) argues that this visibility captures both the economic importance and the technical nature of these inventions. As such, they are a useful proxy for discerning *ex post* realised quality.[16]

Each patent is matched up to its respective number of references through the Woodcroft Reference Index (WRI). However, this index was only constructed for patents which were granted in England; patents granted solely in Scotland did not receive such scores. Instead, I replicate the citation process of Woodcroft. My approach has been to search digitised contemporary journals and magazines for the listed title, inventor, and year. This search also aided in identifying patents which had been incorrectly categorised as "uniquely Scottish". Once the search was completed, I counted the number of documented references to determine a WRI score.

Nuvolari and Tartari (2011) provide a list of the journals which appear most frequently within the WRI. To ensure that I have derived a representative body of references for the uniquely Scottish data, I contrast the prevalence of my reference sources with that of Woodcroft. This is summarised in Table 3. The table shows the top six journals which appear in the list of references from both datasets. Half of the journals in my investigation match those in Woodcroft. Similarly, the relative frequency of the top journals in my list matches very closely to that of Woodcroft. Notably, of my top journals, *The Edinburgh Philosophical Journal* is never mentioned in the WRI. This suggest Woodcroft restricted his observations of references to only English or London based publications. Inventions with an importance to other areas of the UK are likely then to be under-referenced in this index.[17]

[16] While it is possible that "failed patents" may be overly cited, this is not the case. Most citations are assigned once the patent is granted, as journal and magazine editors (who are commonly patent agents) inspect the specifications of recently granted 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 description of how to work the invention, and what is new or novel about it. Editors then choose patents based on the preferences of their readership; they are likely only to publish novel, or valuable, patents.

[17] This is unlikely to be a serious problem. Inventions which are valued in England are likely to be equally valued in Scotland. Scotland was industrialising alongside England; inventions valuable in one region are then likely to be valuable in the other. Ireland, by contrast, remained predominantly agrarian; it is likely that agricultural inventions are under-estimated for their value to the Irish economy. However, Irish patents are few, and most were also patented in England, implying that they would have

Figure 1: *Time Series of Patents By Polity*

Notes: The figure shows the number of patents granted in each patent jurisdiction by year.

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

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).

Of course, this approach can only ever be approximate, as I am reliant entirely upon digitised journals and trade magazines that are searchable online. However, it is unlikely that the results are going to produce a significant bias, as it is the relative number of citations on a patent which matters. I have obtained a reasonable sample of citations, which should then produce an accurate variation in quality scores. Also, countries are controlled for, meaning that the distribution of patent citations is examined rather than the absolute number of citations.[18]

3.2 Occupations

The patent data includes information concerning the occupations of patentee(s). This information allows me to control, approximately, for their wealth and human capital. To quantify occupational status, each listed occupation was matched with their British HISCO code (Van Leeuwen et al., 2002). HISCO is a classification scheme, designed to create: 'an occupational information system that is both international and historical, and simultaneously links to existing classifications used for present-day conditions'.[19] The scheme is intended to assign occupations a five digit code, which allows them to be

been valuable to both regions.

[18] The same process was attempted for the uniquely Irish patents, but I did not find a single citation. Either these patents were not important, or they were not mentioned as they were never filed in England. Most journals and magazines were produced by patent agents and engineers in London, so it is probable that they restricted their observations to English journals.

[19] For more information concerning HISCO, see https://socialhistory.org/en/projects/hisco-history-work.

grouped with similar occupations across countries and time. Once attached, these scores were then matched up to two additional metrics. The first, HISCLASS, is a categorical social status scheme (Van Leeuwen and Maas, 2011). Occupations are assigned to one of twelve categories. Each group is divided based upon the skill of each occupation, the amount of supervision required, and whether the occupation is manual or non-manual. The breakdown of these codes is presented in Appendix B.

HISCAM scores, the second metric, are attached to each occupation through the assigned HISCO codes (Lambert et al., 2013).[20] The HISCAM metric is a continuous scale, where the mean is scaled to 50 and a standard deviation of 10. Persons with scores above 50 are considered to be in a more advantageous social position.

Both metrics attempt to capture potential wealth, education, or "power" effects an individual may have as measured by their occupation. Patent quality may be influenced by the human capital of the inventor, conferring upon them superior ideas or the skills required to produce valuable inventions. Likewise, wealth influences the number of polities an inventor could initially obtain patents in, and may also exert influence over the quality of the invention through access to capital to support continual R&D. Lastly, power, in terms of how much control a person is likely to have over his contemporaries, may influence the number of citations. Persons of greater social standing may have been able to influence which journals cited their patents. They may also have been able to obtain internal and external financing much easier than their lower social class counterparts.

3.3 Patent Classes

Moser (2005) shows that the propensity to patent in history varies greatly across industries. Machine inventions, due to the ease of reverse-engineering, are more likely to be patented. Chemical inventions, by contrast, are less likely to be patented. Accordingly, certain technologies have different characteristics than others. It is then vital to control accurately for technology groups. Indeed, Billington and Hanna (2017) show that patent analysis can be contingent upon the choice of classification taxonomy.

[20] This study uses the Male Only, British HISCAM scale.

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. These are listed from highest to lowest by England.

To ensure consistency, and transparency, I adopt the 19 static patent classes derived in Billington and Hanna (2017). Patent titles contain detailed information concerning the purpose of the invention. As such, certain classes of inventions are associated with a particular vocabulary. For example, inventions pertaining to 'Textiles' would likely be associated with the following words: 'weaving, looms, carding, cleaning, washing, bleaching, leather'. These word associations are derived from machine-learning techniques. In essence, the machine scours the patent titles to derive words commonly associated with each other. These associations, or 'topics', are then assigned one of the 19 static classes. Each patent is then 'scored' according to its top two topics, in order to capture potential spillover effects between classes. In this way, the degree of subjectivity required to assign classes is mitigated. "TopicOne" refers to the highest scoring class and "TopicTwo" refers to the second-highest scoring class associated with a particular patent. This study follows the approach in Billington and Hanna (2017) by controlling for both classes individually, and then simultaneously.

Table 4 presents the breakdown of the assigned TopicOne classes by each patent jurisdiction. As can be seen, most patents granted were for 'Machinery', 'Manufacturing', and 'Textiles' inventions. Furthermore, Ireland attracts relatively more 'Construction' and 'Agriculture' related inventions than the rest of the polities, whilst Scotland attracts more 'Power' related inventions, which would comprise different kinds of engines. Notably, each polity attracts a high degree of 'Chemicals' inventions. Indeed, of the patents protected in all polities, 'Chemicals' is one of the most prevalent. Either such inventions were incredibly valuable, or chemical inventions were the most popular in Britain, as the literature suggests that such inventions are less likely to be patented.

3.4 Additional Control Variables

The list of control variables used in my ensuing regression analysis is presented in Table 5 below. This subsection briefly describes the motivation for the inclusion of key variables from this list.

'Another Patent' determines whether or not a patentee had at least one previous patent. This controls for potential experience or wealth effects. Had the previous patent been successful, then a patentee may have earned enough capital (or gained a business partner) to pursue future inventions; they may also have "moved up" the social ladder as a result. Similarly, having navigated through the system once, the patentee may have greater certainty in the institution to protect his inventions, or greater experience, leading him to pursue future patents.

'For Inventor Use' captures whether the patentee's occupation matches to that of his patent. This metric intends to capture "true inventors" against mere "tinkerers". MacLeod and Nuvolari (2006) argues that "vanity patenting" was prevalent in the British patent system. This occurs when patents are granted to 'gentlemen' inventors who regard patenting as a hobby rather than a career. Nuvolari and Tartari (2011) follow a similar approach, but determine this metric to capture "Insiders" versus "Outsiders". They suggest, based on the modern innovation literature, that major innovations are produced by outsiders who have a fresh perspective. Likewise, Howes (2017) argues that it was generally inventors who were not skilled in the art who produced the most valuable inventions for particular industries.

'Patent Agents' control for patentees with an occupation of patent agent.[21] Patent agents provided their services to any paying customer, and they would often procure patents in their own name but on behalf of another. Since I cannot account for patents obtained for patent agents from those obtained for others, I treat all patent agents as patenting on behalf of a client. Patent agents required an additional fee, on top of the patent fee, suggesting that those who employed them were likely to have been wealthier than the average patentee. Also, some patent agents acted as editors for various trade journals and magazines, and so may have influenced the number of citations their associated patents received. For example, William Newton was the editor for the 'London Journal of Arts, Sciences, and Manufactures, and Repertory of Patent Inventions', but was also a patent agent and partner of Newton & Co. (Bottomley, 2014b).

Each patentee is required to provide their address. Patentees are then grouped based on their geographical location. These locations are matched up to their historical counties, and the average distance from each county to the English, Scottish, and then Irish patent offices are calculated. Euclidean distance from the patent office captures the associated transport costs. Similarly, each patentee is assigned to one of five nationalities: English, Irish, Scottish, Foreign, and Patent Agent.[22]

3.5 Summary

Table 6 displays selected descriptive statistics for England, Ireland, Only Scotland, and Scotland.[23] The difference between Scotland and Only Scotland is that the latter

[21] They are identified through their listed occupation, and by references in Bottomley (2014b).

[22] Patent Agents, whilst clearly not being a nationality, can be employed by anyone. Thus, English, Irish, Scottish, or Foreigners have access to employ an agent. As the nationality of the original inventor is unknown, patent agents must be treated separately.

[23] Full summary statistics are presented in Appendix C for each polity.

Table 5: *Definitions of Dependent and Independent Variables*

	Unit	Definition	Description
Dependent Variable			
AdjustedWRI	Continuous	number of citations per patent weighted by average citations of a given time interval	measure of patent quality
Only-Scotland	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 all polities	captures patents which received additional protection
Occupation Variables			
HISCAM	Continuous	0-100 representing Social Status	measures potential wealth, education, and status of a patentee; a higher score indicates 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
Occupation Dummies			
Higher	Dummy	1 if HISCLASS score is 1-5	captures effect of higher status occupations
Skilled	Dummy	1 if HISCLASS score is 6-7	captures effect of skilled occupations
Farmer	Dummy	1 if HISCLASS score is 8	captures effect of farmer occupations
Low Skilled	Dummy	1 if HISCLASS score is 9-10	captures effect of low skilled occupations
Unskilled	Dummy	1 if HISCLASS score is 11-12	captures effect of unskilled occupations
Non-manual	Dummy	1 if HISCLASS score <6	captures effect of manual vs non-manual occupations
I	Dummy	1 if HISCLASS score is 1-2	captures effect of higher status occupations
II	Dummy	1 if HISCLASS score is 3-5	captures effect of upper skilled occupations
III	Dummy	1 if HISCLASS score is 6-7	captures effect of lower skilled occupations
IV	Dummy	1 if HISCLASS score is 8	captures effect of farmer occupations
V	Dummy	1 if HISCLASS score is 9	captures effect of low skilled occupations
VI	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			
TopicOne	Factor	first related patent technology class	control for related patent characteristics
TopicTwo	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); HISCAM (Lambert et al., 2013); 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.

represents patents which were not also granted in England or Ireland.

The HISCAM scores represent an empirical approximation as to the social status of an individual, based on pairwise occupations linked through marriage or birth records. The higher the score, the higher the associated social standing. Likewise, the HISCLASSNONMANUAL (HNM) metric categorises occupations based on whether they are manual or non-manual. Non-manual occupations are likely associated with a higher social standing, higher skills, and greater wealth.

Observing Table 6, the associated HISCAM scores lie above the mean of 50 for each polity. Each polity also shows a significant majority of non-manual occupations. This suggests higher social status occupations select into the patent system. It is also clear that Ireland and Scotland possess higher average scores than England. Higher social status persons would be capable of obtaining further protection, due to their associated wealth. By contrast, Only Scotland exhibits a mean score very close to England. This suggests that single polity protection is associated with lower scores, and therefore potentially with lower wealth.

Observing HISCLASS scores, combined with data from the 1851 British Census[24] shows that occupations belonging to groups 1-2 (higher professionals and managers) represent approximately one per cent of the British male population, but these occupations account for at least 40 per cent of all patents granted in 1851. By contrast, individuals who belong to groups 7-9 (medium to lower skilled) represent roughly 20 per cent of the British male population, but they hold 23 per cent of all patents granted in 1851. Elite occupations then are overrepresented in the patent statistics.

The bottom third of the table displays the WRI citation scores. As with the occupational scores, patents found in Ireland possess higher average citations than England; the same is true for patents found in Scotland. Only Scotland displays the lowest average score, but this may also be due to the fact this metric was constructed by myself, whilst the other scores were constructed by Woodcroft. Regardless, the scores for Ireland and Scotland suggest that patents which receive additional protection

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

Table 6: *Comparison of Descriptive Statistics*

	Number	Mean	Std. Dev.	Min	Max
HISCAM					
England	10,725	61.2	9.4	28.28	93.73
Ireland	238	64.1	8.3	42.84	93.73
Only Scotland	183	61.6	7.7	36.61	84.08
Scotland	2,886	62.5	8.9	33.04	99
All	1,431	63.2	8.8	33.04	84.08
HNM					
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
WRI					
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: HISCAM represents a continuous scale from 0-100, with 100 representing the highest social standing. HNM shows the percentage of non-manual occupations associated with patents in each jurisdiction. WRI shows the *ex post* number of citations, which are not adjusted by cohort.

Source: Author's calculations using data from Table 5.

also have more citations in the WRI. This would appear to support the results posited in Bottomley (2014a): higher cited patents are extended because they have higher potential returns.

4 Why Extend Patent Protection?

The decision for an inventor to select into patent extension is likely strongly correlated with the relative value of his invention. More valuable inventions cannot be convincingly kept secret; eventually the invention will be re-discovered by competitors, effectively eliminating any potential returns for their efforts. Indeed, Dutton (1984) downplays the role of secrecy as an important mechanism for protection, based on the accounts of contemporary inventors. But, the costs of patents also influence the choice to kept inventions secret: the more expensive the patent, the less likely it can be obtained.

The decision to engage in the art of invention has been argued as part of either a "demand-side" or "supply-side" process. The demand-side school of thought argues that invention, and patenting, is a response to profitable market conditions; we invent because it pays to do so (Schmookler, 1966; Allen, 2009). The supply-side school of thought argues that inventors merely supply their skills to invention. We invent because we are good at it, or because of some deeper incentive, such as being the "first inventor" or discovering new knowledge have been posited as such reasons (Mokyr, 2009; McCloskey, 2011).

Patents are acquired when an inventor deems their invention worthwhile, and also has the capital to cover the necessary fees. However, the literature has, to some extent, considered quality to be independent of inventor characteristics. Bottomley (2014a) has argued that extension is driven by potential market opportunities. But, MacLeod et al. (2003) have shown that high cost institutions create an exclusive club of patentees: those with significant wealth. MacLeod and Nuvolari (2006) have presented the idea that some inventors simply patent their trivial ideas.[25] The literature then suggests that the patent system was not effective at weeding out "useless" inventions, and thus, could not have contributed to the Industrial Revolution.

To understand what drives patent extension, and therefore the decision to obtain a patent, I use a probit model, outlined in equation 1. Here, the dependent variable is a dummy representing which polities an invention is patented in. The model then attempts to explain where an invention was protected, based on the *ex post* value of that invention, the inventor's occupation, and a set of controls. 'AdjustedWRI' is the proxy for patent quality, weighted by the average number of citations for a given time interval.[26]

[25] Indeed, in 1851, the engineer Richard Roberts suggested that, in spite of the high fees, many wealthy inventors were patenting completely useless inventions: 'a great number of very silly things, which no man who had been long in a workshop would ever think of patenting; and the reason is, that the patentee has money, though deficient in experience and mechanical talent' (MacLeod and Nuvolari, 2010: p. 21)

[26] The number of patent citations increases mechanically over time, as more journals and magazines are established. To adjust for this, I adopt the approach of Nuvolari and Tartari (2011) and Bottomley (2014a). Namely, I calculate the average number of citations for a given cohort of patents, and then

'Occupation' controls for the inventor's occupation through their assigned HISCLASS code. 'X' is a vector of control variables, including: whether the inventor possessed at least one prior patent; the distance of the inventors listed location from the patent office of a respective polity; 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 polity the patent is extended to; the difference between social status scores for patents with more than one inventor; and whether the invention was communicated by a foreigner.

$$Pr(AdditionalPolity = 1) = \beta_1 AdjustedWRI_i + \beta_2 Occupation_i + X_i + \epsilon_i \qquad (1)$$

The decision to extend patent protection under the British system is made during the initial stages of the patent application. A patentee cannot obtain protection in one polity, earn profits, and then use these profits to extend their patent protection to other UK jurisdictions. Once the patent has been granted, it is counted as prior use and voids the opportunity to obtain additional protection.

Patentees either possessed realistic expectations of the value of their invention, or had enough wealth to finance the initial patent fee. It is unlikely that, during this period, external funding would have been widely available for such an uncertain endeavour (Dutton, 1984).[27] Matthew Boulton, James Watt's long-term financial partner, would only support the manufacture of Watt's inventions once patent protection was obtained (Dutton, 1984: p. 151). This suggests creditors were interested in patents after they had been granted, as the patent represented a method of preventing copying and duplication, and therefore provided a greater degree of certainty.

Table 7 reports the results for the probit model. Columns 1-2 contrast patents extended to Scotland against those solely in England. Columns 3-4 contrast patents

weight the citations on each individual patent by this average. The cohorts, taken directly from Nuvolari and Tartari (2011), are as follows: 1617-1701; 1702-1721; 1722-1741; 1742-1761; 1762-1781; 1782-1801; 1802-1811; 1812-1821; 1822-1831; 1832-1841; 1842-1852.

[27] There is some evidence of lower class inventors within the patent series. In some cases, these inventors are observed with their financier on the patent. In most cases, however, they are not. But, these patentees represent less than 10 per cent of the sample, but account for a more significant share of the British population, suggesting that this was not a common affair.

protected only in Scotland against those protected only in England. Columns 5-6 examine patents extended to Ireland against those solely in England. Columns 7-8 examine patents protected in all jurisdictions against those solely in England. In this manner, all results are interpreted against the same base unit (patents protected solely in England) and are thus comparable. Appendix D presents a complete set of regression results for each polity. The results shown in Table 7 are in line with the additional tables in this appendix.

Each polity is examined with respect to two alternative HISCLASS group breakdowns. The first group, Non-Manual, splits all inventor occupations into manual or non-manual. This approach follows Klemp and Weisdorf (2012). Non-manual occupations are likely to be associated with higher skills, status, and wealth than manual occupations. The second group, which splits HISCLASS into six groups, has a detailed breakdown in Appendix B. The six groups are hierarchical, with "Group I" (the omitted category) representing the occupations associated with the highest social classes, and "Group VI" is associated with the lowest social classes. This follows the approach of Meier zu Selhausen et al. (2017).

Observing Scottish extension, patent quality is shown to be positively correlated with patent extension. A one standard deviation increase in the average number of *ex post* citations on a patent is associated with a 8.5-10 per cent increase in the probability that the patent was extended to Scotland. However, the Non-Manual metric posits no statistically significant association with extension. This is likely because this metric does not observe enough variation; most patents granted in this dataset belong to Non-Manual occupations. Observing the I-VI breakdown of occupations provides some evidence that higher social status inventors were more likely to have extended their patents. Group III presents a negative association, suggesting this group was less likely to extend protection than inventors assigned to Group I. However, Group V is found to be more likely to extend protection to Scotland than inventors from Group I. One possible explanation is that inventors with occupations in Group V have financial partners who likely agreed to pay the patent fees in return for a share of any future profits. In some cases, Group V inventors are observed alongside a wealthy inventor, which shows that some external

Table 7: *Probit Results by Patent Jurisdiction*

VARIABLES	(1) Scotland	(2) Scotland	(3) OnlyScotland	(4) OnlyScotland	(5) Ireland	(6) Ireland	(7) All	(8) All
AdjustedWRI	0.051***	0.051***	-0.008***	-0.008***	0.006***	0.006***	0.057***	0.057***
	(0.008)	(0.008)	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)
Non-Manual	0.013		-0.001		0.007*		0.030***	
	(0.010)		(0.002)		(0.004)		(0.009)	
II		-0.001		-0.002		-0.002		-0.019*
		(0.012)		(0.002)		(0.004)		(0.010)
III		-0.046***		0.001		-0.003		-0.042***
		(0.012)		(0.002)		(0.004)		(0.010)
IV		-0.026		-0.003		-0.002		-0.095**
		(0.056)		(0.011)		(0.017)		(0.044)
V		0.051***		-0.000		-0.021***		-0.007
		(0.016)		(0.003)		(0.008)		(0.014)
VI		-0.060						-0.036
		(0.080)						(0.061)
Time	Y	Y	Y	Y	Y	Y	Y	Y
TopicOne	Y	Y	Y	Y	Y	Y	Y	Y
TopicTwo	N	N	N	N	N	N	N	N
Observations	11,224	11,224	8,280	8,251	8,672	8,641	9,874	9,874
Pseudo R-Squared	0.105	0.107	0.265	0.265	0.116	0.118	0.0914	0.0926

Notes: Coefficients are marginal effects at the means, and can be interpreted as a unit increase in, for example, the AdjustedWRI increases the probability of a patent being extended to that jurisdiction by 0.051, or 5 per cent, in column 1. For a categorical variable, belonging to a Non-Manual occupation increases the probability of extension by 0.013, or 1.3 per cent for the same column. Columns 2, 4, and 6 breakdown HISCLASS into 6 groups. Columns 1, 3, and 5 break HISCLASS into 'manual' against 'non-manual' occupations. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.

financing was likely available. However, patentees were not required to list all named inventors, or their creditors, on their patent. As such, it is unclear whether these inventors had a wealthy financier or not.

Only-Scottish protection yields a negative relationship against patent quality. The magnitude of this coefficient, however, is small. A one standard deviation increase in the *ex post* average number of citations on a patent decreases the probability that it was protected only in Scotland by approximately one per cent. Furthermore, both measures of social status are not significant at the standard levels, suggesting that potential wealth played no role in determining where to protect an invention. An English patent cost approximately £110, whilst a Scottish patent cost approximately £75. This small difference in fees could explain the non-significant results associated with occupations. However, the negative association with quality suggests that inventors with less valuable inventions sought only-Scottish protection. English markets would have likely been the desired destination for new inventions, as England was the home of the Industrial Revolution, and the great power of the nineteenth century (Mokyr, 2009). By contrast, Scotland had industrialised alongside England, but to a lesser degree. Comparatively, England would have been a more attractive market than Scotland (Devine, 2004). This is supported by the negative association against quality.

Irish patent extension likewise supports the argument that relative market opportunities influence the decision to extend protection. The results suggest that only marginally more valuable inventions were attracted to Ireland. A one standard deviation increase in the *ex post* average number of citations increased the probability of that patent being extended to Ireland by less than one per cent. Furthermore, social status metrics provide some evidence that belonging to a higher social status group is also positively associated with patent extension. Non-Manual occupations are approximately one per cent more likely to possess a patent which was extended to Ireland. Similarly, those inventors who belong to Group VI are two per cent less likely to extend protection to Ireland. Irish fees were nearly double the Scottish fees, and would be more restrictive in terms of who could extend protection to Ireland. However, Ireland was likely to have been a less attractive destination than Scotland; Ireland consistently lagged behind the remainder of the UK in terms of living standards, development, and industrialisation (Mokyr, 1983). Patents which sought Irish protection are likely to have been less valuable, as the potential returns from this market are lower, and are potentially unattractive to holders of valuable inventions.

Finally, observing patents granted in all patent jurisdictions provides further evidence that demand-side incentives likely influence patenting behaviour. Only the most valuable inventions *ex post* were protected *ex ante* in all polities. The AdjustedWRI metric posits a positive and statistically significant association with full patent extension. A one standard deviation increase in the average number of *ex post* citations on a patent is associated with a 10-11 per cent increase in the probability of that patent being protected in all polities. The results would suggest that inventions which were protected everywhere were of the greatest economic value, which would allow them to earn profits in all polities. The profitability of an invention is likely a function of both the relative market opportunities of the geographic scope an invention is protected in, and the economic value of that invention. Regions with greater market opportunities will attract inventions of value which are suited for that region; inventions of greater economic value are likely to earn greater profits on average in any region.

The social status metrics likewise show a strong association with extension. The magnitude of these relationships are stronger than the results of the Scottish or Irish models. Only inventors of great wealth would be able to afford "complete" UK-wide patent protection. Indeed, this finding is further supported when employing additional social status metrics. Appendix E present a robustness check by employing different HISCLASS groupings, and the HISCAM scheme. The results provide strong support for social status as an important determinant of patent extension; only those in the top HISCLASS groups are likely to patent in all jurisdictions.

5 What Determines the Quality of Inventions?

This section examines how occupations, which are proxied by social class metrics, influence the quality of inventions, and whether this relationship changes over time with regard to the falling real costs of patenting. Subsection 5.1 examines the relationship between patent quality and occupations; and subsection 5.2 investigates whether faster rising inflation encouraged lower class inventors into the patent system.

5.1 Patent Quality and Occupations

The prior results suggest that the decision to extend the geographical scope of patent protection, and by extrapolation the initial decision to obtain a patent, is strongly correlated with the *ex post* quality of the invention. This decision is also related to the occupation of the inventor; occupations relating to higher skills and wealth are positively related to patent extension. For the most expensive patents – those covering all three polities – the occupational metric is relatively more important than for protection in just one or two jurisdictions.

Because occupations and quality matter for patenting behaviour, it is possible that a relationship exists between them. The supply-side school of thought advocates that the Industrial Revolution was the result of superior levels of British human capital; whether through the adoption of the scientific method (Mokyr, 2009), a superior British mentality (Howes, 2017), or the dissemination of knowledge through institutions (Dowey, 2017). British inventors have been argued as more capable at the "art" of invention, and were thus able to produce the technologies of the Industrial Revolution.

This argument is advanced to explain why Britain industrialised first, instead of France or the rest of the world. Pomeranz (2000) argues the importance of coal in the location of the Industrial Revolution; Western European countries had cheaper access to coal, whilst China did not. Likewise, Allen (2009) argues in favour of the higher wages of British workers, compared to their continental counterparts, as an important determinant of Industrialisation. By contrast, the literature is also concerned with within-Britain heterogeneity. Instead of asking the causes of Britain industrialising before other countries, this literature is concerned with the distribution of industrialisation inside Britain. Fernihough and O'Rourke (2014) argue that proximity to coal was an important determinant of city population growth during the Industrial Revolution, suggesting that the location of British (and European) Industrial cities was partly a response to the location of natural coal deposits. Likewise, within-Britain, Dowey (2017) finds that the rate of patenting was higher for regions which had greater access to KAIs. The distribution of innovation within-Britain, was partially determined by the geographical access to knowledge. This present study is concerned with the latter. The question addressed here concerns within-Britain industrialisation, and what drove the quality of inventions inside the UK.

A positive relationship between patent quality and occupations would support the supply-side argument. Such a finding would suggest that the high costs of the British patent system were less retarding than previously thought. If wealthy inventors are capable of producing valuable inventions, but are also capable of obtaining patent protection, then the British patent system may have actively encouraged innovation from the elite subset of the population. Elite inventors are likely to engage in capital-intensive innovation (Khan, 2005). As many of the inventions of the Industrial Revolution are capital-intensive, it is likely that these elite inventors produced the technology of the Industrial Revolution.

The examination of patent quality requires a negative binomial specification. This follows the approach set out in Hall et al. (2005) and Nicholas (2010) and Brunt et al. (2012). Negative binomial models account for the issues of dispersion associated with count variables. In this instance, many patents receive particularly low citation counts, and few are cited more frequently. The negative binomial approach accounts for this issue because it 'relaxes the equidispersion restriction of the Poisson model' (Greene, 2008: p. 586). The model is written as:

$$E[AdjustedWRI_i|X_i, \alpha_i] = \alpha_i exp(Occupation + (X_i\beta) + \epsilon_i \quad (2)$$

The equation then explains the expected number of citations on a patent i as a function of the occupation of the inventor, as proxied through HISCLASS groups, and a vector of control variables denoted X. Here, the control variables are similar to those in the probit specification: the number of inventors named per patent; whether the patentee had at least one prior patent; whether the invention matches the inventors 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.

Table 8 presents the results of the negative binomial model. Columns 1-3 proxy for social status by using the I-VI groupings of Meier zu Selhausen et al. (2017). Columns 4-6 employ a similar breakdown of occupations, following that of Dribe and Helgertz (2016). Columns 7-9 then follow the approach of Klemp and Weisdorf (2012) by splitting occupations into either manual or non-manual categories. The results present a consistent, positive relationship between higher social status occupations and patent quality. On average, an individual belonging to a non-manual occupation receives approximately 5-6 per cent more citations on their patent. This is contrasted against individuals who possess a patent and work in a manual occupation. It is likely that this is an underestimate, because of the lack of variation within non-manual occupations. Occupations are being grouped by a shared characteristic, and so individual characteristics are unable to be observed.

This lack of variation is, to some degree, overcome by observing the alternative HISCLASS groupings in columns 4-9. Those inventors who belong to Group I are associated with more heavily cited patents than those in Groups III or V. Similar results are found when observing "Higher" occupations in columns 4-6. Again, however, the size of the coefficients are likely underestimates. Occupations are proxied by group characteristics; I am unable to observe the social status of individual inventors, and must therefore rely on the social status of a specific occupation. As such, I am unable to observe within occupation variation. Likewise, observing the HISCAM metric in Appendix E produces another smaller coefficient for the same reason.

Table 8: *Negative Binomial Results for Entire Patent Series*

VARIABLES	(1) AdjustedWRI	(2) AdjustedWRI	(3) AdjustedWRI	(4) AdjustedWRI	(5) AdjustedWRI	(6) AdjustedWRI	(7) AdjustedWRI	(8) AdjustedWRI	(9) AdjustedWRI
II	0.002	-0.002	0.002						
	(0.014)	(0.014)	(0.014)						
III	-0.045***	-0.055***	-0.046***						
	(0.013)	(0.013)	(0.013)						
IV	-0.028	-0.042	-0.024						
	(0.056)	(0.056)	(0.056)						
V	-0.056***	-0.066***	-0.053***						
	(0.019)	(0.019)	(0.019)						
VI	-0.077	-0.086*	-0.076						
	(0.052)	(0.052)	(0.052)						
Skilled				-0.045***	-0.054***	-0.047***			
				(0.013)	(0.013)	(0.013)			
Farmer				-0.028	-0.041	-0.024			
				(0.056)	(0.056)	(0.056)			
LowSkilled				-0.056***	-0.066***	-0.053***			
				(0.019)	(0.019)	(0.019)			
Unskilled				-0.078	-0.085*	-0.077			
				(0.052)	(0.052)	(0.052)			
Non-Manual							0.048***	0.058***	0.049***
							(0.011)	(0.011)	(0.011)
Constant	0.189***	0.157***	0.161***	0.189***	0.157***	0.162***	0.140**	0.099*	0.112*
	(0.058)	(0.058)	(0.060)	(0.058)	(0.058)	(0.060)	(0.059)	(0.059)	(0.061)
Time	Y	Y	Y	Y	Y	Y	Y	Y	Y
TopicOne	Y	N	Y	Y	N	Y	Y	N	Y
TopicTwo	N	Y	Y	N	Y	Y	N	Y	Y
Observations	15,279	15,279	15,279	15,279	15,279	15,279	15,279	15,279	15,279
Pseudo R-Squared	0.00323	0.00280	0.00360	0.00323	0.00280	0.00360	0.00322	0.00279	0.00360

Notes: 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 0.058 (Column 8) can be interpreted as follows: a one unit change in a variable leads to a 1-exp(0.058)=0.06, or a 6 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 5.

However, the results are consistent with the hypothesis that the quality of an invention is associated with the potential skills and wealth of an inventor, insofar as the social status metrics employed in this study accurately account for social class. The results presented provide support for the supply-side argument of innovation; the quality of inventions is associated with the skills of the inventors.

5.2 Patenting Rates

Occupations, as proxied by social status metrics, are found to be positively associated with the number of *ex post* citations found on a patent. However, one important characteristic of this patent system is that the nominal costs of patenting remained constant between 1617 and 1852. The fees were not altered at any point until 1852, when the system evolved into a single unified patent office. During the period 1617-1852, however, the real costs of patenting were falling over time. Figure 2 shows the rate of inflation (RPI) in the UK, 1617-1852. This rate represents an index of inflation, where 2010=100; the data is taken from Clark (2017). Throughout this period, inflation was relatively constant, until approximately 1800, when inflation spiked. This coincides with the beginning of the Napoleonic Wars, which led to rising prices. For fixed nominal fees, rising inflation then reduces real costs. Here, rising inflation made patenting cheaper in real terms; potential patentees would have to pay less of their total earnings to obtain a patent.

Rising inflation, then, leads to an opening up of the patent system to individuals of a lower social status. Lower real costs should, theoretically, allow for more valuable inventions to be patented; the argument of Khan (2005) is that poorer inventors produce valuable inventions too. Indeed, the high-cost thesis of MacLeod et al. (2003) suggests that lower patent costs would facilitate the patenting of further valuable inventions.

The results presented thus far do not accurately account for how changing *rates* of inflation influence the changing *rate* of citations or social status. The analysis controls for inflation, and social status, with regard to patent quality. But, it is limited in its ability to observe the effects of inflation on the change in patent quality or the change in the average social status scores of patentees. Instead, Table 9 presents a fixed effects

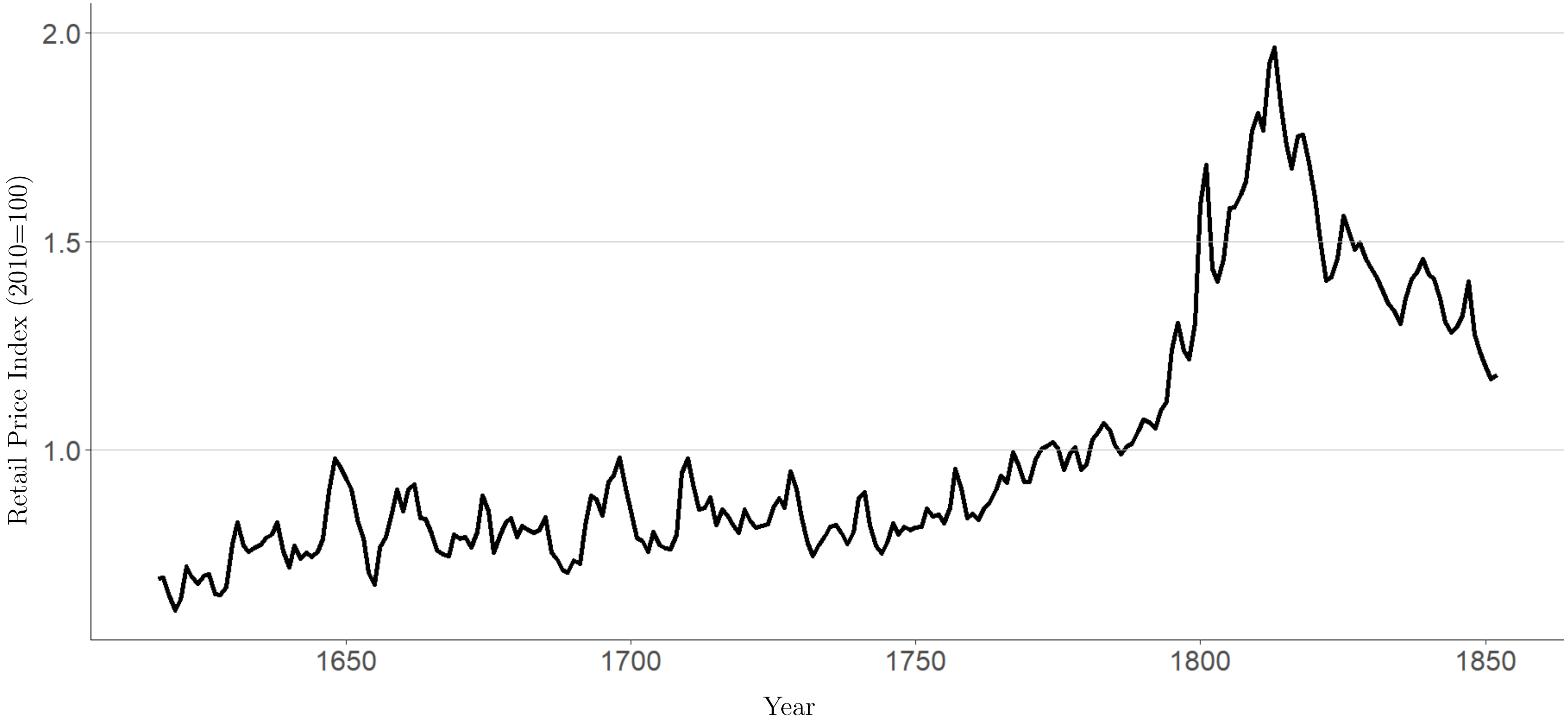

Figure 2: *Inflation in the UK, 1617-1852*

Notes: The figure shows the Retail Price Index (RPI) for each year. It is represented as an index, where 2010=100.

Source: Clark (2017).

analysis of patenting rates. Here, the rate of change in the average number of citations granted is examined with regard to the changing rate of inflation, and to changes in the average social status scores of patentees. The fixed effects are time (in years) and the number of patents per technology class in each period.[28]

'Inflation Rate' controls for the change in inflation across time. 'HISCAM Rate' is the difference in the average HISCAM score of patentees over time, and 'Difference Rate' is the change in the average difference, between the minimum and maximum HISCAM scores for patents with multiple inventors, over time. These metrics attempt to explain the change in the average number of citations over time: 'WRI Rate'. The results show that, for all TopicOne specifications, no statistically significant associations between any of the explanatory variables against the dependent variable. When TopicTwo is controlled for, however, there is a positive and weakly significant relationship between the rate of inflation and the rate of citation. This would suggest that, as the real costs of patenting fell, more valuable inventions were able to be patented. However, this result is insignificant in most specifications, suggesting that the change in the real costs of patents does not open up the patent system to more valuable inventions.

Instead, the changing real costs may encourage poorer inventors into the patent system. Should faster inflation encourage lower social class inventors to patent, then a positive relationship between HISCAM Rate and the Inflation Rate would be observed. To examine this, Table 10 employs a fixed effects approach. Here, 'Scotland Rate' controls for the change in the number of patents which are protected in Scotland over time; 'Ireland Rate' and 'All Rate' then control for the change in the number of patents protected, over time, in Ireland and All, respectively. The results show a positive and statistically significant association between the rate of inflation and the rate of HISCAM; faster inflation is associated with a faster increase in social status scores of patentees. This could suggest that inflation did not rise high enough to open up the

[28] I opt for patent classes as there are too many UK counties to use, but too few nationalities (almost all patentees are English). Fortunately, patent classes are correlated with particular UK regions during this period, so they capture part of this regional variation.

Table 9: *Changes in Patent Quality: Fixed Effects*

VARIABLES	(1) WRI Rate	(2) WRI Rate	(3) WRI Rate	(4) WRI Rate	(5) WRI Rate	(6) WRI Rate
Inflation Rate	0.588	0.600	0.668	0.666	0.727*	0.810*
	(0.378)	(0.387)	(0.438)	(0.439)	(0.399)	(0.449)
HISCAM Rate				-0.096	0.034	-0.112
				(0.287)	(0.274)	(0.310)
Difference Rate				0.005	-0.001	0.002
				(0.005)	(0.003)	(0.005)
Constant	0.031	0.049	0.047	0.045	0.047	0.042
	(0.020)	(0.053)	(0.054)	(0.054)	(0.058)	(0.059)
Year	N	Y	Y	Y	Y	Y
TopicOne	N	N	Y	Y	N	Y
TopicTwo	N	N	N	N	Y	Y
Observations	216	216	216	216	216	216
R-squared	0.010	0.018	0.049	0.050	0.064	0.107

Notes: 'WRI Rate' is the percentage change in the adjusted, average number of citations over time. 'Inflation Rate' is the percentage change in inflation; 'HISCAM Rate' is the percentage change in average HISCAM scores; and 'Difference Rate' is the percentage change in the average difference in HISCAM scores for patents with multiple inventors. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.

Table 10: *Changes in HISCAM Scores: Fixed Effects*

VARIABLES	(1) HISCAM Rate	(2) HISCAM Rate	(3) HISCAM Rate	(4) HISCAM Rate	(5) HISCAM Rate	(6) HISCAM Rate	(7) HISCAM Rate
Inflation Rate	0.162**	0.170*	0.186**	0.189**	0.192**	0.171	0.199*
	(0.081)	(0.087)	(0.091)	(0.095)	(0.096)	(0.104)	(0.104)
Difference Rate				-0.000	-0.000	-0.000	-0.000
				(0.002)	(0.002)	(0.002)	(0.002)
WRI Rate					-0.005	0.001	-0.006
					(0.013)	(0.013)	(0.015)
Scotland Rate				-0.002	-0.002	-0.011	-0.007
				(0.011)	(0.011)	(0.012)	(0.013)
Ireland Rate				0.005	0.005	-0.003	0.001
				(0.007)	(0.007)	(0.009)	(0.010)
All Rate				0.009	0.009	-0.000	0.007
				(0.009)	(0.009)	(0.008)	(0.012)
Constant	0.002	0.001	-0.003	-0.003	-0.002	0.000	-0.004
	(0.005)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Year	N	Y	Y	Y	Y	Y	Y
TopicOne	N	N	Y	Y	Y	N	Y
TopicTwo	N	N	N	N	N	Y	Y
Observations	216	216	216	216	216	216	216
R-squared	0.016	0.020	0.089	0.094	0.094	0.075	0.141

Notes: 'HISCAM Rate' is the percentage change in average HISCAM scores. 'Inflation Rate' is the percentage change in inflation; 'WRI Rate' is the percentage change in the adjusted, average number of citations over time; and 'Difference Rate' is the percentage change in the average difference in HISCAM scores for patents with multiple inventors; 'Scotland Rate' is the percentage change in the number of patents extended to Scotland; 'Ireland Rate' is the percentage change in the number of patents extended to Ireland; 'All Rate' is the percentage change in the number of patents extended to all jurisdictions;. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.

patent system to lower status inventors. Instead, the falling real costs are likely to have encouraged higher social status inventors to obtain further patents. This would partially explain the insignificant results between the Inflation Rate and the WRI Rate: higher social class inventors likely patented their best inventions first and, as costs fell, would subsequently patent their second-best inventions.

6 Patents and the Industrial Revolution

Explanations of the Industrial Revolution generally place technological change at the heart of the story (Landes, 2003; Crafts, 2011). However, the British patent system has been given little credit, if at all, in facilitating innovation. Prior studies have suggested that the system was too cumbersome to have been effective, and that many useful inventions bypassed the system entirely (MacLeod, 2002; Nuvolari, 2004). By contrast, a recent re-examination of this institution argues that it was an important factor in driving innovation (Bottomley, 2014b). The results here further add to our understanding of the British patent system, and the potential role it played in facilitating the Industrial Revolution, by showing that inventors responded to demand-side incentives and patented their inventions that subsequently turned out to be valuable.

The existing debate concerning what motivates inventors has important implications for understanding how to encourage innovation. Demand-side arguments suggest that the patent system is an important institution; its goal is to incentivise innovation by providing a temporary monopoly right over the commercialisation of an invention. But, supply-side arguments would suggest promoting scientific knowledge and human capital, and would support the abolition of the patent system, as argued by Boldrin and Levine (2008).

It is reasonable to assume that the decision to obtain a patent is predominantly based on the desire to protect future revenue streams, and thus earn profits. Such an argument has been posited by Khan (2017) in her examination of the records from the Royal

Society of Arts; valuable inventions are patented because they can obtain profits for a longer period of time. Indeed, patents are the optimal method to do so during this era, as they provide greater certainty and enforceability than the next best alternative (Dutton, 1984).

This study has shown that inventors chose to extend patent protection to multiple UK polities because they had valuable inventions. Furthermore, the results support the argument that inventors were able to respond to market opportunities; Scotland attracted higher quality inventions, whilst Ireland failed to do so. Likewise, inventions protected throughout the UK are found to be the most valuable; such inventions are likely protected widely because of their high economic value. Furthermore, occupations are found to be positively associated with extension. This last relationship is found to be relatively more important when observing full protection compared to single polity extension.

Had the supply-side argument dictated the decision to invent, then inventors would not waste their time and resources pursuing patents. Indeed, their incentive is being the "first true inventor", or adding to the existing body of scientific knowledge (Mokyr, 2009; McCloskey, 2011). Under this condition, there would have been no association between quality and extension. However, I am only able observe patents granted.[29] Without a comparable non-patent dataset, it is difficult to assert such an argument. Yet, as Bottomley (2014b) notes, few of the most important inventions of the Industrial Revolution bypassed the patent system entirely. It is then likely that inventors responded to demand-side incentives, by obtaining protection for their more valuable inventions.

But, this does not mean supply-side conditions did not matter. Human capital is shown to be an important determinant of patent quality. Observing the negative binomial models, occupations associated with greater levels of human capital are likely to attract more citations, and are thus considered to be more valuable. Mokyr (2009) emphasises the role of human capital in Britain as an important determinant of the rate of technological change. This is further supported by Dowey (2017), who finds that access to KAIs is an important determinant of the quality of inventions; because Britain possessed more KAIs

[29] Not all patents filed were granted. Bottomley (2014b) presents some statistics to show that, between 1838-1847, approximately 8.8 per cent of petitions were refused outright.

per capita, British inventors were then able to benefit from knowledge spillover effects. Howes (2017), likewise, argues in favour of human capital, but through mentality rather than a specific set of skills. Meisenzahl and Mokyr (2012) and Kelly et al. (2014) suggest that it is the elite inventors who drove innovation in Britain. The results found here support these arguments; human capital mattered.

The British patent system is likely to have been more important with regard to the Industrial Revolution than previous accounts suggest. The Industrial Revolution is, arguably, the result of a series of important "macro-inventions" (Mokyr, 2009). These are inventions which are defined as "game changers" and are capable of setting industries on an entirely new growth path (or producing entirely new ones). Such inventions were likely expensive to produce, and associated with much greater uncertainty than "micro-inventions". As such, it is likely that individuals with greater wealth would produce them (Meisenzahl and Mokyr, 2012; Kelly et al., 2014). But, these individuals would likely require more certain protection because they possessed more valuable inventions; keeping an invention secret has been argued as a less appropriate protection mechanism (Dutton, 1984). Since the patent system is shown to encourage higher-value inventions into its protection, and the quality of these inventions are positively correlated with human capital and wealth, then it is possible that the Industrial Revolution was driven by these elite inventors. In this case, the British patent system is likely to have been a *causal* mechanism in the advent of the Industrial Revolution. This study highlights the need for further research into the nature of patenting, the quality of patents, and the role of human capital with regard to the patent system. Until such aspects of patenting are understood, future research cannot adequately rule out the role of the British patent system with respect to the Industrial Revolution entirely.

7 Conclusion

The unique structure of the British patent system presents an opportunity to understand why inventors would choose to protect their inventions in one, two, or three polities. This decision is likely representative of the decision to pursue patent protection altogether, as opposed to the decision to keep an invention secret. In this study, I argue that the quality of inventions determines how much protection patentees obtain, and where they chose to protect their inventions.

Inventors who possess more valuable inventions are found to select into patent protection, presumably to secure future profits. This result is in line with the arguments of Schmookler (1966), Allen (2009), Bottomley (2014b), and Khan (2017). Such profits are to compensate the inventor for their time and effort in producing their invention. Inventors are then subject to demand-side incentives.

Furthermore, I have shown that the characteristics of patentees are associated with the decision to extend patent protection. But, patentee characteristics are also positively associated with the quality of their inventions. Higher-skilled inventors are capable of producing more valuable inventions, either because they can invest their resources in further experimentation, or because they possess superior levels of human capital.

Core explanations of the Industrial Revolution focus on the human capital of inventors, but also upon their incentives. This study provides some evidence in support of both conclusions. Inventors choose to protect their inventions where they can maximise profits, but their occupations also suggest they are capable of producing high-quality inventions.

It is likely that the British patent system was more important for innovation than some previous accounts have suggested. Since the quality of inventions is associated with occupations, elite inventors are then likely to have contributed significantly to the Industrial Revolution. Whether the patent system actively encouraged these inventors to produce new inventions, or encouraged them to patent these inventions in an effort to mitigate competition, requires further evidence. However, both outcomes would suggest that the patent system would be necessary for innovation; in the former case the system directly encouraged invention, whilst in the latter case it serves to encourage future inventions, as the system is able to prevent free-riding.

This fragmented institutional setting can be considered alongside the modern day European patent institution. Prior to 1852, the British patent system comprised multiple offices, and individuals desiring patent protection would have to obtain patents from each polity independently. After the 1852 Patent Law Amendment Act, a single British patent was produced, with substantially reduced fees. At present, the European Patent Office (EPO) can grant patents for its member states, but these patents must then be 'validated individually in each country for which the patent is sought'.[30] The EPO has argued that such administrative costs are harmful for firms, particularly small and medium sized enterprises (SME). Their proposal is to adopt a single EU patent, that, once paid, grants patent protection covering all member states. The EPO argues that patent fees will decrease from approximately EUR 32,000 to EUR 680 – a reduction in fees by approximately 98 per cent (Mahne, 2012). In light of my results, I argue that the policy implications of such a reform could be potentially harmful. My study has shown that the high cost system was effective at discouraging the patenting of trivial inventions – as higher value inventions were produced by wealthier inventors – but also that inventors would obtain patents based on the relative market opportunities available. A single EU patent may not encourage more valuable inventions into the patent system, or the usage of these inventions in all EU member states; it may simply lead to more patenting, and consequently, more trivial patents. I suggest that evidence from this historical period would suggest that such a patent reform would have limited effects on encouraging innovation.

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[30] A further discussion of the new proposal for obtaining patents through the EPO can be found at: https://www.epo.org/news-issues/news/2015/20150624.html

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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 Dribe and Helgertz (2016) approach creates the following groupings:

- Higher: HISCLASS 1-5
- Skilled: HISCLASS 6 & 7
- Farmer: HISCLASS 8
- Low Skilled: HISCLASS 9 & 10
- Unskilled: HISCLASS 11 & 12

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

C Summary Statistics

Table C1: *Summary Statistics for Entire Patent Series*

VARIABLE	Number	Mean	Std. Dev.	Min	Max
AdjustedWRI	16,381	1.00	0.56	0.28	11.86
Another Patent	16,157	0.34	0.47	0	1
Difference in Social Status	15,642	1.90	6.90	0	47.47
Distance to Dublin	15,370	438.55	467.58	0	12,079
Distance to Edinburgh	15,370	490.24	488.79	0	11,820
Distance to London	15,370	172.85	528.42	0	11,712
Foreign Communication	16,157	0.05	0.22	0	1
For Inventor Use	15,329	0.45	0.5	0	1
HISCAM_GB	15,280	61.64	9.22	28.28	99
HISCLASS-1	15,280	3.31	2.73	1	12
HISCLASSNONMANUAL	15,463	0.76	0.43	0	1
Inflation	16,382	133.36	23.45	61.5	196.5
Ireland	16,157	0.11	0.31	0	1
Ireland Population	13.542	7,400.16	869.47	5,216	8,295
Number of Inventors	16,157	1.26	0.58	1	6
Patent Agent	16,157	0.03	0.18	0	1
Scotland	16,157	0.28	0.45	0	1
Scotland Population	13,542	2,490.29	360.66	1,625	2,918
Woodcroft Reference Index	16,157	2.68	1.59	1	23

Notes: Summary statistics for all patents in my dataset.

Source: Author's calculations using data found in Table 5.

Table C2: *Summary Statistics for Patents Found Only in Scotland*

VARIABLE	Number	Mean	Std. Dev.	Min	Max
AdjustedWRI	225	0.83	0.58	0.28	2.66
Another Patent	225	0.2	0.4	0	1
Difference in Social Status	225	42.62	14.41	0	47.47
Distance to Dublin	209	430.69	507.19	0	5,442
Distance to Edinburgh	209	385.27	560.97	0	5,570
Distance to London	207	308.34	603.73	0	5,900
For Inventor Use	184	0.4	0.49	0	1
HISCAM_GB	183	61.68	7.75	36.61	84.08
HISCLASS-1	183	3.13	2.66	1	9
HISCLASSNONMANUAL	183	0.77	0.42	0	1
Inflation	225	135.39	14.89	117.1	196.5
Number of Inventors	225	1.12	0.32	1	2
Patent Agent	225	0.11	0.31	0	1
Scotland Population	218	2,591.22	324.15	1,644	2,918
Woodcroft Reference Index	225	2.36	1.66	1	7

Notes: Summary statistics for patents found only in Scotland.

Source: Author's calculations using data found in Table 5.

Table C3: *Summary Statistics for Patents Found in Ireland*

VARIABLE	**Number**	**Mean**	**Std. Dev.**	**Min**	**Max**
AdjustedWRI	1,716	1.12	0.72	0.34	7.45
Another Patent	1,716	0.39	0.49	0	1
Difference in Social Status	1,677	1.62	4.86	0	47.47
Distance to Dublin	1,703	410.29	369.46	0	7,078
Distance to Edinburgh	1,703	451.4	390.84	0	6,827
Distance to London	1,705	198.14	422.36	0	6,707
Foreign Communication	1,716	0.08	0.27	0	1
For Inventor Use	1,672	0.43	0.5	0	1
HISCAM_GB	1,670	63.3	8.69	33.04	93.73
HISCLASS-1	1,670	2.89	2.51	1	12
HISCLASSNONMANUAL	1,670	0.82	0.38	0	1
Inflation	1,718	139.55	17.00	79.8	196.5
Ireland Population	1,664	7,546.79	826.52	5,216	8,295
Number of Inventors	1,716	1.28	0.54	1	3
Patent Agent	1,716	0.04	0.19	0	1
Scotland	1,716	0.86	0.35	0	1
Woodcroft Reference Index	1,716	3.19	2.01	1	23

Notes: Summary statistics for patents found in Ireland and England.

Source: Author's calculations using data found in Table 5.

Table C4: *Summary Statistics for Patents Found in Scotland*

VARIABLE	**Number**	**Mean**	**Std. Dev.**	**Min**	**Max**
AdjustedWRI	4,697	1.08	0.63	0.28	11.86
Another Patent	4,697	0.37	0.48	0	1
Difference in Social Status	4,561	3.48	10.47	0	47.47
Distance to Dublin	4,646	425.77	489.22	0	8,472
Distance to Edinburgh	4,646	441.8	520.36	0	8,588
Distance to London	4,646	231.92	561.86	0	8,932
England	4,697	0.95	0.21	0	1
Foreign Communication	4,697	0.06	0.25	0	1
For Inventor Use	4,506	0.48	0.5	0	1
HISCAM_GB	4,500	62.70	8.79	33.04	99
HISCLASS-1	4,500	3.1	2.63	1	12
HISCLASSNONMANUAL	4,500	0.79	0.41	0	1
Inflation	4,697	135.71	15.96	79.4	196.5
Ireland	4,697	0.31	0.46	0	1
Number of Inventors	4,697	1.28	0.56	1	4
Only Scotland	4,697	0.05	0.21	0	1
Patent Agent	4,697	0.05	0.22	0	1
Scotland Population	4,504	2,577.38	309.39	1,625	2,918
Woodcroft Reference Index	4,697	3.09	1.76	1	23

Notes: Summary statistics for patents found in Scotland and England.

Source: Author's calculations using data found in Table 5.

D Probit Results

Table D1: *Probit Results for Patents found in Scotland and England*

VARIABLES	(1) Scotland	(2) Scotland	(3) Scotland	(4) Scotland	(5) Scotland	(6) Scotland
AdjustedWRI	0.049***	0.052***	0.061***	0.052***	0.050***	0.052***
	(0.008)	(0.008)	(0.011)	(0.008)	(0.008)	(0.008)
II	-0.002	-0.003	-0.011	-0.003	-0.002	-0.003
	(0.012)	(0.012)	(0.018)	(0.012)	(0.012)	(0.012)
III	-0.047***	-0.045***	-0.030*	-0.045***	-0.046***	-0.045***
	(0.012)	(0.012)	(0.016)	(0.012)	(0.012)	(0.012)
IV	-0.027	-0.027	0.005	-0.027	-0.026	-0.025
	(0.056)	(0.056)	(0.060)	(0.056)	(0.057)	(0.057)
V	0.059***	0.052***	0.043**	0.052***	0.054***	0.052***
	(0.016)	(0.016)	(0.019)	(0.016)	(0.016)	(0.016)
VI	-0.068	-0.059	-0.096	-0.059	-0.056	-0.053
	(0.080)	(0.080)	(0.105)	(0.080)	(0.081)	(0.080)
Number of Inventors	0.063***	0.059***	0.074***	0.059***	0.060***	0.058***
	(0.009)	(0.009)	(0.012)	(0.009)	(0.009)	(0.009)
Difference in Social Status	-0.003***	-0.003***	-0.004**	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Another Patent	0.029***	0.028***	0.039***	0.028***	0.027***	0.026***
	(0.009)	(0.009)	(0.012)	(0.009)	(0.009)	(0.009)
For Inventor Use	0.035***	0.025***	0.026**	0.025***	0.030***	0.023***
	(0.009)	(0.009)	(0.012)	(0.009)	(0.009)	(0.009)
Inflation	-0.002***	-0.002***	-0.002**	-0.002***	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Scotland Population	0.362***	0.368***	0.346***	0.368***	0.359***	0.363***
	(0.057)	(0.057)	(0.078)	(0.057)	(0.057)	(0.057)
Foreign Communication	0.057***	0.052***	0.107***	0.052***	0.052***	0.050***
	(0.018)	(0.018)	(0.037)	(0.018)	(0.018)	(0.018)
Distance to London			0.116			
			(0.073)			
Distance to London Squared			0.000			
			(0.000)			
Distance to Edinburgh			-0.393***			
			(0.044)			
Distance to Edinburgh Squared			-0.000			
			(0.000)			
English	-0.002	-0.004	-0.167***	-0.004	-0.001	-0.004
	(0.025)	(0.025)	(0.045)	(0.025)	(0.025)	(0.025)
Scottish	0.501***	0.495***	0.163***	0.495***	0.500***	0.493***
	(0.035)	(0.035)	(0.056)	(0.035)	(0.035)	(0.035)
Irish	-0.040	-0.047	-0.267***	-0.047	-0.036	-0.045
	(0.068)	(0.068)	(0.078)	(0.068)	(0.067)	(0.068)
Patent Agent	0.084***	0.076**	-0.060	0.076**	0.083***	0.074**
	(0.031)	(0.031)	(0.088)	(0.031)	(0.031)	(0.031)
Time	Y	Y	Y	Y	Y	Y
Class One	N	Y	Y	Y	N	Y
Class Two	N	N	N	N	Y	Y
Observations	11,224	11,224	6,567	11,224	11,224	11,224
Pseudo R-Squared	0.0971	0.108	0.152	0.108	0.102	0.111

Notes: The coefficients are the marginal effects at the means, and can be interpreted as a one unit increase in, say, the AdjustedWRI increases the probability of the patent being extended by 0.049, or 5%, in column 1. For a categorical variable, belonging to a Non-Manual occupation increases the probability of extension by 0.029, or 2.9% for the same column. The control group for the nationalities are Foreigners. Column 6 excludes all non-British nationals from the regression. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.

Table D2: *Probit Results for Patents found in Ireland and England*

VARIABLES	(1) Ireland	(2) Ireland	(3) Ireland	(4) Ireland	(5) Ireland	(6) Ireland
AdjustedWRI	0.006***	0.006***	0.007**	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
II	-0.003	-0.003	-0.006	-0.003	-0.002	-0.002
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
III	-0.004	-0.003	-0.007	-0.003	-0.002	-0.002
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
IV	-0.001	-0.002	-0.000	-0.002	0.001	-0.000
	(0.018)	(0.017)	(0.015)	(0.017)	(0.017)	(0.017)
V	-0.021**	-0.021***	-0.020**	-0.021***	-0.021**	-0.021***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Number of Inventors	0.006**	0.005**	0.004	0.005**	0.006**	0.006**
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Difference in Social Status	-0.000	-0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Another Patent	0.013***	0.012***	0.010***	0.012***	0.013***	0.012***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Foreign Communication	0.009*	0.008*	-0.006	0.008*	0.009*	0.008*
	(0.005)	(0.005)	(0.009)	(0.005)	(0.005)	(0.005)
For Inventor Use	-0.004	-0.004	-0.002	-0.004	-0.004	-0.005*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Inflation	-0.001***	-0.001***	-0.000**	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ireland Population	0.017***	0.016***	0.014***	0.016***	0.016***	0.015***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
Distance to London			0.030**			
			(0.014)			
Distance to London Squared			-0.000			
			(0.000)			
Distance to Dublin			-0.016			
			(0.014)			
Distance to Dublin Squared			0.000			
			(0.000)			
English	-0.013*	-0.012*	-0.012	-0.012*	-0.013*	-0.012
	(0.008)	(0.007)	(0.011)	(0.007)	(0.008)	(0.007)
Irish	0.062***	0.060***	0.038**	0.060***	0.060***	0.057***
	(0.011)	(0.011)	(0.015)	(0.011)	(0.011)	(0.011)
Scottish	0.015	0.014	0.003	0.014	0.012	0.011
	(0.013)	(0.012)	(0.014)	(0.012)	(0.013)	(0.012)
Patent Agent	0.017*	0.016*	0.009	0.016*	0.017*	0.016*
	(0.009)	(0.008)	(0.020)	(0.008)	(0.009)	(0.008)
Time	Y	Y	Y	Y	Y	Y
Class One	N	Y	Y	Y	N	Y
Class Two	N	N	N	N	Y	Y
Observations	8,669	8,641	4,809	8,641	8,534	8,510
Pseudo R-Squared	0.109	0.119	0.150	0.119	0.121	0.132

Notes: The coefficients are the marginal effects at the means, and can be interpreted as a one unit increase in, say, the AdjustedWRI increases the probability of the patent being extended by 0.007, or 0.7%, in column 1. For a categorical variable, belonging to a Non-Manual occupation increases the probability of extension by 0.007, or 0.7%, for the same column. The control group for the nationalities are Foreigners. Column 6 excludes all non-British nationals from the regression. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.

Table D3: *Probit Results for Patents Found Only in Scotland*

VARIABLES	(1) OnlyScotland	(2) OnlyScotland	(3) OnlyScotland	(4) OnlyScotland	(5) OnlyScotland	(6) OnlyScotland
AdjustedWRI	-0.009***	-0.008***	-0.008**	-0.008***	-0.007***	-0.006***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
II	-0.002	-0.001	-0.002	-0.001	-0.002	-0.001
	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)	(0.002)
III	0.001	0.001	0.003	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
IV	-0.001	-0.003	0.001	-0.003	-0.001	-0.002
	(0.013)	(0.012)	(0.012)	(0.012)	(0.010)	(0.009)
V	-0.001	-0.000	0.001	-0.000	-0.001	-0.001
	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)
Number of Inventors	-0.009***	-0.009***	-0.006***	-0.009***	-0.007***	-0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Another Patent	-0.005**	-0.004**	-0.004	-0.004**	-0.004**	-0.004**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
For Inventor Use	-0.000	-0.001	0.002	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Inflation	-0.000*	-0.000*	-0.000	-0.000*	-0.000*	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Scotland Population	0.063***	0.058***	0.035**	0.058***	0.050***	0.047***
	(0.013)	(0.012)	(0.015)	(0.012)	(0.011)	(0.010)
Distance to London			-0.016			
			(0.020)			
Distance to London Squared			0.000			
			(0.000)			
Distance to Edinburgh			-0.018			
			(0.014)			
Distance to Edinburgh Squared			-0.000			
			(0.000)			
English	0.002	0.002	-0.020*	0.002	0.002	0.002
	(0.005)	(0.005)	(0.011)	(0.005)	(0.004)	(0.004)
Scottish	0.056***	0.053***	0.018	0.053***	0.044***	0.041***
	(0.008)	(0.008)	(0.013)	(0.008)	(0.008)	(0.008)
Irish	0.034***	0.031***	0.007	0.031***	0.029***	0.027***
	(0.008)	(0.008)	(0.011)	(0.008)	(0.007)	(0.007)
Patent Agent	0.017***	0.017***		0.017***	0.015***	0.014***
	(0.006)	(0.006)		(0.006)	(0.005)	(0.005)
Time	Y	Y	Y	Y	Y	Y
Class One	N	Y	Y	Y	N	Y
Class Two	N	N	N	N	Y	Y
Observations	8,062	7,786	4,502	7,786	7,875	7,617
Pseudo R-Squared	0.254	0.275	0.345	0.275	0.292	0.307

Notes: The coefficients are the marginal effects at the means, and can be interpreted as a one unit increase in, say, the AdjustedWRI decreases the probability of the patent being extended by 0.009, or 0.9%, in column 1. For a categorical variable, belonging to a Non-Manual occupation decreases the probability of extension by 0.001, or 0.1% for the same column. The control group for the nationalities are Foreigners. Column 6 excludes all non-British nationals from the regression. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.

Table D4: *Probit Results for Patents Found in All Polities*

VARIABLES	(1) All	(2) All	(3) All	(4) All	(5) All	(6) All
AdjustedWRI	0.058***	0.057***	0.052***	0.057***	0.059***	0.057***
	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)	(0.006)
II	-0.022**	-0.023**	-0.032**	-0.023**	-0.021**	-0.022**
	(0.010)	(0.010)	(0.015)	(0.010)	(0.010)	(0.010)
III	-0.048***	-0.042***	-0.033**	-0.042***	-0.046***	-0.041***
	(0.010)	(0.010)	(0.013)	(0.010)	(0.010)	(0.010)
IV	-0.097**	-0.096**	-0.103**	-0.096**	-0.096**	-0.093**
	(0.045)	(0.044)	(0.049)	(0.044)	(0.045)	(0.044)
V	-0.006	-0.006	0.013	-0.006	-0.007	-0.007
	(0.014)	(0.014)	(0.016)	(0.014)	(0.014)	(0.014)
VI	-0.044	-0.034	-0.010	-0.034	-0.045	-0.034
	(0.062)	(0.061)	(0.064)	(0.061)	(0.061)	(0.059)
Number of Inventors	0.037***	0.034***	0.036***	0.034***	0.036***	0.034***
	(0.008)	(0.007)	(0.010)	(0.007)	(0.007)	(0.007)
Difference in Social Status	0.000	-0.000	0.001	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Another Patent	0.007	0.006	0.009	0.006	0.006	0.005
	(0.007)	(0.007)	(0.010)	(0.007)	(0.007)	(0.007)
For Inventor Use	-0.009	-0.014**	0.001	-0.014**	-0.012*	-0.016**
	(0.007)	(0.007)	(0.010)	(0.007)	(0.007)	(0.007)
Inflation	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Scotland Population	-0.106**	-0.105**	-0.088	-0.105**	-0.107**	-0.107**
	(0.048)	(0.048)	(0.065)	(0.048)	(0.048)	(0.047)
Ireland Population	0.024***	0.025***	0.016	0.025***	0.026***	0.027***
	(0.009)	(0.009)	(0.011)	(0.009)	(0.009)	(0.009)
Foreign Communication	0.057***	0.052***	0.021	0.052***	0.052***	0.049***
	(0.015)	(0.015)	(0.033)	(0.015)	(0.015)	(0.015)
Distance to London			0.168***			
			(0.059)			
Distance to London Squared			-0.000			
			(0.000)			
Distance to Edinburgh			-0.102			
			(0.071)			
Distance to Edinburgh Squared			-0.000			
			(0.000)			
Distance to Dublin			0.036			
			(0.083)			
Distance to Dublin Squared			0.000			
			(0.000)			
English	-0.037*	-0.037*	-0.053	-0.037*	-0.037*	-0.037*
	(0.021)	(0.021)	(0.043)	(0.021)	(0.021)	(0.021)
Irish	0.224***	0.226***	0.191***	0.226***	0.220***	0.221***
	(0.034)	(0.034)	(0.059)	(0.034)	(0.034)	(0.033)
Scottish	0.297***	0.286***	0.203***	0.286***	0.290***	0.279***
	(0.029)	(0.029)	(0.048)	(0.029)	(0.029)	(0.029)
Patent Agent	-0.092***	-0.097***	-0.016	-0.097***	-0.094***	-0.098***
	(0.029)	(0.028)	(0.080)	(0.028)	(0.029)	(0.028)
Time	Y	Y	Y	Y	Y	Y
Class One	N	Y	Y	Y	N	Y
Class Two	N	N	N	N	Y	Y
Observations	9,874	9,874	5,660	9,874	9,874	9,874
Pseudo R-Squared	0.0804	0.0942	0.126	0.0942	0.0880	0.100

Notes: The coefficients are the marginal effects at the means, and can be interpreted as a one unit increase in, say, the AdjustedWRI increases the probability of the patent being extended by 0.059, or 5.9%, in column 1. For a categorical variable, belonging to a Non-Manual occupation increases the probability of extension by 0.037, or 3.7%, for the same column. The control group for the nationalities are Foreigners. Column 6 excludes all non-British nationals from the regression. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.

E Robustness Check

Table E1: *Robustness Checks Using HISCLASS and HISCAM Scores*

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
		Probit			Negative Binomial	
AdjustedWRI	0.052***	0.053***	0.053***			
	(0.008)	(0.008)	(0.008)			
HISCAM_GB	0.002***			0.001***		
	(0.000)			(0.000)		
Skilled		-0.029**			-0.045***	
		(0.013)			(0.013)	
Farmer		-0.099**			-0.028	
		(0.049)			(0.056)	
LowSkilled		0.018			-0.056***	
		(0.016)			(0.019)	
Unskilled		-0.004			-0.078	
		(0.064)			(0.052)	
Non-Manual			0.015			0.048***
			(0.011)			(0.011)
Number of Inventors	0.036***	0.036***	0.035***	-0.001	-0.002	-0.002
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Difference in Social Status	0.001	0.001	0.001	-0.002*	-0.002*	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
For Inventor Use	0.005	0.006	0.005	0.012	0.017*	0.017*
	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)	(0.010)
Another Patent	0.009	0.011	0.011	0.029***	0.027***	0.027***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Inflation	-0.000	-0.000	-0.000	-0.002***	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Scotland Population	-0.095	-0.086	-0.092			
	(0.065)	(0.065)	(0.065)			
Ireland Population	0.014	0.015	0.015			
	(0.011)	(0.011)	(0.012)			
Distance to Dublin	0.034	0.042	0.036			
	(0.083)	(0.084)	(0.084)			
Distance to Dublin Squared	0.000	0.000	0.000			
	(0.000)	(0.000)	(0.000)			
Distance to Edinburgh	-0.106	-0.103	-0.103			
	(0.071)	(0.071)	(0.071)			
Distance to Edinburgh Squared	-0.000	-0.000	-0.000			
	(0.000)	(0.000)	(0.000)			
Distance to London	0.157***	0.165***	0.167***			
	(0.060)	(0.059)	(0.060)			
Distance to London Squared	-0.000	-0.000	-0.000			
	(0.000)	(0.000)	(0.000)			
Foreign Communication	0.018	0.018	0.017	-0.051**	-0.053**	-0.053**
	(0.032)	(0.033)	(0.032)	(0.022)	(0.022)	(0.022)
Scotland				0.102***	0.102***	0.102***
				(0.013)	(0.013)	(0.013)
Ireland				0.069***	0.069***	0.069***
				(0.019)	(0.019)	(0.019)
English	-0.056	-0.054	-0.054	0.042	0.043*	0.042*
	(0.043)	(0.043)	(0.043)	(0.025)	(0.025)	(0.025)
Scottish	0.197***	0.204***	0.200***	0.058*	0.059*	0.059*
	(0.048)	(0.048)	(0.048)	(0.035)	(0.035)	(0.035)
Irish	0.180***	0.193***	0.189***	-0.068	-0.065	-0.066
	(0.059)	(0.060)	(0.060)	(0.048)	(0.048)	(0.048)
Patent Agent	-0.038	-0.012	-0.014	0.025	0.022	0.022
	(0.078)	(0.080)	(0.080)	(0.035)	(0.035)	(0.035)
Time	Y	Y	Y	Y	Y	Y
TopicOne	Y	Y	Y	Y	Y	Y
TopicTwo	N	N	N	N	N	N
Observations	5,660	5,660	5,660	15,279	15,279	15,279
Pseudo R-Squared	0.126	0.125	0.124	0.00311	0.00323	0.00322

Notes: Columns 1-3 show robustness check for the probit model, where the dependent variable is patents existing in all polities. Columns 4-6 show robustness check for the negative binomial specifications. Columns 1 and 4 use the HISCAM scores from the GB datafile of Lambert et al. (2013). Columns 2 and 5 use HISCLASS categories, based on the groupings of Dribe and Helgertz (2016), the omitted variable is the 'Higher'. Columns 3 and 6 use alternative HISCLASS groupings from Meier zu Selhausen et al. (2017), the omitted class is the 'I' class. Robust Standard Errors in Parentheses ***p<0.001, **p<0.05, *p<0.1.

Source: Author's calculations using data found in Table 5.