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‘CLAUSE AND EFFECT’: INVENTION AND STATE INTERVENTION DURING THE FRENCH REVOLUTIONARY AND NAPOLEONIC WARS

Stephen D. Billington (Ulster University)
Joe Lane (University of Reading)

Working Paper 23-05

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

February 2023

‘Clause and Effect’: Invention and State Intervention during the French Revolutionary and Napoleonic Wars*

Stephen D. Billington† Joe Lane‡

Abstract

Did the outbreak of the French Revolutionary and Napoleonic Wars influence technical change during the Industrial Revolution? We address this question by investigating an instance of state intervention into the market for inventions from 1793-1820: the introduction of a new proviso into British patents compelling inventors to supply the military, and also attracting military inventions from outside the patent system. We present new patent data alongside previously unused archival evidence to argue that the state’s intervention helped direct technical change in Britain. Our evidence provides additional support for the military-demand-induced hypothesis as a credible explanation for Britain’s ongoing industrialisation.

Keywords: Industrial Revolution, Institutions, Invention, Patents.

JEL Codes: N43, N73, O31.

* We thank Gerben Bakker, Sean Bottomley, Chris Colvin, Christopher Coyle, Alan Fernihough, Matthias Flückiger, Anton Howes, David Jordan, Zorina Khan, Patrick K. O’Brien, and John Turner for comments and encouragement. Thanks also to seminar and conference participants at London School of Economics (May 2019), the Irish Postgraduate and Early Career Economics Conference (NUI Galway, June 2019), and Ulster University (December 2019).

† Corresponding author. Department of Accounting, Finance & Economics, Ulster University. Email: s.billington@ulster.ac.uk.

‡ Henley Business School, University of Reading. Email: j.lane@henley.ac.uk.

1. Introduction

Britain industrialised amidst the French Revolutionary and Napoleonic Wars (c. 1793-1815). The scale and timing of this conflict means warfare itself cannot be ignored in explanations of the Industrial Revolution (O'Brien, 2017). An emerging body of literature has begun to investigate how warfare may influence industrialisation either indirectly by changing access to inputs into the production process (Hanlon, 2015; Juhász, 2018), or directly through the demands placed by warfare on industrial production of participants (O'Brien, 2021).

The latter literature emphasises what is known as the 'military-demand-induced' hypothesis of industrialisation (Ruttan, 2006) and has been advanced to explain Britain's Industrial Revolution through its influence on technical change (Kaempffert, 1941; O'Brien, 2017; 2021): rising military demands accelerated improvements to existing technology; demands for ordnance raised demand for iron and steel which raised demand for coal, spurring the innovation of steam engine and blast furnace technologies. Satia (2018) extends the military-demand-induced hypothesis, by arguing that the British government's intervention in private markets to contract for military supplies stimulated industrialisation further. By increasing the demands placed on private contractors, the State indirectly spurred on technical change.

This paper examines an unexplored aspect of the military-demand-induced hypothesis: the direct intervention of the State in the market for inventions. Following the outbreak of the French Revolutionary Wars, the British State introduced the 'Navy Clause proviso' the British patent procedure.[1] Prior to the 1852 Patent Reform Act, a patentee had to bring their application, also known as a petition, to various Crown Officials for their signatures. Those Officials also had discretionary power to insert various provisos into the petition, the most well-known being the proviso requiring the applicant to submit a specification which detailed the exact workings of their invention. The Navy Clause proviso was inserted to ensure that the patentee would supply their invention, or their invention's output to the British military, in exchange for a price that would be settled by Crown Officials.

The appearance of the Navy Clause proviso in the petition marks a notable change in the involvement of the British State in patenting. Unlike past amendments to the patent procedure, the Navy Clause was not the result of Act of Parliament, or the result of decades of evolution in case law. Instead, it was enacted at the behest of the then Home Secretary, Henry

[1] The term 'Navy Clause' was used first by Bottomley (2014a). We opt to use the same phrase.

Dundas, who directed the Law Officers of the Crown to insert a Navy Clause into inventions that were relevant for the military. The clause could also be inserted by other Crown officials who were involved with the petition procedure and did not require the applicant's consent. In this way the clause could only be avoided if the applicant opted to abandon their petition altogether. The Home Secretary also directed the Master-General of the Board of Ordnance to settle the terms of supply with the patentee.

We exploit Britain's rich patent data, covering the period 1793-1820, to examine what role, if any, the State had in influencing the rate and direction of patenting behaviour through the mechanism of the Navy Clause. Patent data are useful because although they are not representative of all inventive activity (Schmookler, 1966), they provided a means for Crown Officials to contract for military inventions without the same need for *ex ante* private bargaining. The patent data allow us to identify exactly which patents were subject to the Navy Clause, what kind of patents were desirable by the State, and whether the forcible insertion of the clause altered patenting activity in any meaningful way.

We further supplement our patent analysis by examining archival evidence from a non-random sample of non-patented inventions that were submitted directly to the British Board of Ordnance in hopes of a pecuniary reward. This sample is useful to contrast the experiences of patenting and non-patenting inventors, and to what extent to which the Board of Ordnance attempted to intervene in private innovation activity to procure useful inventions for the war effort.

Taken together, our patent analysis and archival evidence shed light on how the British State influenced the rate and direction of inventive activity in Britain during the Industrial Revolution. Our findings indicate that the French Revolutionary and Napoleonic Wars did not coincide with any fundamental change in the rate of patenting activity. Instead, the Navy Clause – and the interaction between the Board of Ordnance and inventors more generally – arguably influenced the direction by attracting capital-saving and labour-saving inventions to help supply Crown forces.

Our research contributes to existing literature in two ways. First, we contribute to our understanding of the workings of the patent system by investigating the introduction of the Navy Clause proviso (Dutton, 1984; Macleod, 2002; Bottomley, 2014a; Cox, 2020). Our evidence shows that the proviso was administered on a discretionary basis by Crown Officials and was not subject to systematic abuse. Instead, we argue the proviso was used primarily to attract useful inventions into supply for the military to help with the war effort.

Our research contributes to the significant literature concerning invention during the Industrial Revolution (Mokyr, 2009; Allen, 2009; Bottomley, 2014a; b; Howes, 2016; Dowey, 2017; Lane, 2019; Billington, 2021), as well as the effects of warfare on technical change (O'Rourke et al., 2007; Khan, 2015; O'Brien, 2017;2021; Satia, 2018). Our evidence suggests that the French Revolutionary and Napoleonic Wars acted aided the Industrial Revolution by encouraging the invention and diffusion of key technologies. The clause may have helped spur innovation, as the State were known to provide substantive financial rewards in exchange for useful military inventions. In addition, by securing supplies from inventors, the State also guaranteed inventors a market for their inventions which would have resulted in further demands on industry to meet that supply.

This paper is outlined as follows. Section 2 discusses the available evidence concerning the origin and use of the Navy Clause. Section 3 describes our patent data. Section 4 analyses the likelihood that a patent would receive the Navy Clause. Section 5 discusses our archival evidence. Section 6 concludes.

2. The Navy Clause

2.1 Before the Navy Clause

The origins of the formal Navy Clause, introduced at the outbreak of the French Revolutionary and Napoleonic Wars are found in the second half of the eighteenth century. Examination of public record documents relating to patented inventions reveals similar provisos requiring the patentees to supply their inventions to one of Britain's military boards.

One of the earliest records, to our knowledge, is the case of Elizabeth Taylor, who patented '[a] set of engines, tools, instruments, & other apparatus for the making of blocks, sheavers, & pins…' in 1762. Taylor was listed on her patent as a widow, and her late husband, Walter Taylor, was a blockmaker who had contracted with the Navy on several occasions during his lifetime (House of Commons, 1803).[2] The patent itself contains no record of Elizabeth being directed or required to supply the British Navy, but an excerpt in the *Sixth Report of the Deputy Keeper of the Public Records, 1845* lists the publication of Elizabeth's patent, which ends with the following statement: '…whereby the Patentee has been able to supply his Majesty's Navy […] the Commissioners of the Navy had contracted with the Patentee for the supply of those blocks to the Navy.' The statement indicates the Navy Board

[2] Their son, also named Walter Taylor, held several patents for similar inventions.

had contracted with Elizabeth for her to supply her invention to the Board, after she had already obtained her patent.

Further reference to Elizabeth's patent is found in House of Commons papers in which the discussion of 'Taylor`s patent' takes place (House of Commons, 1803). The discussion concerns a request for the extension of Elizabeth's patent. In the record, the patent title includes the following phrase: '…for the use of the Royal Navy, Merchants, and others…,' though whether this was part of the actual patent title is unclear, nor is it clear whether the invention was patented solely for trade with the Navy. In any case, several witnesses informed the Commons Committee of the great utility of Elizabeth's patent, stating that the blocks produced by the invention were superior to any blocks in prior use. The witness testimony indicates the patent was for a valuable invention, and that Elizabeth also supplied the Navy with the said blocks. Clearly, then, there is a case to be made that Britain's military boards had an interest in those patented inventions which had military applications, which they acted on by contracting for supply.

Earlier cases than Elizabeth's patent exist, though with much less detail. For example, William Johnson's 1754 patent for an invention relating to 'double and single kettles, furnaces, and boilers made of wrought iron plate,' was subject to public intervention by the Admiralty. Like Elizabeth's patent, Johnson's patent contains no reference or proviso guiding him to supply the military with his invention. However, the statements found in the public records show that Johnson was compelled to supply his invention to the Navy: '[…] the Commissioners of the Admiralty have directed the Navy to be supplied.' (Sixth Report of the Deputy Keeper of the Public Records, 1845). A further record in *Mechanics Magazine* from 1847 states that Johnson's patented invention was indeed used in the Navy, with the same proviso listed above (Mechanics Magazine, 1847).

The decision to institute a regular proviso into the patent petition, directing applicants to supply their inventions to the military, had some precedent before the French Revolutionary Wars. Whilst procedurally this was done in a more informal manner, in practice the State was experienced in identifying useful inventions and making efforts to secure their supply.

2.2 The Navy Clause

Sean Bottomley, in his seminal work, was one of the first to reference the existence of the Navy Clause proviso in patent titles (Bottomley, 2014a). Though we cannot observe the patent documents themselves, Bottomley points to the patent records collated by Bennet Woodcroft – an engineer, and later Superintendent of the Patent Office after its 1852 Reform – as a means

of identifying the Navy Clause. One of Woodcroft's official publications was a chronological list of patent titles.[3] The first patent which Woodcroft lists as having the Navy Clause proviso belonged to Christopher Wilson, a master mariner from Scarborough and living in Westminster, for a patent relating to, '…new invented method of combining timbers applicable to the improvement of naval architecture, and all ponderous and large works composed of wood…' granted in 1795. Wilson's patent contains the proviso as it typically appeared in later patents:

> *"…be required to enter into by His Majesty's attorney and solicitor general for the time being, or one of them, for the supplying or causing to be supplied His Majesty's ships and vessels, or any of them, with the said invention, or any part thereof (if he or they shall be thereto required), in such manner and at and upon such reasonable price and terms as shall be prescribed in any by such bond, obligation, or recognizance…"* (Woodcroft, 1854; patent number 2,098).

The patent title also states that, should the patentee not fulfil their obligations (including supplying the Navy), then the patent could be made void. In addition, the terms of supply and the price received by Wilson were to be prescribed through some form of debt, though the Clause did not yet indicate who would determine this. It would only be in later patent titles which contain Navy Clause provisos that the Master-General of the Board of Ordnance (or some other Crown Official) would settle these terms and prices.

Though Wilson's patent is the first to contain the Navy Clause in Woodcroft's records, it is not the first to be considered for it. In the typical patent petition procedure (prior to 1852), the applicant would bring their petition to the Secretary of State (either the Home Secretary or Foreign Secretary), who would then write to the one of the Law Officers of the Crown (the Attorney General or the Solicitor General) with a draft of the King's/Queen's Warrant for the Officer to examine.

The original warrants appear to have largely survived and are held at the National Archives in a collection entitled, 'Home Office: Invention Warrant Books' (collection HO 89), which contain the warrants sent by the Home Secretary to the Law Officers. In 1794, one such warrant sent to a Law Officer (at the time, either Sir John Scott or Sir John Mitford) was for a petition from William Fitzgerald, seeking to patent, '…an apparatus by which ships & vessels may be discharged of water by means of their own motion…'. The Home Secretary at the time

[3] Though Woodcroft names the records as titles, in practice he recorded the title as well as additional relevant information and provisos listed on the original patent document.

– Henry Dundas, appointed under the Pitt the Younger administration – wrote to the Law Officer with the petition, directing them to draft the Bill for the Royal Signature. Dundas provided explicit instructions to the Law Officer to, in effect, draft the Navy Clause proviso:

> *"…and you are to insert in the said Bill a clause containing some provision requiring the said William Fitzgerald, or the person or persons enjoying the benefit thereof to supply Our Ships and Vessels with the invention at such reasonable prices as shall be fixed in some mode to be prescribed in our said Letters Patent which on the one hand may secure the benefit of the invention for such our ships and vessels upon reasonable terms, and the other may secure to the petitioner his executors, administrators, and assignees a liberal compensation for such benefit."* (HO 89/3).

Fitzgerald's patent petition was submitted in April 1794. At the same time, Sir Evan Nepean – Dundas' Secretary – wrote to the Board of Ordnance concerning an earlier patent petition submitted by Richard Webb.[4] Whilst the original letter is not found in either the Home Office records or the Board of Ordnance records, we know the letter was received in April 1794 (WO, 47/2557). We were able to trace the response from the Board of Ordnance to Nepean, dated 24th November 1794, which states:

> *"[the Master-General of the Board of Ordnance] command[s] me to acquaint you that no patent ought to be granted for improvements in fire-arms which might prevent the ordnance from making use of such invention unless there be a clause specifying that such improvement may be used for His Majesty's Service on paying a reasonable allowance to the Inventor to be previously agreed upon with the Board of Ordnance."* (HO 89/3).

The response ends with a proposed clause to be inserted into Webb's patent, which is similar to the clause inserted into Fitzgerald's patent. Extensive searching of the Board of Ordnance archival records suggests that there was no communication between Nepean and the Board other than Nepean's original letter of April 1794, and the Board's response of November 1794. Given the timeline presented and given the content of the Board's response, it is likely that Nepean wrote to the Board at the behest of Dundas – who at the same time had directed the Law Officer to draft a proviso that would become the Navy Clause. Moreover, given the similarity between the wordings of the provisos provided by the Board of Ordnance and by the

[4] Webb's patent warrant is dated to January 1795, and the patent itself was granted in February 1795. It is likely Webb's original petition was dated later than Fitzgerald's while the Home Secretary awaited a reply from the Board of Ordnance. We have checked the original law officer warrant books, and the Board of Ordnance minutes to confirm the timeline of patent petitions.

Law Officer independently, it is likely that Dundas pitched the same proviso to both parties.[5] It is also likely that Dundas suggested to the Board that they should settle the terms of supply. Instead, the Board states in their response that the Master-General or other principal officers would be responsible.

Exactly how the terms of supply were settled in practice during the French Revolutionary and Napoleonic Wars is not clear from the available records. We have searched through the Board of Ordnance minutes and are unable to identify any records relating to the Master-General or other principal officers settling either the prices or quantities of supply of Navy Clause patents. We have spent extensive time trawling the National Archives Board of Ordnance collection to identify any records concerning the settlement of prices.[6] The most likely source of information concerning the settlement of supply is the Board's treasury accounts. But searching for such information is akin to looking for a needle in a haystack; we do not know what year the patentee finally supplied their invention, as it is well known that it could take inventors many years to get their inventions into a workable condition (Dutton, 1984; Macleod, 2002; Bottomley, 2014a). In addition, the treasury records do not provide enough detail for us to accurately identify whether a contractor was supplying their invention or invention's output or something else entirely.

Though we have no available evidence for our period of interest, there are debates concerning the Navy Clause proviso and its usage later in the nineteenth century. The debates concern whether the proviso was abused by Crown Officials and how the reasonable prices were settled.

Two main perspectives are represented in the sources. The first, is that Crown Officials acted with monopsonistic power as they could effectively settle prices unilaterally. Evidence supporting this perspective come from two Parliamentary Select Committees formed to inquire into the workings of patent law in the United Kingdom, once convened in 1851, the other in 1864. In the 1851 Select Committee, testimony provided by Matthew Davenport Hill, a lawyer, states that the Crown Officials dictated the terms of supply:

> *"...Now in the form which is in use at the present day, there is this proviso, 'That a patent shall be void if the patentee shall not supply, or cause to be supplied for Our Service [i.e. for the service of the Crown] all such articles of the said invention as*

[5] Dundas was also appointed to the newly formed Secretary of State for War post by Pitt, which commenced in July 1794. Dundas had an incentive to ensure he could procure useful inventions for the war effort.
[6] We have searched through the following records which cover minute books, in-letters and out-letters: WO 45/33-39, WO 46/23-25, WO, 47/2558-2559.

> *he shall be required to supply, by the Officers or Commissioners administering the department of Our Service, for the use of which the same shall be required, in such manner, at such prices, and at and upon such reasonable prices and terms as shall be settled for that purpose by the Officers or Commissioners so requiring the same."* (House of Commons, 1851, XVIII: 353).

A similar viewpoint is stated in the 1864 Select Committee by William Carpmael, a renowned patent agent and later President of the Chartered Institute of Patent Agents, who outlines a brief history of the usage of the Navy Clause proviso prior to the 1852 reform. Carpmael argues that the Navy Clause proviso was inserted into patents with military relevance and that the Crown reserved the right to take articles produced by patentees at prices set by Crown Officials. Carpmael suggests that this procedure has resulted in no dissatisfaction among patentees, and that patentees were adequately remunerated for their articles.

The second perspective does not dispute that prices were settled unilaterally by the Crown, but instead suggests that this power was subject to abuse by Crown Officials. The evidence supporting this perspective come from two Select Committees, one convened to inquire into the workings of patent law, and another which inquired into the function of various Crown offices. The first instance of this viewpoint is stated in the 1829 Select Committee by John Farey, a well-known mechanical engineer and patent agent, who state the following:

> *"I have before stated to the Committee, that patents for inventions relating to naval or military affairs, which may be required for the King's service, often had a clause to compel the patentee to supply all that might be wanted for the King, at reasonable prices; how the price was regulated I do not know; but I once knew a patentee, during the war, who complained of injustice; he told me that after he had set up a manufactory to supply Government with the patent articles, they set up a larger manufactory of their own, with his patent machines, and all his own remain idle."* (House of Commons, 1829, III: 147-148).

Farey confirms the monopsonistic power of the Crown, as he argues patentees whose patents included the Navy Clause proviso were compelled to supply, though he does not indicate how Crown Officials settled that matter. But his evidence indicates that during a period of warfare, which was likely the French Revolutionary and Napoleonic Wars, the Crown Officials attempted to circumvent their own terms.

Further evidence to suggest Crown abuse of the proviso comes from Thomas Webster, a lawyer and author on patent laws, who provided testimony on the necessity of various

provisos inserted into patent petitions during their application procedure, before the 1849 Select Committee inquiring into the workings of the Signet Office and Privy Office. The Committee question Webster on whether it is necessary for a patent to receive so many provisos, and whether any of the provisos are objectionable. Webster himself brings up the Navy Clause proviso and states that, '… [the Navy proviso] is a most improper proviso. It has been used, and has, very improperly at times, been held as a threat over patentees, and I think ought not to stand.' (House of Commons, 1849, XXII: 45). Webster then goes onto recall a case in the Court of the Queen's Bench where the Admiralty chose to use a patent anchor but without paying the patentee for it, and the Court would not compel the Admiralty to pay referring to the abuse of the Clause as 'embarrassing'.

Aside from the allegations of abuse of power by Crown Officials, witness testimony in the various Select Committees claims that the discretionary power held by the Crown Officials to insert the Navy Clause proviso was, perhaps unsurprisingly, subject to human error. Witnesses before the 1849 Select Committee provide the clearest evidence of errors in the administration of the clause. H. W. Sanders – a record keeper in the Signet Office – states to the Committee that he frequently discovered errors which required alteration, specifically citing the omission of the Navy Clause proviso, '…in inventions we used to find that the clause for obliging patentees to supply the Army and Navy with the invention which might be essential to them, was frequently omitted, and we have therefore been obliged to have the clause inserted…' (House of Commons, 1849, XXII: 9). Another witness, William Goodwin, a junior clerk in the Privy Seal Office, attributes the error of omission to the Attorney-General's or Solicitor-General's clerks, and states that the Lord Privy Seal had the power to detain an invention so as to insert the appropriate provisos; he alleges that the Earl of Rosslyn, in his tenure as Lord Privy Seal, once did this in consequence of the Navy Clause proviso being omitted, the result of which was to cause that proviso to be inserted in all cases under his jurisdiction (House of Commons, 1849, XXII: 13). William Carpmael also provides testimony to this Committee and affirms that the responsibility for inserting any and all relevant clauses and provisos belonged to the Attorney-General's and Solicitor-General's offices (House of Commons, 1849, XXII: 27).

Given the evidence available to us, then, and the discussion above it is clear that the Navy Clause proviso was frequently used, subject to some degree of quality control by the various clerks employed under the Crown and did not appear to be subject to systematic abuse. Therefore, we argue that there is a case to be made that the Clause had the capacity to influence patenting activities of inventors during the time of the French Revolutionary and Napoleonic

Wars. The extent to which this capacity was realised, will be explored through the following sections.

3. Data

Our study exploits Britain's rich patent data, which we restrict to observe the period 1793-1820.[7] The patent data are taken from Woodcroft (1854), which lists the titles of patented inventions in England and Wales up to 1852. This is supplemented by the Irish and Scottish patent lists collected in Bottomley (2014b), which gives us a series of patents granted throughout the United Kingdom. The patent data include the patentees' name, their patent's title, their listed residence up to county level, their occupation, the year the patent was granted, and whether the patent was a foreign communication from abroad.

We then follow the same procedure as Nuvolari et al. (2011), by constructing several additional variables, including the number of inventors listed per patent, the number of patents held by inventors and whether an inventor is an 'insider' which means their occupation matches the industry-type of their patent title. We then adopt the Billington & Hanna (2021) patent classification procedure, adopting two technology classes per patent, which we term 'MachineOne' and 'MachineTwo'.

In addition, we follow the approach of Billington (2021) and classify all patentee occupations into HISCO-HISCLASS groupings, which represent ordinal measures of the social status, skill, and wealth associated with occupational titles. We also classify each patent into either labour-saving, capital-saving or not specified technology categories based on the text of the patent titles, using the definitions from MacLeod (2002).

To proxy for the 'quality' or economic value of a patent, we adopt two measures used for British patent data for this period: the Woodcroft Reference Index (WRI) – pioneered by Nuvolari and Tartari (2011), and the Bibliographic Composite Index (BCI) – pioneered by Nuvolari et al. (2021). The WRI counts up the number of references each patent received within the contemporary scientific and trade literature, as collated by Woodcroft (1860). By contrast, the BCI is a composite index of quality, combining the WRI with supplementary measures of a patent's value based on bibliographic dictionaries of either a patent's historical importance or the patentee's contribution to technical progress.

Finally, we identify Navy Clause patents in two ways. First, we classify patents as 'Navy Clause' if a patent title in Woodcroft (1854) contains some variation of the Navy Clause

[7] The Navy Clause proviso disappears from the Warrant books after 1820.

proviso, which give us 203 such patents. Second, we construct a measure called 'Navy Warrants' which classifies patents based on whether their original warrant contained the Navy Clause proviso, as instructed by the Secretary of State to the Law Officers. The source of the patent warrants is the Home Office Law Officer Reports (collection HO 89). This provides us with 256 patents whose warrants contained the proviso. We then combine our two measures into one measure simply called 'Navy,' which leaves us with 349 distinct patents that were considered for the proviso.

It is worth noting that it is unclear whether the 349 patents we have identified all received the proviso by the time they were granted, or whether only 203 received the proviso and the rest were either accidentally omitted or ultimately not considered useful for military service. In addition, it is not clear whether other patents were considered for the proviso at some stage during the petition procedure, but it is likely. We opt to examine all 349 patents on the grounds that, at one time or another, they were deemed of interest to Britain's military boards.

Figure 1 below graphs the time-series of total patents granted and total Navy patents granted between 1793 – 1820.[8] The figure shows a steady increase in the number of patents granted across the period. Both series exhibit similar trends, though the 'Total Patents' series has more extreme fluctuations than the 'Navy Patents' series.

Figure 2 exhibits the time-series trends of 'Navy Clause' patents and 'Navy Warrants' patents. Here again the trends are similar, though the Navy Clause appears to lag the Navy Warrants to some degree. The Navy Warrants line shows a steady upward trend in the early 1790s, before spiking to roughly 20 patents in 1802. After the outbreak of the Napoleonic Wars, the average number of Navy Warrants patents is around 12-15 per annum, before disappearing after 1820. By contrast, the Navy Clause appears mainly for patents granted after 1803, and disappears from Woodcroft's patent titles after 1815. The difference between the two series likely reflects the insertion of the proviso at other stages during the patent petition procedure.

[8] We restrict ourselves to 1793-1820, as there are no patents containing a Navy Clause proviso before 1793.

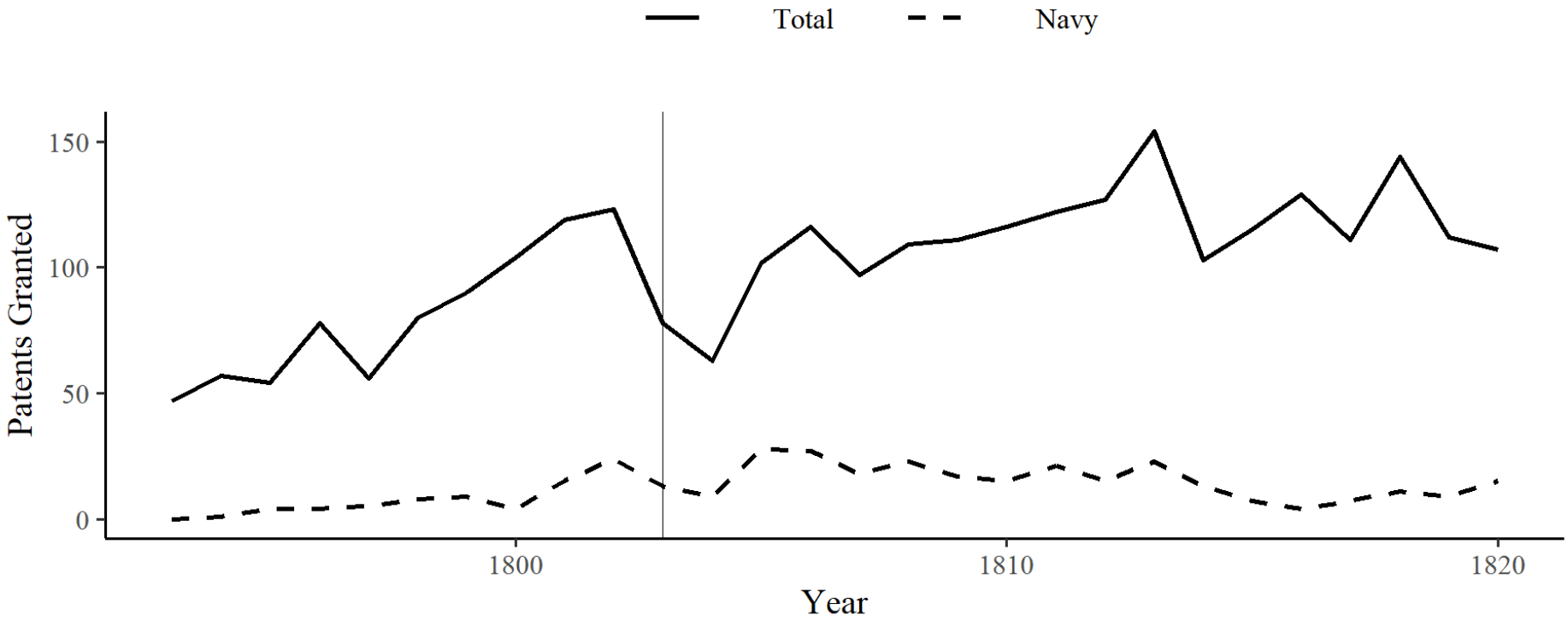


Figure 1. Time-series of patents granted, 1793 – 1820.

Notes: the figure shows the number of patents granted annually alongside the number of 'Navy' patents granted, where Navy is defined as a patent whose Woodcroft patent title or whose original warrant contains the Navy proviso. The vertical line intersects at year 1803, to coincide with the onset of the Napoleonic conflict.

Source: authors' calculations using data from Woodcroft (1854), and HO 89.

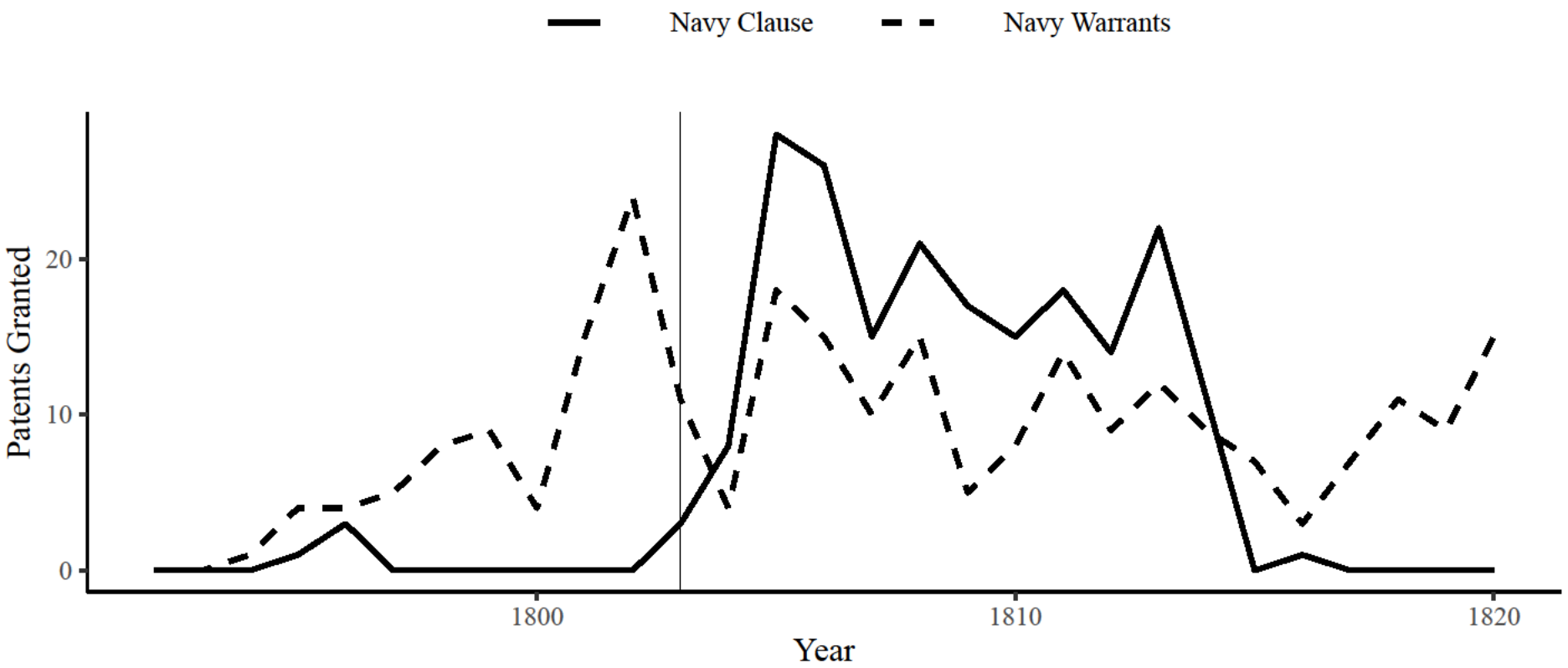


Figure 2. Time-series showing the number of 'Navy Clause' and 'Navy Warrant' patents granted, 1793-1820.

Notes: The graph shows the number of Navy Clause patents – defined as patents whose Woodcroft patent title contains the Navy proviso – and Navy Warrant patents – defined as patents whose original warrant to the Law Officer contained the proviso – granted annually. The vertical line intersects at year 1803, to coincide with the onset of the Napoleonic conflict.

Sources: authors' calculations using data from Woodcroft (1854) and HO 89.

3.1 Summary Statistics

Table 1 below reports the breakdown of Navy patents by occupational grouping, using the HISCLASS classification scheme (Van Leeuwen and Maas, 2011). The table is divided into two halves, based on whether a patentee held a patent which did or did not contain the Navy Clause proviso. For each HISCLASS category, the 'No.' variable displays the total number of patents granted to each group that had proviso patents and non-proviso patents, with a percentage share represented in brackets. The 'Occupations' column reports the top 5 most frequently appearing occupations within each HISCLASS group.

Looking first at the 'Without Proviso' group, the estimates show that the largest share of patentees were Higher Managers, at 35%, but closely followed by Medium-skilled Workers, at 27%. The former group represent the wealthier or more connected members of society, while the latter group encompass those skilled occupations associated with the development of key industrial technologies (MacLeod, 2002; de Pleijt et al., 2020). The third largest group representing 16% of patentees, comprise the engineering classes who were much more akin to a professional inventor than other occupations (Hanlon, 2022).

The 'With Proviso' group report a largely similar distribution across HISCLASS categories. Within the categories themselves, there exists a notable difference in the occupations represented, particularly within groups: 1, 2, 5, 6, and 7, which report a greater prevalence of military-related occupations. Given the Navy Clause proviso was applied for the purposes of procuring supplies for the military, it is unsurprising that most patentees associated with proviso-patents also reported a military occupation.

Table 2 reports the distribution of patent technology classes conditional on whether the patent contains a Navy Clause proviso. The findings indicate that, for most patent classes, the proportion which received a Navy Clause proviso were smaller than those which did not. The notable patent classes which were over-represented in the Navy Clause proviso estimates are for 'Military' patents – which refer primarily to ordnance inventions – and 'Transportation' patents – which refer primarily to improvements in ships and other vessels. The representation of such inventions is expected, given the purpose of the proviso.

Table 1. HISCLASS Occupations by Navy proviso, 1793 - 1820

HISCLASS Group	Without Proviso		With Proviso	
	No.	Occupations	No.	Occupations
1 – Higher Managers	954 (35%)	Glass maker, gentlemen, Iron master, Advocate, Coal viewer	126 (36%)	Gentlemen, manufacturers, Lieutenant of Royal Navy, Commander of Royal Navy
2 – Higher Professionals	436 (16%)	Engineer, chemist, Doctor in Physic, physician, surgeon	53 (16%)	Engineer, Master of Arts, Doctor of Physic, surgeon in the Royal Navy, Chemist
3 – Lower Managers	8 (0.3%)	Wharfinger, stone mason and sculptor, wholesale upholsterer, navy contractor, colourman	1 (0.3%)	Wharfinger
4 – Lower Professionals, and Clerical and Sales Personnel	293 (11%)	Merchants, druggist, ship chandler, optician, leather seller	37 (11%)	Merchants, ironmongers, optician, cheesemonger, printseller
5 – Lower Clerical and Sales Personnel	28 (1%)	Clerk, pawnbroker, collector of natural history, warehouseman, minister of parish	4 (1%)	Purser of Royal Navy, clerk, warehouseman
6 – Foremen	4 (0.1%)	NA	4 (1%)	Master mariner, Master of military band
7 – Medium-skilled Workers	71 (27%)	Mathematical instrument maker, watch maker, potter, smith, coach spring maker	99 (29%)	Gun carriage maker, gun maker, mathematical instrument maker, cabinet maker, watch maker
8 – Farmers and Fishermen	25 (0.9%)	Planter, farmer, yeoman, grazier	0 (0%)	NA
9 – Lower-skilled workers	223 (8%)	Weaver, whipmaker, spring maker, miller, frame smith	12 (4%)	Rope maker, scale beam maker, brazier

10 – Lower-skilled Farm Workers	0 (0%)	NA	0 (0%)	NA
11 – Unskilled Workers	5 (0.2%)	Mariner, coal fitter, leather dresser, enameller, packer and setter	2 (0.5%)	Mariner
12 – Unskilled Farm Workers	3 (0.1%)	Botanic gardener, gardener, seedsman	1 (0.3%)	Gardener

Notes: The table shows the distribution of HISCLASS groups, including the top 5 most frequently occurring occupations within each group, divided into whether they held a patent which contained a Navy proviso. 'With proviso' refer to those patents containing either the Navy Clause or Navy Warrant. 'No.' is a count of how many patents were granted to each group, with the percentage of each group's share of all patents granted represented in brackets, rounded up.

Source: authors' calculations using data from Woodcroft (1854) and Van Leeuwen and Maas (2011).

Table 2. Patent technology classes by Navy proviso, 1793 - 1820

Patent Class	**Count**		**Patent Class (contd.)**	**Count**	
	Without Proviso	**With Proviso**		**Without Proviso**	**With Proviso**
Agriculture	162 (6%)	18 (5%)	Machinery	173 (6%)	24 (7%)
Apparel	17 (0.6%)	0 (0%)	Manufacturing	73 (3%)	16 (5%)
Chemicals	224 (8%)	8 (2%)	Metal	74 (3%)	3 (0.9%)
Commodities	128 (5%)	8 (2%)	Military	66 (2%)	45 (13%)
Construction	140 (5%)	8 (2%)	Mining	44 (2%)	8 (2%)
Electricity	5 (0.2%)	2 (0.5%)	Paper	97 (3%)	1 (0.3%)
Food	16 (0.5%)	0 (0%)	Power	184 (7%)	10 (3%)
Hardware	360 (13%)	48 (14%)	Textiles	356 (13%)	33 (9%)

Health	31 (1%)	0 (0%)	Transportation	188 (7%)	79 (23%)
Instruments	317 (11%)	16 (5%)	Utility	169 (6%)	22 (6%)

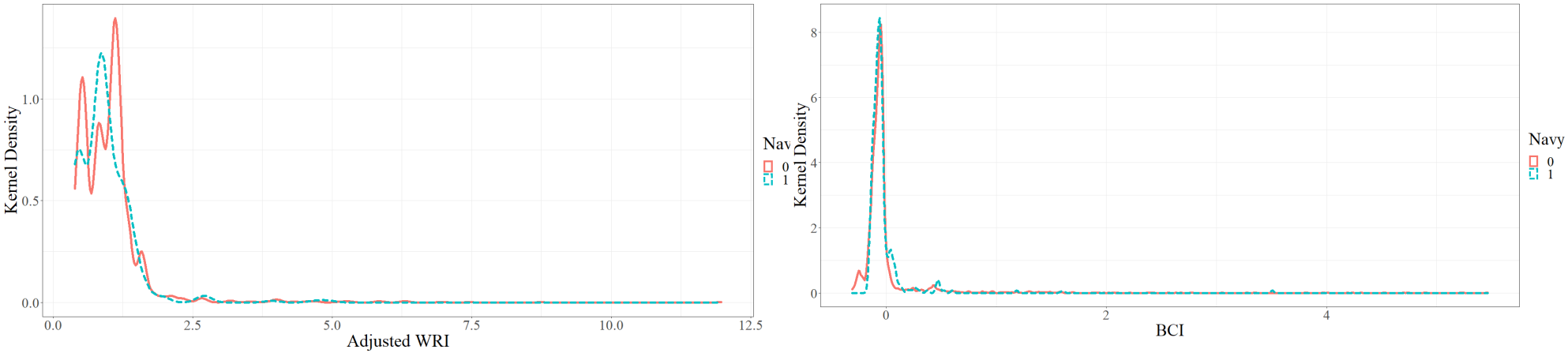
Notes: the above table shows the distribution of patents by the 'MachineOne' technology class, divided into those patents which contained a Navy proviso and those that did not. The number in the brackets indicates the percentage of patents granted either containing or not containing that proviso, rounded up.

Source: authors' calculations using data from Woodcroft (1854) and Billington and Hanna (2021).

To observe for potential quality differences between patents receiving a Navy Clause proviso and those which did not, figure 3 below plots the density functions of our two patent-quality metrics: the WRI and BCI estimates. The WRI estimate, as per Nuvolari and Tartari (2011), is adjusted for the time trend, as the number of references artificially increases over time due to the increase in the number of scientific and technical journals in circulation. Figure 3a shows the WRI plot, which is heavily right-skewed, showing that few patents had many references, and many patents had few references. A similar trend is reported in Figure 3b for the BCI estimates. Both estimates demonstrate no difference in patent quality, though the WRI estimate for non-proviso patents is much more volatile.

Finally, summary statistics for a set of explanatory variables are reported in Table 3, divided into those patents with and without the Navy Clause proviso. The estimates report some small differences between patent groups for certain variables. For example, the mean HISCLASS score is smaller for proviso-patent holders suggesting that, on average, more affluent or higher social status patentees were receiving the proviso, as reflected in Table 1. Other notable differences concern the 'Gentleman', 'Capital-saving', and 'Patent Agent' variables. 'Gentlemen' is a dummy variable indicating whether a patentee's listed occupation is that of a status; 26% of proviso-patents went to gentlemen, while only 19% of non-proviso-patents did so. 'Capital-saving' is a dummy variable indicating whether a patent was for a capital-saving invention, as defined in Macleod (2002); a greater share of proviso-patents was for capital-saving inventions than non-proviso patents. Lastly, 'Patent Agent' is a dummy indicating whether the patentee's occupation was a patent agent. No proviso-patents are associated with such agents, who would have had considerable expertise in both the petition procedure and the functioning of the patent laws (Pretel, 2018).

Figure 3. Kernel density plots of patent quality estimates, 1793-1820



a. WRI

b. BCI

Notes: the figures report kernel density plots for the WRI measure (adjusted for time) and the BCI measure. Each plot splits patents into two categories based on the 'Navy' variable, where patents which contain a Navy proviso are coded as '1' and patents without are coded as '0'.

Sources: authors' calculations using data from Nuvolari and Tartari (2011), and Nuvolari et al. (2021).

Table 3. Summary statistics by Navy proviso, 1793 - 1820

Variable	Proviso	No.	Mean	Std. Dev.	Min	Max
HISCLASS	No	2,475	3.73	3.00	0.00	12.00
	Yes	349	3.62	2.85	0.00	12.00
Number of Inventors	No	2,475	1.18	0.46	1.00	4.00
	Yes	349	1.21	0.47	1.00	3.00
Insider	No	2,475	0.42	0.49	0.00	1.00
	Yes	349	0.38	0.48	0.00	1.00
Capital-saving	No	2,475	0.13	0.34	0.00	1.00
	Yes	349	0.26	0.44	0.00	1.00
Labour-saving	No	2,475	0.02	0.14	0.00	1.00
	Yes	349	0.06	0.23	0.00	1.00
Metropolitan	No	2,475	0.56	0.50	0.00	1.00
	Yes	349	0.60	0.49	0.00	1.00
Patent Agent	No	2,475	0.00	0.04	0.00	1.00
	Yes	349	0.00	0.00	0.00	0.00
Scotland	No	2,475	0.17	0.37	0.00	1.00
	Yes	349	0.16	0.37	0.00	1.00
Ireland	No	2,475	0.09	0.29	0.00	1.00
	Yes	349	0.11	0.31	0.00	1.00
Patent Stock	No	2,475	1.82	1.95	1.00	18.00
	Yes	349	1.87	1.74	1.00	15.00
WRI (adjusted)	No	2,475	1.01	0.59	0.39	7.46
	Yes	349	0.93	0.51	0.39	4.94
BCI	No	2,475	0.01	0.32	0.32	4.90
	Yes	349	0.03	0.24	0.15	3.51
Gentlemen	No	2,475	0.20	0.40	0.00	1.00
	Yes	349	0.26	0.44	0.00	1.00

Notes: the table presents summary statistics for patents granted from 1793-1820, grouped by the variable 'Navy'. 'HISCLASS' is an ordinal occupational score; 'Number of Inventors' are the number of named inventors per patent; 'Metropolitan' is a dummy variable scoring 1 if a patentee lives in a town with 50,000 or more persons; 'Insider' is a dummy variable scoring 1 if a patentee's occupation matches their patent's technology class; 'Capital-saving' is a dummy variable scoring 1 if a patent is a capital-saving invention; 'Labour-saving' is a dummy variable scoring 1 if a patent is a labour-saving invention; 'Patent Agent' is a dummy variable scoring 1 if a patentee's occupation is a patent agent; 'Scotland' is a dummy variable scoring 1 if a patent was protected in England and Scotland; 'Ireland' is a dummy variable scoring 1 if a patent was protected in England and Ireland; 'Patent Stock' is the cumulative count of patents granted to each inventor at the time of each new patent grant; 'WRI (adjusted)' is the adjusted number of references per patent; 'BCI' is the bibliographic composite index; 'Gentlemen' is a dummy scoring 1 if a patentee's occupation is a status.
Source: authors' calculations using data from Mitchell (1988); Nuvolari and Tartari (2011); and Nuvolari et al. (2021).

4. Determinants of the Navy Proviso

The summary statistics indicate that patents related to military purposes - such as ordnance or ship-related technologies - were much more likely to receive the proviso. However, this feature alone is insufficient to explain the insertion of the proviso into non-military technologies; 36% of proviso-patents were military and transportation but 64% were related to other not obviously military technologies. We explain this pattern using two econometric models.

Our first model focuses on the likelihood that a patentee's patent would receive a proviso. The second model focuses on the likelihood that a patent which received the warrant recommending the insertion of the proviso would also contain the proviso in Woodcroft's records, which we call a 'complete proviso'. We restrict our focus to patents granted 1793 – 1820, as this is the period within which patents were eligible to receive the proviso. We begin by estimating our first model, which is presented in equation 1.

$$P\left(Navy_{it} = 1 \middle| X_{ijt}\right) = \alpha_{it} + \beta_j X_{ijt} + \beta_j Z_{jt} + \epsilon_{it} \quad (1)$$

The equation estimates the probability that a patent granted to person i in year t received the Navy Clause proviso, as a function of X_j explanatory variables, conditional on Z_j control variables. Our explanatory variables are: HISCLASS occupational scores, split into four skill-based categories, 'High Skilled', 'Medium Skilled', 'Low Skilled' and 'Unskilled' as per Van Leeuwen and Maas (2011); patent quality scores; the Number of Inventors per patent; the cumulative patent stock held by an inventor at time t; whether the patentee is classed as an insider; whether the patent was protected also in either Scotland or Ireland; and the patent's primary technology classification. The control variables are year dummies. We estimate our equation using a logit regression model. Table 4 reports our estimates.

The results report several statistically significant estimates. Of the HISCLASS variables, 'Low Skilled' inventors were approximately 45-46 per cent less likely to hold a proviso-patent compared to 'High Skilled' inventors, while 'Unskilled' inventors were much more likely. The latter result is driven primarily by the small number of 'Unskilled' patentees in the dataset, resulting in an inflated coefficient. The 'Medium Skilled' category is not statistically significantly different to the 'High Skilled' category, though their odds ratios suggest they were more likely to receive provisos.

The 'Patentee characteristics' indicate that patents which were explicitly for the purpose of saving either on capital or labour were much more likely to receive the proviso compared to those patents which did not state either. The coefficients imply that labour-saving patents, for example, were almost four times more likely to receive a proviso, while capital-savings patents

were three times as likely. Typically, labour-saving patents indicate that they will reduce the amount of manpower necessary to carry out certain activities, while capital-saving patents increase the consistency of machine output, or increase fuel efficiency, or increase output relative to inputs. The military may have sought such patents to meet the rising demands placed on industry from Britain's conflict with France, and as such, 'savings' patents would be particularly fruitful.

The 'Patent value' characteristics suggest proviso-patents were less economically valuable. The 'WRI' estimate suggests each additional weighted reference per patent reduced the likelihood of receiving the proviso by approximately 24-34 per cent. The BCI estimates report similar coefficients but are not statistically significant at any conventional level. Another proxy for a patent's value is to examine whether it was protected in an additional British patent jurisdiction (see Bottomley, 2014; Billington, 2021). We include both the 'Scotland' and 'Ireland' dummies to indicate whether a proviso-patent was protected in more than one jurisdiction. Billington (2021) finds that more economically valuable patents were extended to Scotland rather than Ireland. Our estimates suggest that patents extended to Scotland were no less likely to receive a proviso, but patents extended to Ireland were approximately 64 per cent more likely to receive a proviso, though the latter is only statistically significant in column 9. Ireland was a much more expensive jurisdiction to extend protection to compared with Scotland, and our estimate may then be capturing a partial wealth effect; inventors opting to patent in Ireland may have done so because they had means rather than because of their invention's value.

Table 4. Logit regressions on the determinants of receiving a Navy proviso

	Dependent variable: Navy									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
HISCLASS										
Medium Skilled	1.055								1.091	1.094
	(0.128)								(0.161)	(0.161)
Low Skilled	0.461***								0.552**	0.554**
	(0.125)								(0.165)	(0.166)
Unskilled	4.059*								9.317**	9.432**
	(2.982)								(8.448)	(8.536)
Patentee characteristics										
Number of Inventors		1.152							1.121	1.141
		(0.133)							(0.153)	(0.156)
Patent Stock			1.013						0.994	1.004
			(0.029)						(0.035)	(0.035)
Insider				0.796*					0.822	0.828
				(0.094)					(0.117)	(0.118)
Labour-saving					3.685***				3.972***	3.997***
					(1.013)				(1.347)	(1.351)
Capital-saving					2.500***				3.399***	3.388***
					(0.342)				(0.574)	(0.571)
Patent Value										
WRI						0.742**			0.656***	
						(0.093)			(0.103)	
BCI							0.625*			0.662
							(0.174)			(0.188)
Scotland								0.858	0.939	0.930
								(0.169)	(0.234)	(0.232)
Ireland								1.281	1.644*	1.614
								(0.306)	(0.483)	(0.476)

Technology Class		
Apparel	0.000	0.000
	(0.000)	(0.000)
Chemicals	0.345**	0.344**
	(0.160)	(0.160)
Commodities	0.575	0.582
	(0.270)	(0.273)
Construction	0.558	0.552
	(0.260)	(0.257)
Electricity	3.057	2.892
	(3.108)	(2.951)
Food	0.000	0.000
	(0.000)	(0.000)
Hardware	1.451	1.443
	(0.473)	(0.470)
Health	0.000	0.000
	(0.000)	(0.000)
Instruments	0.490*	0.515*
	(0.190)	(0.200)
Machinery	1.276	1.320
	(0.466)	(0.481)
Manufacturing	2.865**	2.795**
	(1.193)	(1.162)
Metal	0.410	0.404
	(0.275)	(0.271)
Military	32.417***	30.935***
	(13.415)	(12.763)
Mining	1.596	1.660
	(0.808)	(0.835)
Paper	0.114**	0.111**
	(0.119)	(0.116)

Power									0.476*	0.457*
									(0.207)	(0.199)
Textiles									0.907	0.899
									(0.313)	(0.310)
Transportation									7.666***	7.648***
									(2.510)	(2.502)
Utility									1.203	1.183
									(0.448)	(0.439)
Constant	0.148***	0.119***	0.138***	0.158***	0.113***	0.188***	0.140***	0.141***	0.000	0.000
	(0.012)	(0.018)	(0.011)	(0.012)	(0.008)	(0.025)	(0.008)	(0.009)	(0.000)	(0.000)
Observations	2,694	2,824	2,824	2,707	2,824	2,824	2,824	2,824	2,694	2,694
Time Controls	N	N	N	N	N	N	N	N	Y	Y
Log Likelihood	-1,012	-1,055	-1,057	-1,021	-1,029	-1,053	-1,054	-1,056	-755	-758
Akaike Inf. Crit.	2,032	2,115	2,116	2,046	2,064	2,110	2,112	2,117	1,626	1,632

Note: The table reports the results of our logit regression model. Each column 1-8 reports estimates for single variate regressions, while columns 9 and 10 report our model including the explanatory variables and control variables. Time controls are not reported for brevity. 'Capital-saving' and 'labour-saving' are dummy variables where the omitted category is 'No-saving', which are defined as patents whose titles do not indicate that they are explicitly labour- or capital-saving. 'Technology classes' are compared to the omitted category of 'Agriculture'. The omitted HISCLASS category is 'High Skilled'. All coefficients are reported as odds ratios. Standard errors reported in brackets. *p<0.1; **p<0.05; ***p<0.01

Finally, the patent technology classes report that, compared to 'Agricultural' patents, 'Military' patents were approximately 30 times more likely to receive the proviso, while 'Transportation' patents were over seven times more likely to receive it. The result is hardly surprising, given the purpose of the proviso. In addition, 'Manufacturing' patents were almost three times as likely to receive the proviso. This may reflect the demands placed on Britain's military boards; increased demand for items such as uniforms, ships, and ordnance require a significant increase in production said. As such, manufacturing patents would have helped meet this need.

Table 5 reports the results of a logit regression model explaining the probability that a patent which received a Navy Warrant would also receive the Navy Clause proviso. We estimate this in two ways. First, in columns 1 and 2, we restrict our observations only to patents

which received a Warrant. Second, in columns 3 and 4 we restrict our observations to those patents which received either a Warrant or a proviso. The results are generally similar in both specifications. Firstly, the patentee's occupation is not correlated with conversion to a proviso in any statistically significant way, though the coefficients suggest that 'Medium Skilled' and 'Low Skilled' individuals had patents with a higher rate of conversion from Warrant into proviso compared to the 'High Skilled' category.

Second, the patentee characteristics suggest that the 'saving' element of a patented invention was correlated with conversion. Those patents which explicitly stated that they were 'Labour-saving', or 'Capital-saving' were much more likely to receive a proviso, whether they also received a Warrant or not. The 'Capital-saving' estimates report much more consistent coefficients compared with the 'Labour-saving' estimates. The latter estimates appear sensitive to the choice of patent quality control variable, whereas the former estimates are independent of quality. 'Capital-saving' appears to be a more important determinant than 'Labour-saving'.

The patent value estimates also report correlation with conversion. In both specifications, the BCI estimate is positive and statistically significant, suggesting that more valuable patents (or patents belonging to influential inventors) were much more likely to have their Warrant convert into a proviso, though the size of the coefficients may suggest they are inflated. By contrast, the WRI estimates report no statistically significant relationship, nor do the 'Ireland' or 'Scotland' estimates, suggesting that a patent's value had little overall effect on the rate of conversion.

Finally, the technology classes report little statistically significant correlation with conversion. Only 'Manufacturing' and 'Power' patents report any significance; the former may simply be random while the latter is constant across specifications. 'Power' patents were significantly less likely to convert to receive a proviso. These patents are typically related to steam engines or any other kind of engine that generates force from a source of fuel. The result suggest that proviso-patents were often not for such general-purpose technologies.

Table 5. Determinant of conversion of Warrant into Navy Clause proviso, 1793 - 1820

	Dependent variable: Navy Clause			
VARIABLE	(1)	(2)	(3)	(4)
HISCLASS				
Medium Skilled	1.127	1.210	1.389	1.554
	(0.354)	(0.388)	(0.379)	(0.429)
Low Skilled	1.422	1.220	2.297	2.149
	(1.112)	(0.972)	(1.415)	(1.343)
Unskilled	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Patentee characteristics				
Number of Inventors	1.058	0.938	0.865	0.751
	(0.316)	(0.289)	(0.238)	(0.213)
Patent Stock	1.020	0.942	1.115	1.026
	(0.108)	(0.109)	(0.086)	(0.089)
Insider	0.875	0.884	0.973	0.933
	(0.273)	(0.278)	(0.259)	(0.251)
Labour-saving	3.460*	2.627	4.193**	4.000**
	(2.488)	(1.944)	(2.732)	(2.675)
Capital-saving	2.603***	2.326**	2.846***	2.755***
	(0.933)	(0.848)	(0.905)	(0.885)
Patent value				
WRI	1.735		1.636	
	(0.590)		(0.495)	
BCI		24.041*		27.054**
		(39.527)		(41.584)
Scotland	1.167	1.088	0.876	0.856
	(0.561)	(0.527)	(0.377)	(0.368)
Ireland	0.542	0.497	0.461	0.425
	(0.318)	(0.295)	(0.244)	(0.227)

Technology class				
Chemicals	0.267	0.322	0.383	0.392
	(0.300)	(0.353)	(0.360)	(0.365)
Commodities	0.513	0.266	0.822	0.612
	(0.570)	(0.348)	(0.757)	(0.580)
Construction	0.943	0.719	0.843	0.733
	(0.960)	(0.748)	(0.775)	(0.682)
Hardware	0.556	0.563	0.952	0.951
	(0.408)	(0.412)	(0.599)	(0.597)
Instruments	0.852	0.854	1.294	1.169
	(0.804)	(0.799)	(1.045)	(0.938)
Machinery	0.306	0.344	0.347	0.356
	(0.252)	(0.282)	(0.247)	(0.256)
Manufacturing	0.362	0.297	0.274*	0.228*
	(0.306)	(0.254)	(0.213)	(0.180)
Metal	0.000	0.000	0.481	0.633
	(0.000)	(0.000)	(0.687)	(0.888)
Military	1.638	1.587	1.301	1.276
	(1.106)	(1.069)	(0.803)	(0.787)
Mining	0.301	0.267	0.279	0.244
	(0.318)	(0.285)	(0.263)	(0.234)
Power	0.132*	0.095*	0.078**	0.059**
	(0.161)	(0.119)	(0.093)	(0.071)
Textiles	0.380	0.331	0.460	0.412
	(0.293)	(0.251)	(0.306)	(0.270)
Transportation	0.668	0.613	0.786	0.695
	(0.430)	(0.395)	(0.455)	(0.404)
Utility	2.532	2.340	1.957	1.858
	(2.001)	(1.839)	(1.451)	(1.376)
Constant	0.484	1.340	0.817	2.181
	(0.393)	(1.051)	(0.588)	(1.520)

Observations	249	249	339	339
Time Controls	Y	Y	Y	Y
Log Likelihood	-148.142	-146.284	-197.461	-195.290
Akaike Inf. Crit.	350.283	346.569	450.922	446.581

Note: The table reports the results of our logit regression model. Columns 1 and 2 report estimates for all patents containing a 'Navy Warrant', while columns 3 and 4 report estimates for all 'Navy' patents. Time controls are not reported for brevity. Several technology classes are omitted due to lack of observations. 'Capital-saving' and 'labour-saving' are dummy variables where the omitted category is 'No-saving', which are defined as patents whose titles do not indicate that they are explicitly labour- or capital-saving. 'Technology classes' are compared to the omitted category of 'Agriculture'. The omitted HISCLASS category is 'High Skilled'. All coefficients are reported as odds ratios. Standard errors reported in brackets. *p<0.1; **p<0.05; ***p<0.01

Consequently, the results suggest that being a 'saving' patent was an important determinant of whether that patent having received a warrant would also receive the proviso, or whether that patent received a proviso anyway. Our interpretation is that, given the significant demands on British industry to increase production to meet the demands of the war effort (O'Brien, 2017; Satia, 2018), the Board of Ordnance were keen to acquire any such technologies or inventions that would help them to meet this demand.

Our results thus far suggest that the Board of Ordnance's proviso was targeting 'saving' inventions. However, this does not tell us whether the proviso itself altered inventor behaviour. To understand this, we run two further logit regression models, as per equation 2.

$$P\left(Y_{it} = 1 \middle| X_{ijt}\right) = \alpha_{it} + \beta_j X_{ijt} + \beta_j Z_{jt} + \epsilon_{it} \quad (2)$$

Our equation attempts to explain a dependent variable, Y, which represents either: whether a patent was primarily a military technology (defined using the Billington and Hanna (2021) schema); or whether the inventor was a new patentee in the system (defined as a 'Patent Stock' value equal to 1). The purpose is to understand whether the introduction of the proviso induced new patentees into the system, and also to understand whether the propensity to patent a military technology changed as a result of the outbreak and duration of the French Revolutionary and Napoleonic Wars. In order to do so, we extend our period of analysis to 1760-1820.[1]

The control variables, Z, are those statistically significant variables from Table 4: a patentee's HISCLASS code; whether a patent was 'capital-saving' or 'labour-saving' and the patent's value. Our explanatory variables, X, are a set of dummy variables indicating whether:

[1] We extend back to 1760 to mark the traditionally dated beginning of the Industrial Revolution. We do not extend forward in time to avoid potentially biasing our investigation by the post-1820 patent boom.

a patent was granted during the Napoleonic War; a patent was granted during the French Revolutionary War; and whether a patentee was a 'serial patentee', which we define as a patentee who held at least three patents in their career and obtained at least one during the French Revolutionary and Napoleonic Wars and at least one during the period either before or after these conflicts.

It is important to note that we are no longer controlling for either the year the patent was granted, nor the technology class of the patent. In this instance, our explanatory variables are correlated with our time variable, while our dependent variable is a subset of our technology class variable. The results are therefore simple correlations with some relevant control variables and should be interpreted cautiously.

Our estimates are reported in Table 6. Columns 1-3 estimate the likelihood that 'serial patentees' obtained patents for military inventions, as a function of when the patent was granted (either during the Napoleonic War, or the French Revolutionary War, or peacetime). In column 1, the 'Napoleonic' dummy reports that, on average, the number of military patents increased during the Napoleonic war by about 50 per cent in comparison to peacetime. Columns 2 and 3 include 'serial patentees' as an explanatory dummy variable. In both specifications, our estimates suggest that 'serial patentees' were twice as likely to obtain military patents as non-serial patentees, while the interaction term in column 3 reports that serial patentees did not increase their military patenting during the Napoleonic War. Column 4 reports our logit model which explains the likelihood that a patent granted belonged to a new inventor, and whether this increased during times of war. Our estimates show that, on average, the likelihood of a new patentee entering the patent system decreased by approximately 26 per cent. In all specifications, the 'French' dummy reports no statistically significant result, indicating that there is little correlation between patenting activity and the French Revolutionary Wars.

Together, the results suggest that there is little correlation between serial patentees and their propensity to patent military inventions during the Napoleonic Wars, but the Wars did coincide with fewer new inventors entering the patent system. However, as Figure 1 demonstrates, the rate of patenting did not exhibit any significant decline following the outbreak of the Napoleonic Wars, which suggests that patenting activity at that time was driven by the stock of existing patentees. At the same time, our estimates suggest that military patenting increased during the Napoleonic Wars but also that serial patentees were more likely to obtain patents for military inventions. Consequently, we argue that the direction of patenting in Britain did change as a result of the Napoleonic Wars, which correlates with the consistent application of Navy Clause provisoes to patents, as evidenced in Figure 2.

Table 6. Logit regression estimates on patenting behaviour

	Military			New Patentee
VARIABLE	(1)	(2)	(3)	(4)
Serial Patentee*Napoleonic			0.840	
			(0.471)	
Serial Patentee		2.086***	2.249**	
		(0.584)	(0.821)	
Napoleonic	1.505*	1.508*	1.559*	0.732***
	(0.359)	(0.360)	(0.407)	(0.058)
French	0.731	0.714	0.712	0.907
	(0.255)	(0.249)	(0.249)	(0.088)
HISCLASS	1.032	1.043	1.042	1.090***
	(0.038)	(0.039)	(0.039)	(0.013)
Capital-saving	0.987	0.977	0.979	1.083
	(0.280)	(0.277)	(0.278)	(0.099)
Labour-saving	0.000	0.000	0.000	1.247
	(0.000)	(0.000)	(0.000)	(0.280)
WRI	0.898	0.874	0.875	0.946
	(0.184)	(0.182)	(0.182)	(0.051)
Constant	0.020***	0.018***	0.017***	2.022***
	(0.007)	(0.006)	(0.006)	(0.193)
Observations	3,899	3,899	3,899	3,899
Log Likelihood	-403	-400	-400	-2,326
Akaike Inf. Crit.	821	817	819	4,666

Note: the table reports logit regression estimates using equation 2. All coefficients are expressed as odd ratios. Column 1 estimates the probability that a patent was obtained for a military patent, covering the period 1760 – 1820. Column 2 restricts the observations to 'serial patentees' who held patents both during the French wars period

and either before or after the French wars. Column 3 includes 'serial patentees' as an explanatory variable using the unrestricted set of observations. Column 4 includes an interaction term between 'serial patentees' and 'Napoleonic' patents. Column 5 estimates the probability that a new inventor entered the patent system $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

5. Invention Outside the Patent System

The patent estimates indicate that, typically, the Law Officers were inserting Navy Clause provisos primarily into capital- or labour-saving military inventions which were typically more likely to be patented by the highest social status patentees or those patentees associated with the upper-tail of human capital, as well as experienced patentees. However, the results do not explain whether Britain's military intervened solely in the market for patents or the market for inventions altogether.

To provide an explanation, we draw on qualitative sources to gain a better understanding of whether the intervention into the patent system was accompanied by a similar intervention into the market for private inventions. Given the property rights associated with a patent, intervention into the patent system is a sensible policy insofar as the State can appropriate inventions for their own needs, while directing the Board of Ordnance to settle any prices and terms as they see fit else the patentee loses their patent right.

The sources we draw on concern a sample of inventions pro-actively submitted by inventors directly to the Board of Admiralty and the Board of Ordnance, for the purpose of obtaining a reward. The sample in question comes from the War Office records held at the National Archives in Kew, which contain a set of correspondence between the Board of the Admiralty, the Board of Ordnance, and inventors. The collection – WO 44/498 – covers the cases of 19 military inventions across the period 1812 – 1821, which coincides with the continued use of the Navy Clause proviso. Table 7 reports the inventions, their inventors, the subject-matter of the invention, whether the Board chose to adopt the invention into service, and whether the invention has a corresponding patent.

The sample highlights several things. First, inventors who chose to submit inventions to the Board were typically of a military occupation; 11 of the 19 inventions were presented either by an officer or by an inventor employed in the service of the Royal Laboratory at Woolwich. Second, of the 19 inventions, only two were previously or subsequently patented as indicated in Woodcroft (1854). Third, the submitted inventions were predominantly ordnance inventions, which contrasts the patent records presented in Section 4 that indicate the majority of Navy Clause proviso patents were not for ordnance. Fourth, the correspondence

highlights that the ordnance inventions were typically capital-saving, insofar as we can define capital-saving as raising the amount of output produced per a given set of inputs. For example, Mr Fane's invention of fire balls was an attempt to increase the damage dealt by chainshot, while the various 'sights for naval guns' attempted to increase the accuracy of fire. Fifth, the table details that there is an almost even split between inventions accepted and rejected by the Board of Ordnance.

The correspondence contained in the records demonstrate a typical pattern of communication: an inventor writes to the Board of Ordnance or the Admiralty, detailing an invention they think would be useful for service; the Admiralty then write to the Board directing them to inquire into the utility of the invention; the Board may direct that the invention be tried or experimented upon at Woolwich or in front of a selection of field officers; the attendants draft a report of their findings and recommendations and submit this to the Board; the Board reviews the findings and may then call on Sir William Congreve for his expert opinion; the Board then communicates their decision to the Admiralty and the inventor. In many cases, several letters are exchanged between the Board of Ordnance and the inventor.

The correspondence highlights several things: the Board could identify and did reject low-quality inventions, suggesting they had a pragmatic approach to deciding whether to accept an invention; inventors were likely aware of the compensation other innovators were receiving, which at times was considerable; the Board treated inventions as though they were protected private property, insofar as they adhered to patent case law, and did not opt to appropriate any inventions they considered valuable.

Table 7. Sample of inventions submitted directly to the Board of Ordnance

Invention	Year	Inventor	Decision	Patent
12-pounder B.L. gun	1819	Lieutenant Jackson	Declined	No
Improved 68-pounder carronade	1821	Captain Millar	Declined	No
Mr Fane's fire balls	1812	Mr Fane	Declined	No
Rammer of wad	1818	Lieutenant Rodgers	Declined	No
Rocket apparatus for saving lives	1818	Mr Henry Trengrouse	Declined	No
Sights for naval guns	1817	Captain Farquhar	Accepted	No
Carronade carriages and slides for sea service	1814	William Congreve	Accepted	Yes
Sights for naval guns	1819	John Hookham	Declined	No
Improved cannon and carriages for sea service	1815	John Gover and James Hardum	Accepted	Yes
Quill tubes for use in the Royal Navy	1818	Lieutenant Fynmore	Accepted	No
Furnaces for heating round shot on board His Majesty's Ships	1815	NA	Unclear	No
Tangent sights for naval guns	1814	Captain Truscott	Unclear	No
Tangent sights for naval guns	1815	John Hookham	Accepted	No
Method of mounting carronades	1818	Captain Jekyll	Accepted	No
Improvements in carronade slides	1819	William Congreve	Declined	No
Mode of fixing naval cartouche box	1819	Captain Bagnold	Accepted	No
Mode of firing a 32-pounder gun	1816	Thomas Manton	Declined	No
Locks on the percussion principle for the 'Great Guns' of His Majesty's Ships	1820	Various	Unclear	No
New construction of ordnance	1813-1815	William Congreve	Unclear	Unclear

Notes: The table describes a sample of inventions submitted to the Board of Ordnance. The table reports the title of the invention; the year the invention was submitted; the inventor's listed name; whether the Board of Ordnance accepted the invention; and whether the invention was patented. "Accepted" is classed as any positive support for the use of the invention in the military, or its recommendation for adoption. "Unclear" is listed when the outcome was not reported.

Source: WO 44/498

Two particular cases highlight the Board's ability to identify and reject poor-quality inventions through experimentation, and a third case shows how the Board dealt with inventions which were potentially useful but required further development. The first case concerns Thomas Manton's invention for firing a 32-pounder gun. At one of the trials for Manton's invention, a Colonel Lloyd attended and reported to the Board:

> *"Mr Manton attended, and having fitted the vent, the Gun was loaded with the usual sea service charge and fired, when, as was anticipated, his Tube and the Button intended to configure it, were both blown away and consequently the Experiment totally failed." ('Mr Thomas Manton's mode of firing a 32-pounder gun', WO 44/498, p. 15.)*[2]

The second case relates to Lieutenant Jackson's swivel gun. On submission, the gun was sent to Woolwich Royal Laboratory for Sir William Congreve to experiment with. In contrasting Jackson's gun with the established model used onboard British Naval vessels, Congreve noted: '[…] the workmanship in Jackson's piece is so extremely bad, that it can hardly be considered a fair trial.' ('12-pounder B.L. swivel gun, Lieut. Jackson Royal Marines', WO 44/498, p.5).

The third case concerns Mr Fane's fire ball. The invention worked by igniting chain shot as it fired, with the ignition triggered by the spark of the cannon shot, and it was kept aflame by the chemical paste that Fane invented to coat the cannon shot. Fane's invention itself was the paste and he wished to supply the paste to the Board rather than sell them the invention directly ('Mr Fane's Fire Balls', WO 44/498).[3] To determine whether the invention was useful, the Board requested a trial of Fane's paste in front of field officers. The officers note, quite unanimously, that the invention is highly destructive, but they also point out that the shot is just as damaging to the firing ship as it is to the enemy. The Board concluded that, while the invention is too destructive, they were willing to purchase the knowledge of how to produce the paste to refine it further. Fane ultimately refused the offer and attempted to instead sell his invention to the French.[4]

The three cases highlight the rigor with which the Board sought to identify the potential value of the inventions submitted to them. In each case, the invention was submitted for experimentation, where the experimenters assessed the invention's accuracy, trajectory, and reliability using a variety of different sizes of shot, different distances to targets, and different elevations to shoot from. In the case of Fane's fire ball, the experimenters also noted how often the paste ignited when fired. The experimentation phase appears quite effective at identifying an invention's value. The low-quality inventions failed almost immediately. Fane's invention,

[2] Colonel Lloyd later remarked that Manton, '[…] seemed perfectly satisfied at the utility of his invention.'
[3] Fane's correspondence suggests that, at one stage, he worked as an artificer for the Board of Ordnance and likely experimented with cannon shot, though the Board gives no corroboration of this claim.
[4] Following the Board's decline to purchase Fane's supplies, Fane then wrote several self-pitying letters to the Board, one of which outlines his attempts to sell the invention to the French. Fane claims he chose not to in the end, out of a sense of duty to England. Though it is likely that, like the Board of Ordnance, the French found the invention too destructive to manage.

though not a complete failure, demonstrates the Board's discretion: they were still willing to compensate Fane in exchange for his knowledge.

Fane's case also highlights another important factor: remuneration. At several points in his correspondence with the Board of Ordnance, Fane requests varying sums of money from them, which he declares he is owed as expenses for his efforts. Fane initially requested £280, arguing that he was in service to the Board when he invented his paste. However, Fane later demands a lifetime pension of £1,200 per annum. Though the sum is significant, the most striking thing about it is that Fane demands the exact same reward that was granted to William Congreve and Henry Shrapnel, a comparison which was explicitly raised by a Colonel Wood who was sent by the Board to ascertain Fane's desired monies. Congreve's pension was a reward for his famous 'Congreve rocket'.[5] Shrapnel received his pension for his invention of spherical case shot – the precursor to the modern-day fragmentation grenade (House of Commons, 1815, IX:340). Fane's request may then have been based on his observation of the rewards granted for highly destructive and highly valuable inventions; that Fane's fire ball was considered so destructive is likely why he thought he should receive the same pension as Congreve and Shrapnel.

The correspondence also includes two inventions for which a corresponding patent is found in the patent records. One of the inventions is also accompanied by a considerably detailed narrative of the development of the invention as well as the troubles experienced by the inventor and named patentees. The invention of 'Improved Cannon and Carriages for Sea Service' was submitted by co-patentees, John Gover and James Hardum. In their narrative, written by Hardum in the likely hopes of deriving sympathy from the Board and thereby increasing their chances of remuneration, Hardum emphasises the utility of their invention by citing the several instances in which it was tried in front of field officers. Hardum focuses on the utility of the invention onboard the vessels of famous officers from the Napoleonic era, such as Alan Gardner and Sir Sidney Smith.

Aside from the mention of famous persons, Hardum's narrative reveals two important factors: their invention was patented despite prior public use, and the Board of Ordnance were, at the very least, content to allow Hardum to patent it. The first point contrasts our understanding of the working of British patent law, in which prior public use could void any patent right (Dutton, 1984; MacLeod, 2002). Presumably, Britain's Board of Ordnance would

[5] The rockets were famously used as part of the Second Battle of Copenhagen in 1807, in which the rockets helped ensure the destruction or seizure of the entire Danish fleet.

have had sufficient influence to overcome any objections of prior use (particularly given the Home Secretary's desire to include the Board in the development of the Navy Clause proviso). The second point stands in contrast to Satia (2018), who claims that the Board of Ordnance actively discouraged inventors from obtaining patent rights, though this argument may be restricted to the period before the Navy Clause proviso had been drafted. In this case, Hardum was allowed, and may even have been supported in obtaining two patents for similar inventions.

The invention in question was patented by John Gover in 1796; Hardum is not named on the patent and acted then as a silent partner. Gover's patent petition contains instruction by the Home Secretary to the Law Officer to insert the Navy Clause proviso (thus it is considered a 'Navy Warrant' patent in Table 5). However, Woodcroft's patent records do not indicate that the Navy Clause proviso was ever applied to Gover's patent. Given that it was petitioned for in 1796, it is likely that the Law Officer clerks may have forgotten to include the proviso. Ultimately, Gover would go on to lose his patent right as he fell victim to a fraudster calling himself "Colonel Sinclair", who promised Gover that he would satisfy his debts (which were considerable) in exchange for a share of the patent right. Sinclair, described as being associated with a very dangerous gang in London, would then proceed to take out £3,000 - £4,000 in debts in Gover's name and thus causing Gover's creditors to take ownership of the patent to satisfy the debt ('Improved Cannon & Carriages for Sea Service', WO 44/498). It is likely that such hardship may not have befallen Gover had the Navy Clause proviso been included in the final patent grant, thus providing Gover and Hardum with greater financial security.

Finally, the correspondence also highlight that the Board was unwilling to consider non-novel inventions. The case of H. Trengrouse and his invention of an apparatus for saving lives emphasises the precedent set by patent case law. In this case, Congreve is called on to examine the invention himself (he was the Comptroller of the Royal Laboratory in Woolwich at the time). After Trengrouse submits his invention for inspection to the Royal Laboratory, Congreve states to the Board that the invention's originality is questionable (`Rocket Apparatus for Saving Lives', WO 44/498). Congreve recalls two publications relating to Captain Manby's device in 1809 and 1810, several years before Trengrouse had submitted his invention.[6] Congreve's report emphasises the importance of remunerating only those inventions that were truly original, adopting the definition as laid out in British patent law; the first to publish their

[6] Captain Manby's invention was for saving ship-wrecked persons by firing deep-sea lines to distressed ships, to either reel in the ship or allow the crew to traverse the ropes (House of Commons, 1811, XI: 215).

invention is considered the original inventor. Though other members of the Board acknowledged that Trengrouse conceived the idea before Manby, the fact that Manby published first renders Trengrouse's invention as non-novel.

The evidence here supports our argument that the Board of Ordnance may have actively encouraged useful invention during the French Revolutionary and Napoleonic Wars. The Board's use of trial and experimentation acted as a means of screening, allowing them to identify an invention's value. The reports also highlight the degree of compensation the Board was willing to award, while the correspondence suggest that inventors were aware of compensation received by others, in some cases using this as the basis of their own claim. The Board also followed the precedent set by patent law, insofar as they appeared unwilling to reward inventions which were not original.

6. Conclusion

This paper makes three important contributions to our understanding of the role of the State in procuring military inventions during the Industrial Revolution, because of the outbreak of the French Revolutionary and Napoleonic Wars. First, we provide new evidence documenting the introduction of the Navy Clause proviso. For the first time, our research demonstrates how the clause worked in practice from inception to completion. Second, we present a new dataset of patents which received the proviso, by combining existing patent data with a new set of hand-collected archival records. We present and analyse this new dataset to identify the key characteristics of an invention that made it attractive to and thereby subject to intervention from the State. Third, we introduce new qualitative evidence concerning the State's involvement in procuring military inventions from outside the patent system.

Together, these findings allow us to make the argument that the British State intervened in the market for inventions, and also helped direct technical change in Britain toward labour-saving and capital-saving military innovations. Coupled with the work of Satia (2018) and O'Brien (2017), we reinforce the military-demand-induced hypothesis as a credible explanation for industrialisation in Britain the late-eighteenth and early-nineteenth centuries. While Satia (2018) provides evidence that the State stimulated industrialisation indirectly through private contracting, and O'Brien (2017) argues that demands for ordnance stimulated heavy industry and by extension industrialisation, we explore the State's direct involvement in the market for innovation as another source of fuel for the engine of growth.

The implications of our findings shed further light on how we understand the role of the State during the Industrial Revolution. Our evidence provides a strong indication that the State was keen to ensure inventors were rewarded in proportion to the value of their invention. In this way, the State made a deliberate and conscientious effort to intervene into the patent system, with a clear idea of what they wanted to achieve: a reliable supply of valuable, state-of-the-art military inventions for the sole purpose of ensuring a well-equipped fighting force capable of winning wars, and thus helping establish Britain as the global hegemon.

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