

Procuring promising provisions: the British patent system and the Navy Proviso, 1794-1831

Article

Published Version

Creative Commons: Attribution 4.0 (CC-BY)

Open Access

Billington, S. and Lane, J. ORCID: <https://orcid.org/0000-0002-0216-1508> (2025) Procuring promising provisions: the British patent system and the Navy Proviso, 1794-1831. *European Review of Economic History*. ISSN 1474-0044 doi: 10.1093/ereh/heaf011 Available at <https://centaur.reading.ac.uk/123310/>

It is advisable to refer to the publisher's version if you intend to cite from the work. See [Guidance on citing](#).

To link to this article DOI: <http://dx.doi.org/10.1093/ereh/heaf011>

Publisher: Oxford University Press

All outputs in CentAUR are protected by Intellectual Property Rights law, including copyright law. Copyright and IPR is retained by the creators or other copyright holders. Terms and conditions for use of this material are defined in the [End User Agreement](#).

www.reading.ac.uk/centaur

CentAUR

Central Archive at the University of Reading

Reading's research outputs online

Procuring Promising Provisions: the British Patent System and the Navy Proviso, 1794–1831

Stephen D. Billington^{1,*}, Joe Lane²

¹*Department of Accounting, Finance & Economics, Ulster University, 2-24 York Street, Belfast BT15 1ED, UK*

²*Department of International Business & Strategy, Henley Business School, University of Reading, Whiteknights Road, Reading RG6 6UD, UK*

Corresponding author: Department of Accounting, Finance & Economics, Ulster University, 2-24 York Street, Belfast, BT15 1ED, UK. Email: s.billington@ulster.ac.uk.

In 1794, the British State intervened in the patent system by introducing the Navy proviso, a legal proviso targeted at select patents compelling the patentee to supply their invention to the State on terms set by state-appointed adjudicators. This study employs new patent and archival data to examine the proviso's origins, administration, and which technologies it was targeted at. Our findings reveal the state targeted technologies to enhance logistical and operational capacities during wartime, addressing potential undersupply in private markets. Functioning similarly to patent buyouts and compulsory licensing, the proviso may have encouraged technical change and knowledge dissemination.

1. Introduction

Britain's patent system has long been a source of enquiry amongst economic historians interested in explaining the rise of innovative activity in Britain during the First Industrial Revolution. The debate concerns the efficacy of Britain's patent system in incentivizing invention and innovation. Some scholars argue patents incentivized invention because the alternative of secrecy was highly risky (Dutton, 1984). Similarly, patentees were responsive to market conditions (Billington, 2021; Bottomley, 2014a), with evidence demonstrating they were capable of profiting considerably from their patents (Bottomley, 2019). There is also evidence that demonstrates the system aided the dissemination of patented knowledge (Cox, 2020).

By contrast, other scholars are more skeptical: Macleod (1988) argues the system's high fees and cumbersome administration procedures were not conducive to invention, while Khan (2005) claims the fees limited patents only for capital-intensive inventions. Consequently, a considerable amount of inventive activity bypassed the patent system entirely. Moser (2005) provides evidence that the propensity to patent varies by technology and industry; not all technologies were developed because of patents or appropriated using them. Indeed, patents did not incentivize the development of the high-pressure steam engine (Nuvolari, 2004), nor were patent rights the sole appropriability mechanism to earn returns from invention, as evidenced by the brewing industry in the nineteenth century (Nuvolari and Sumner, 2013). Inventive activity was also incentivized through prize-giving institutions such as the Royal Society of Arts (Brunt, Lerner, and Nicholas, 2012; Howes, 2021), National Fairs and

Exhibitions (Moser and Nicholas, 2013), or through State-sponsored institutions such as the Board of Longitude (Burton and Nicholas, 2017).

To frame the debate in this paper, we draw on the “three Ps” of patronage, procurement, and property, which highlights the different institutional approaches to incentivizing invention (David, 1993). Patronage concerns the role of institutions that provide *ex ante* rewards to inventors, like cash or non-monetary prizes; procurement relates to the purchase or license of an invention by the State; property concerns granting inventors legal rights to secure the returns from their inventions formally, such as through patent systems. From this perspective, much of the difficulty in evaluating Britain’s patent system is that legal form of intellectual property protection co-existed alongside forms of patronage with some degree of overlap; for example, obtaining a patent did not preclude exhibiting an invention at the 1851 Great Exhibition, while prize winners subsequently patented more inventions (Moser and Nicholas, 2013). However, while we know a great deal about the role of property and patronage, we know little about procurement.

This paper contributes to our understanding of Britain’s patent system, and how it might have influenced incentives to invent, by documenting an important yet hitherto overlooked episode of procurement: the introduction in 1794 of the “Navy Clause proviso,” or “Navy proviso.”¹ The Navy proviso marked the first instance of direct State intervention into the administration of the patent system, with the State targeting selected patents to obtain access to supplies. Little is known about the origins of this proviso, why and how it came about, how it was administered and specifically, which types of inventions it targeted.

By exploiting a new hand-collected dataset of previously unexplored records of British patents, we detail the origins of the Navy proviso and investigate which technologies the State targeted. We identify Navy proviso patents by examining surviving patent application records, which passed through the offices of the Law Officers (Attorney or Solicitor General). We show the introduction of the Navy proviso marked the formalization of an approach that was hitherto ad hoc, and one which also mirrors the procurement of inventions outside the patent system, such as submission of any invention by an individual directly to the Board of Ordnance. Such was the volume of inventions submitted outside the patent system, a standing committee of field officers was formed in 1805 to handle them (LeClair, 2015; Skentelbery, 1964, p. 2 cited in Raudzens, 1979, p. 92). Furthermore, we show the State frequently appointed the Board of Ordnance (hereafter “the Board”) or Commissioners of the Navy (hereafter “the Commissioners”) to settle terms of supply by listing them within the proviso as an adjudicator. Evidence concerning how adjudicators settled prices for patented articles indicates a reliance on market-based price signals.

We also present a new collection of correspondence between private inventors and the Board to gain further insights into how the Navy proviso may have been settled in practice. The correspondence concerns both patented and non-patented inventions under consideration by the Board for adoption into the service. These sources demonstrate how the Board bargained and contracted with inventors for inventions they deemed useful; the Board’s procurement of inventions from private inventors arguably mirrors the approach they may have taken in settling the terms of the Navy proviso as well. We argue the Board’s approach to inventors reflected the importance they placed on obtaining access to useful technologies; the Board regularly engaged in time and labor-intensive examination of submitted inventions. They also demonstrated a flexibility toward the adoption and

¹ Bottomley (2014b) first coined the phrase “Navy Clause proviso.” For brevity, we adopt the term “Navy proviso” for the remainder of this paper.

development of more experimental inventions and were prepared to grant considerable financial rewards for useful technologies.

The introduction of the Navy proviso also occurs within a broader context of the Board's increasing procurement of ordnance-related supplies through private contracts across the eighteenth and nineteenth centuries (Moss, 2012; Torres-Sánchez and Brandon, 2018). Satia (2018) argues the procurement efforts of the Board created positive spillover effects for innovation; by increasing demands for supplies from private contractors, the Board incentivized them to adopt cost-saving or output-enhancing technologies.

Using OLS regression models, we show the Navy proviso was not targeted toward inventions of a high economic value.² The State did not appear interested in technologies commonly associated with the Industrial Revolution, but rather, targeted patents based on their functional characteristics and utility particularly in operational and logistical capabilities to wage war. Our evidence suggests the proviso provided the procurement of more speculative and experimental technologies. Our findings suggest the State procured supplies of inventions that may not have been easily or readily obtainable through private markets; the State targeted inventions that might otherwise have been undersupplied.

Use of the Navy proviso resembles the mechanism of a patent buyout. Kremer (1998) argues patent buyouts aid the spread of technology, highlighting the buyout of the Daguerreotype patent by the French State in 1839, resulting in its widespread adoption and dissemination. The Navy proviso differs from a buyout, however, in that it did not seek to gain ownership of patents, nor to disseminate them publicly. The focus of the British State was procurement and control of the supply of useful inventions, with failure to comply resulting in the State obtaining the right to work or license the invention—the patent itself was not purchased.

A considerable challenge when settling *ex ante* prices through patronage or procurement systems, as highlighted by David (1993), concerns informational asymmetry between the institution and the patentee; patent buyout mechanisms also face a similar challenge (Chari, Golosov, and Tsyvinski, 2012; Galasso, Mitchell, and Virag, 2016, 2018; Weyl and Tirole, 2012). This paper shows how the State dealt with this regarding the Navy proviso. In one instance, the State prescribed an above-market price for the supply of an invention, from which we infer the contracting experience of the Board was drawn upon. In another case, the State imposed an unspecified price ceiling, based on the prices observed for related goods in private markets. By relying on market-based price signals, the State limited its exposure to informational asymmetries.

The terms offered to patentees feature characteristics of compulsory licensing. A compulsory license is a legal mechanism available to the State to ensure patent rights are not left idle for rent-seeking purposes. Our evidence shows the State used the proviso to ensure the targeted patent would be worked, either by the patentee or, if the patentee was incapable, by a third party. Existing evidence suggests compulsory licensing enables innovation, such as in the case of the US Trading with the Enemy Act of 1917, which saw the compulsory licensing of German-owned US patents to US firms, increasing innovation by US inventors (Moser and Voena, 2012) and German inventors (Baten, Bianchi, and Moser, 2017). The Navy proviso may have yielded similar kinds of outcomes on patenting and invention in Britain.

The rest of the paper is arranged as follows: Section 2 details the origins and workings of the Navy proviso. Section 3 provides evidence concerning the settlement of terms of supply. Section 4 identifies the inventions the States were interested in. Section 5 concludes.

² The authors thank the anonymous reviewers for the suggestion of this approach.

2. The Navy proviso

Sean Bottomley, in his seminal work, was one of the first economic historians to explicitly reference the existence of the Navy proviso (Bottomley, 2014b), pointing to Bennet Woodcroft's 1854 publication of a chronological list of the titles of all patents granted in England up to 1852 (Woodcroft, 1854a). Bottomley outlines Woodcroft's recorded patent titles occasionally referred to a clause compelling a patentee to supply His Majesty's Service. However, the Navy proviso does not mark the first recorded instance of State efforts to obtain supplies of patented inventions, with prior efforts laying the foundation for the formalization of this ad hoc approach.³

Using Woodcroft (1854a), we can identify the first recorded insertion of the Navy proviso into a patent granted in 1795 to Christopher Wilson, a Master Mariner from Scarborough, for a "[...] new invented method of combining timbers applicable to the improvement of naval architecture, and all ponderous and large works composed of wood [...]" (patent 2068, p. 381).⁴ Wilson's patent entry in Woodcroft outlines the proviso:

"[Wilson] shall, within one month from the date hereof, 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 [...]" (ibid).

In Wilson's case, the Navy proviso states that should the patentee not fulfil their obligations, then the patent would be rendered void. This could be considered a credible threat given the mistrust toward patentees in the eighteenth century (Macleod, 1988). In addition, the terms of supply and price received by Wilson were to be prescribed through a legal contract secured by debt, which had to be entered before the Law Officers within one month, though the proviso did not indicate who would settle this; in later patent titles containing the Navy proviso the Master-General of the Board (or some other adjudicator) would be volunteered.

Though Wilson's patent is the first to contain the Navy proviso in Woodcroft's records, it is not the first to be considered for it. Surviving records of patent applications, which passed through the chambers of the Law Officers provide another means of identifying patents receiving the Navy proviso. In the typical patenting procedure prior to Amendment Act of 1852, an applicant would bring their petition to the Secretary of State who would then write to the Law Officers of the Crown with a draft of the Monarch's Warrant for the Officer to examine. Notably, this was an early yet expensive part of the patenting process, costing approximately £20–£30 (almost a third of the total cost of an English patent) by the 1840s (Carpmael, 1842). The surviving patent application records are held at the National Archives in a collection entitled, "Home Office: Invention Warrant Books" (HO 89), which cover the period 1783–1834. From these records (which we term "warrants"), we identify an earlier patent targeted with the Navy proviso, dated April 5, 1794 and granted June 9, 1794, belonging to William Fitzgerald for, "[...] an apparatus by which ships & vessels may be discharged of water by means of their own motion [...]" (patent 1994, p. 367). The Home Secretary at the time, Henry Dundas wrote privately to the Law Officers, directing them to

³ See Appendix A1 for a discussion of known instances of past State procurement efforts.

⁴ All patent numbers reported in this paper are found in Woodcroft (1854a).

draft the Monarch's Warrant including a separate instruction to draft what would become the Navy proviso:

"[...] and you are to insert in the said Bill a clause containing some provision requiring the said William Fitzgerald [...] 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 [...] a liberal compensation for such benefit." (HO 89/3: p. 191).

At the same time, Sir Evan Nepean—Dundas' Secretary—wrote to the Board concerning an even earlier patent petition submitted by Richard Webb (patent 2042, p. 376).⁵ Whilst the original letter is not found in either the Home Office records or the Board's records, we know from examination of the minutes of the Board the letter was received in late April 1794 (WO 47/2557). We trace the response from the Board to Nepean seven months later, dated November 24, 1794:

"[the Master-General of the Board] 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: p. 258).

The response ends with a proposed proviso to be inserted into Webb's patent like the proviso found in Fitzgerald's patent. Extensive searching of the Board's archival records yields no further communication between Nepean and the Board on this issue. Given the timeline presented and the content of the Board's response, Nepean likely wrote to the Board at the behest of Dundas, who at the same time had directed the Law Officers to formulate the Navy proviso. Moreover, given the similarity of wordings in the provisos produced by the Board and Law Officer independently, Dundas likely pitched the same draft proviso to both parties.⁶ It is also likely Dundas suggested the Board should settle the terms of supply. Instead, the Board states in their response that the Master General or other principal officers would be responsible.

3. Settling the terms of supply

3.1 Evidence from patentees

Exactly how the terms of supply were settled in practice is not clear from the available records. We have searched through the Board's minutes but are unable to identify any records concerning the settling of either the prices or quantities of supply of Navy proviso patents. We have also systematically examined the National Archives Board of Ordnance collection

⁵ Webb's patent warrant is dated to January 1795, and the patent itself was granted in February 1795. It is likely Webb's original warrant was dated later than Fitzgerald's while the Home Secretary awaited a reply from the Board. We have checked the original Law Officer warrant books, and the Board's minutes that confirm the timeline of patent petitions.

⁶ Dundas was also appointed to the newly formed position of Secretary of State for War, which commenced in July 1794, thus providing a strong incentive to ensure he could procure useful inventions for the war effort.

to identify any records concerning the settlement of prices.⁷ The most likely source of this information is the Board's treasury accounts. Searching for such information is akin to looking for a needle in a haystack; we do not know the year the patentee finally supplied their output, as it is well known it could take inventors many years to get their inventions into a workable condition (Bottomley, 2014b; Dutton, 1984; Macleod, 1988). In addition, the treasury records do not provide enough detail for us to accurately identify whether a contractor supplied their invention or invention's output or something else entirely.

Instead, we draw inferences from two cases that we do know of, concerning the settlement of patentee's terms of supply. The first case comes from the Treasury Solicitor collection at the National Archives. Record "TS 21/25" concerns the entry of a recognizance by Christopher Wilson in 1795; the same Wilson discussed earlier.⁸ The patent record stated Wilson's terms of supply were to be, "[...] prescribed in any by such bond, obligation, or recognizance [...]" (patent 2068, p. 381). Wilson entered a recognizance before the Solicitor-General, Sir John Mitford, on November 12, 1795—less than one month after his patent was sealed and secured by a bond of £1,000.⁹

The recognizance defined Wilson's obligations to the State, with the Commissioners listed as the adjudicator. Namely, he was to supply articles, "[...] of such dimensions and proportions as shall be required and shall be fit and proper for the Ships and Vessels in about or connected with [his Majesty's Navy]" (TS 21/25). In exchange, he would receive, "prices not exceeding such prices as [he] shall ordinarily receive for the same articles or works from other persons," or "prices not exceeding his rate of profit, which [he] shall ordinarily receive for articles or works of the same sort from other persons" (ibid). The latter instance applied when the Navy's requirements were substantially different to what Wilson would normally produce and sell. Nominally, Wilson was to be paid his market rate.

Notably, the recognizance explicitly accounts for breach of contract. Aside from losing his patent right and the £1,000 bond, two scenarios are dealt with: one where Wilson provides advance notice to the Commissioners of his failure to meet his obligations, and another where he does not. If the former case arose, Wilson was permitted to provide 21 days notice, upon which he must:

"[...] instruct some person or persons, to be nominated by the said Commissioners to make the same articles or works under the order and directions of the said Commissioners, upon condition that [Wilson] be allowed by his said Majesty's Commissioners a profit thereon not exceeding twenty five pounds per cent on the expenditure in workmanship and materials of such articles or works [...]" (ibid).

In essence, the Commissioners could grant a compulsory license for the working of Wilson's patent to a contractor of their choosing, with Wilson receiving remuneration akin to a licensing fee. However, if Wilson failed to provide notice, then the Commissioners were entitled to, "authorize any person or persons to make all such articles or works for the use of His Majesty's Navy without any allowance to the said Christopher Wilson" (ibid). The

⁷ 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.

⁸ Unfortunately, the Treasury Solicitor records do not seem to contain recognizances for any other Navy proviso patents. Wilson's recognizance may be unique or may be the only surviving and catalogued record of its kind.

⁹ It is unclear whether Wilson had to provide the £1,000 upon sealing his recognizance, or whether it would be paid only in the event of his default. The latter case is more probably the more likely one, as £1,000 would have been an extreme sum of money to provide in addition to the patent fees; it would arguably have served to dissuade inventors from sealing their patents.

recognizance therefore specifies Wilson’s patent had to be worked, and the patented articles had to be supplied, regardless of whether Wilson worked and supplied them himself—either way the State procured a supply of the invention.

Wilson’s recognizance highlights several things. First, it was written to ensure the invention would be worked and supplied to the Navy. Second, it details penalties against Wilson for breach of contract, including a compulsory licensing of his invention to a third party. Lastly, the financial cost for Wilson’s breach of contract was a £1,000 bond, which would have been approximately ten times the cost of his original patent. This sum was significant, which was likely intended to incentivize Wilson to begin production of his patented articles immediately. Collectively, the recognizance was intended to ensure Wilson would not renege on his responsibilities for supplying the State, which may be indicative of how much the State wanted access to his invention. Most notably though, more emphasis was placed on the threat of punishment.

To complement the findings from Wilson’s recognizance, we know of a second instance of a proposed price settlement being offered to a patentee, this time within their proviso itself. In August 1795, Johnathan Grove, a manufacturer from Warwickshire, petitioned to patent “a gun lock or lock for guns or firearms of a new construction” (patent 2072, p. 382). Grove’s was the fifth warrant to receive the Navy proviso. However, it is also the first and only warrant to include notes written by the Duke of Portland, then Home Secretary, to the Law Officers, outlining detailed proposals of the terms of supply:

“[...] One shilling premium upon each lock over and above the real value of the lock which may be agreed upon until the supply of our service shall amount to thirty thousand locks and that when the supply of thirty thousand locks of the petitioner Johnathan Grove’s invention are delivered to our service our board of ordnance may be at liberty to employ the petitioner or such other manufacturers as they may think proper in furnishing such further quantities of the said locks as shall be from time to time required for our services without paying any premium [...]” (HO 89/3: p. 315).

Grove’s warrant, then, suggests the State was willing to offer above-market price premiums for a fixed initial supply. The State also signaled their openness to continue transacting with Grove at the market price once this initial order had been met. In essence, this offered an attractive, albeit obligatory, initial commercial proposition to entice suppliers of useful inventions, and serving to out-compete in the short-term other buyers of ordnance-related inventions. The proviso also indicates the Home Secretary held discretionary power to propose terms of supply though given the content of the Board’s earlier letter to Dundas in November 1794, it is unlikely Portland would have offered any terms without the Board’s permission or involvement.

The combined evidence concerning the settlement of terms of supply for patentees highlights the various approaches taken by different adjudicators, with both instances demonstrating how each sought to incentivize the patentee to provide the State with preferential access to supplies. The Commissioners incentivized Wilson through threat of punishment, whilst the Board highlighted the price premium for Grove; the State used both the carrot and the stick to obtain what it required.

3.2 Evidence from the Board of Ordnance

Though systematic evidence concerning the settlement of the Navy proviso in practice is unavailable, we turn to new archival evidence concerning interactions between the Board

Table 1. *Sample of inventions submitted directly to the Board of Ordnance.*

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

Source: WO 44/498. Notes: "Accepted" denotes any positive support for the use of the invention in the military, or its recommendation for adoption.

and private inventors. Namely, we draw on a series of correspondence between the Board of the Admiralty, the Board, and a number of inventors, concerning a sample of inventions proactively submitted by inventors to the State, for the purposing of obtaining a financial reward, rather than protection of intellectual property through the patent system. The collection in question (WO 44/498) covers the cases of 19 military inventions submitted to the Board during 1812–1821, which coincides with the continued use of the Navy proviso. Table 1 shows the inventions, their inventors, whether the Board chose to adopt the invention into service, and whether the invention has a corresponding patent.

The communication flowed as follows: an inventor writes to the Board or the Admiralty, with an invention they thought useful for service; the Admiralty writes to the Board directing them to inquire into the utility of the invention; the Board may request that the invention be tried or experimented upon at Woolwich or for a standing committee of field officers; a report of their findings and recommendations is submitted to the Board; the Board reviews this and may then consult the Comptroller of Woolwich Royal Laboratory for their expert opinion; and the Board communicates their decision to the Admiralty and the inventor.

The cases highlight the Board's ability to identify and reject poor-quality inventions through experimentation, and how they dealt with inventions, which were potentially useful but required further development. One case concerns Thomas Manton's invention for firing a 32-pounder gun.¹⁰ At the trial of the 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.)¹¹

A second case relates to Lieutenant Jackson's swivel gun. On submission, the gun was sent to Woolwich Royal Laboratory for Sir William Congreve (then Comptroller) to experiment with. In comparing 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).

A third case concerns Mr Fane's fire balls.¹² The invention worked by igniting chain shot coated in a chemical paste—the shot was ignited by the powder spark inside the cannon as it was fired. Fane's invention was the paste itself, which he wished to supply to the Board rather than selling the invention directly ("Mr Fane's Fire Balls," WO 44/498).¹³ To determine the invention's utility, the Board ordered a trial of Fane's fireballs in front of field officers. The officers note, unanimously, its highly destructive nature, but also point out the shot was just as damaging to the firing ship as it was to the enemy. The Board concluded that while the invention was too destructive, they were willing to purchase the knowledge of how to produce the paste to refine it further themselves, demonstrating their discretion. Fane ultimately refused the offer and attempted instead to sell his invention to the French.¹⁴

The three cases highlight the rigor applied by the Board in determining the potential value of inventions submitted to them. The experiments conducted in each case were considerable, assessing accuracy, trajectory, reliability, and suitability across a range of calibres, distances, and elevations. Whilst time- and labor intensive, it was clearly effective and successfully filtered out low-quality inventions. In effect, the experimentation phase here acted in a similar manner to more formal patent examination processes.

Fane's case also highlights another important factor: remuneration. At several points in his correspondence with the Board, Fane requests varying sums of money, which he claims

¹⁰ Thomas Manton is likely a member of the Manton family of gunmakers, of which Joseph Manton is a well-known figure. Thomas' appearance in the Board's records might indicate his desire to obtain contracts similar to Joseph.

¹¹ Colonel Lloyd later remarked Manton, "[...] seemed perfectly satisfied at the utility of his invention."

¹² "Mr Fane" is a pseudonym for a William Parr, who held a patent in 1810 for "an improved gunpowder" (patent 3328), which received the Navy proviso. "Fane" then had prior experience in dealing with the Board via the Navy proviso and likely became acquainted with the Board because of it.

¹³ Fane's correspondence suggests at one stage he worked as an artificer for the Board and likely experimented with cannon shot, though the Board gives no corroboration of this claim.

¹⁴ Following the Board's declination 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 ultimately abandoned this plan, out of a sense of duty to England, though it is likely the French would also find the invention too destructive to adopt.

he is owed as expenses for his efforts. He initially requests £280, arguing he was in service to the Board when he invented his paste.¹⁵ However, Fane later demands a lifetime pension of £1,200 per annum, a considerable sum and the exact same remuneration granted to Sirs William Congreve and Henry Shrapnel, a comparison explicitly raised by a Colonel Wood through whom Fane communicated his desired monies. Congreve's pension was a reward for his famous "Congreve rocket" famously used against the Danish fleet during the Second Battle of Copenhagen in 1807. Shrapnel received his pension for his spherical case shot, from which the term "shrapnel" derives (House of Commons, 1815, IX: p. 340).¹⁶ Fane's request, then, may have been based on his knowledge of the rewards granted for highly destructive inventions; that Fane's fireballs were considered so destructive is possibly why he felt deserving of the same exact reward as Congreve and Shrapnel.

The collection of correspondence also includes letters regarding two inventions for which a corresponding patent exists. One of these, John Gover and James Hardum's "Improved Cannon and Carriages for Sea Service," is accompanied by a detailed narrative of the development of the invention as well as the troubles experienced by the inventors—information not included in patent records. In their account, written by Hardum, emphasis is placed on the utility of their invention by citing the several instances in which it was tried in front of field officers, highlighting specifically its potential use onboard the vessels of famous officers from the Napoleonic era, such as Alan Gardner and Sir Sidney Smith.

The invention was patented by Gover in 1796 with Hardum as a silent partner. The warrant contains instruction by the Home Secretary to the Law Officer to insert the Navy proviso, although Woodcroft's patent records do not confirm whether it was applied (patent 2151). Ultimately, Gover would lose his patent right as he fell victim to a fraudster calling himself "Colonel Sinclair," who promised to satisfy Gover's considerable debts in exchange for a share in the patent. Sinclair, described as being associated with a very dangerous gang in London, proceeded to take out £3,000—£4,000 in debts in Gover's name, causing Gover's creditors to take ownership of the patent as collateral ("Improved Cannon & Carriages for Sea Service," WO 44/498). Of course, such hardship may not have befallen Gover had the Navy proviso been included in the patent grant, possibly providing greater financial security.

In any case, the sources suggest Gover and Hardum were able to demonstrate the effectiveness of their invention to field officers before obtaining their patent. This demonstration may have taken place during the petition procedure, in which case the Board was arguably applying their standard approach to trialing the utility of an invention before deciding to obtain a supply of it. This case, then, may be indicative of the approach the Board took once listed as an adjudicator in a patent right: to conduct a trial immediately before deciding whether to contract a supply of the invention.

The evidence above demonstrates the Board willingly and regularly engaged in some form of examination of submitted inventions and was also willing to remunerate an inventor based on their invention's value. How this may have applied to cases involving the Navy proviso is less clear because it was inserted before the patent was granted. Petitioners were then potentially left with weakened bargaining power when settling terms of supply; failure to supply the service would void the patent. As shown in Gover and Hardum's case, however, the Board may have taken the opportunity to hold a trial during the petition period. In those instances where a patent article was not available to demonstrate, it is unclear whether the

¹⁵ The Board seems to have paid him at least part of this requested sum, though it is not clear how much.

¹⁶ Shrapnel's invention was the precursor to the modern-day fragmentation grenade.

listed adjudicators would willingly agree to contract for supplies: the patented article may have been of poor quality, which would leave the adjudicator contractually obligated to obtain a certain supply of articles.¹⁷ Risk, then, existed on both sides.¹⁸

3.3 Evidence from later select committees

Further evidence concerning the operation of the Navy proviso appears in various secondary accounts from debates held later in the nineteenth century. These relate to how prices were settled, and whether the proviso was abused by the State. Two main perspectives emerge from the sources. Firstly, Crown Officials acted with monopsonistic power as they could effectively settle prices unilaterally. Two Parliamentary Select Committees formed to inquire into the workings of patent law in the UK in 1851 and 1864 provide evidence to support this. Testimony given at the first by Matthew Hill, a lawyer, claims the State 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 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: p. 353).

A similar viewpoint is found in evidence presented at the second Select Committee in 1864 by William Carpmael, a renowned patent agent and later President of the Chartered Institute of Patent Agents. Carpmael argues the Navy proviso was inserted into patents with military relevance, and the State reserved the right to take articles produced by patentees at prices set by Crown Officials. He then suggests this procedure had resulted in no dissatisfaction among patentees, and patentees were adequately remunerated for their articles (House of Commons, 1864, XXXV: p. 137).

The second perspective emerging from the sources does not dispute prices were settled unilaterally by the State, but instead suggests this power was subject to abuse by Crown Officials. The evidence supporting this comes from two additional Select Committees, one convened to inquire into the workings of patent law in 1829, and another in 1849, which inquired into the function of various Crown offices. In 1829 John Farey a well-known mechanical engineer and patent agent provided evidence to the Committee:

¹⁷ An oft-repeated criticism raised by contemporaries on the topic of the early English patent system was its lack of provisional protection. Indeed, witnesses before the several Select Committees convened to investigate the workings of the patent system (1829, 1849, and 1851) regularly suggested inventors often deferred their experimentation phase until the patent was sealed because of the risk (Bottomley, 2014b; Macleod, 1988). This would imply inventors procuring patents that received the proviso would not have had a working model or article of their invention for demonstration. Ultimately, it is unknowable to what extent this took place, but it does suggest pre-grant trials of patented inventions would not have taken place regularly.

¹⁸ It is possible the Board’s observation that a Navy proviso invention was being patented was taken as a signal of that patent’s quality. At a minimum, petitioning for a patent right implies the invention was perceived to be worth at least the cost of the patent right to the petitioner.

"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: p. 147-148).

Farey confirms the State's alleged monopsonistic power, as he argues patentees whose patents included the Navy proviso were compelled to supply, though he does not indicate how Crown Officials settled that matter. Nevertheless, his evidence indicates during "the war," which was likely the French Wars, Crown Officials attempted to circumvent their own terms.¹⁹

Further evidence to suggest Crown abuse comes from Thomas Webster, a lawyer and author on patent laws, who provided testimony on the necessity of various provisos inserted into patents during the petition procedure before the 1849 Select Committee. Webster is questioned on the necessity for a patent to receive so many provisos, and whether any of them are objectionable. Webster himself volunteers the Navy proviso and states: "[...] [it] 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: p. 45). He also recalls an "embarrassing" abuse of the proviso in a Court case concerning the Admiralty's use of a patented anchor without paying the patentee for it, in which the Court would not compel the Admiralty to pay.

Aside from alleged abuse of power by Crown Officials, witness testimony across the various Select Committees claims the discretionary power held by Crown Officials to insert the Navy proviso was, perhaps unsurprisingly, subject to human error. The clearest evidence of such administrative errors comes from the 1849 Select Committee: H. W. Sanders, a record keeper in the Signet Office, noted "[...] 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: p. 9). Another witness, William Goodwin, a junior clerk in the Privy Seal Office, attributes the error of omission to the Law Officer's clerks, and states the Lord Privy Seal had the power to detain a petition so as to insert the appropriate provisos; he alleges the Earl of Rosslyn once did this in consequence of the Navy proviso being omitted, the result of which was to cause that proviso to be applied universally (House of Commons, 1849, XXII: p. 13). William Carpmael also provides testimony affirming the responsibility for inserting all relevant clauses and provisos belonged to the offices of the Law Officers (House of Commons, 1849, XXII: p. 27).

Given the evidence available, then, it is clear the Navy proviso was frequently used, subject to some degree of quality control by the various clerks employed by the State and did not appear to be subject to systematic abuse, though some abuse did occur. The State treated the use of the proviso with a considerable degree of seriousness and were prepared to offer market prices or above-market premiums, rather than abuse their stronger bargaining power by offering below-market prices. We can therefore use the available patent data to ascertain what technologies the State was interested in.

¹⁹ Given the evidence presented in Section 3.1, the Government may not have been circumventing their terms, but in fact might have been acting in response to a patentee breach of contract, by licensing the patent right to a third party to work.

4. Procuring inventions using the Navy proviso

4.1 Identifying Navy proviso patents

We identify Navy proviso patents as follows. First, each of the patent titles listed in [Woodcroft \(1854a\)](#) were read for the Navy proviso text noted in [Section 2](#). Second, we examined the surviving hand-written patent application records retained by the Law Officers (HO 89/1–11) for the period 1783–1831.²⁰ The warrant records cover most patents granted in England and contain the same qualitative information as [Woodcroft \(1854a\)](#), allowing us to match each warrant to the corresponding published patent on the basis of title, occupation and listed residence of the patentee. We were able to do this for 4,565 (94%) of the 4,849 patents granted 1783–1831.

We identified 196 patents receiving the Navy proviso in the Woodcroft records: we refer to these as “Navy Clause Patents.” We also identified 321 warrants containing the proviso, referring to these as “Navy Warrant Patents.” Accounting for overlap and duplication across these sources, we identified a total of 421 patents that were considered for the proviso, which we refer to as “Navy Patents”; this is approximately 10 percent of all patents granted across the period.

[Figure 1](#) shows the number of total patents granted 1794–1831, and the share of our measures of Navy proviso patents. The number of patents granted annually increased over the period, with a temporary peak in 1825. The usage of the Navy proviso also became more concentrated across the French Wars, peaking in 1805, at which time more than a quarter of all patents granted included the proviso. The trend then declines to a near constant share of 15 percent, before falling considerably at the conclusion of the Napoleonic Wars. Usage of the proviso continues into the 1820s, before declining to zero by 1825; the Earl of Rosslyn’s universal insertion of the proviso reportedly occurred around this time. Most notably, the “Navy Warrants” series shows the most consistent use of the proviso, with petitions reporting the proviso via the patent warrant continuously up to 1824.

The warrant records also include the name of the Secretary of State who administered the proviso, which is shown in [Table 2](#). The “Warrants by Tenure” estimate indicates how prolific each Secretary of State was with administering the Navy proviso, with the majority being administered by Home Secretaries. Initially, usage of the Navy proviso was limited: Dundas administered one proviso before taking on the role of Secretary of State for War, while William Cavendish-Bentinck (as the Duke of Portland), who took over as Home Secretary, inserted the Navy proviso into six petitions per year. Robert Jenkinson (as Lord Hawkesbury) during his first tenure, and George Spencer (as Earl Spencer) were the most prolific, inserting an average of 26 and 21 provisos per year, respectively. This may well be a result of the intensity of the Napoleonic conflict at this time.

Approximately, half the patent records receiving a Navy proviso make explicit reference to the adjudicator(s) proposed to settle the terms of supply, as reported in [Table 3](#). The process of adjudication evolved to encompass not only the Board, but a range of other institutions and individuals within the military and related services. Principal adjudicators were either the “Officers of the Ordnance” or “Commissioners of the Navy.” “The Trinity” refers to *Elder Brethren of the Corporation of Trinity House*, an institution dating back to the 16th century with responsibility for erecting and maintaining navigational along the coast such as beacons, and

²⁰ Our source covers up to 1834, though we restrict our observation period to 1831 as this covers the period where insertion of the proviso transitions from discrete to universal application.

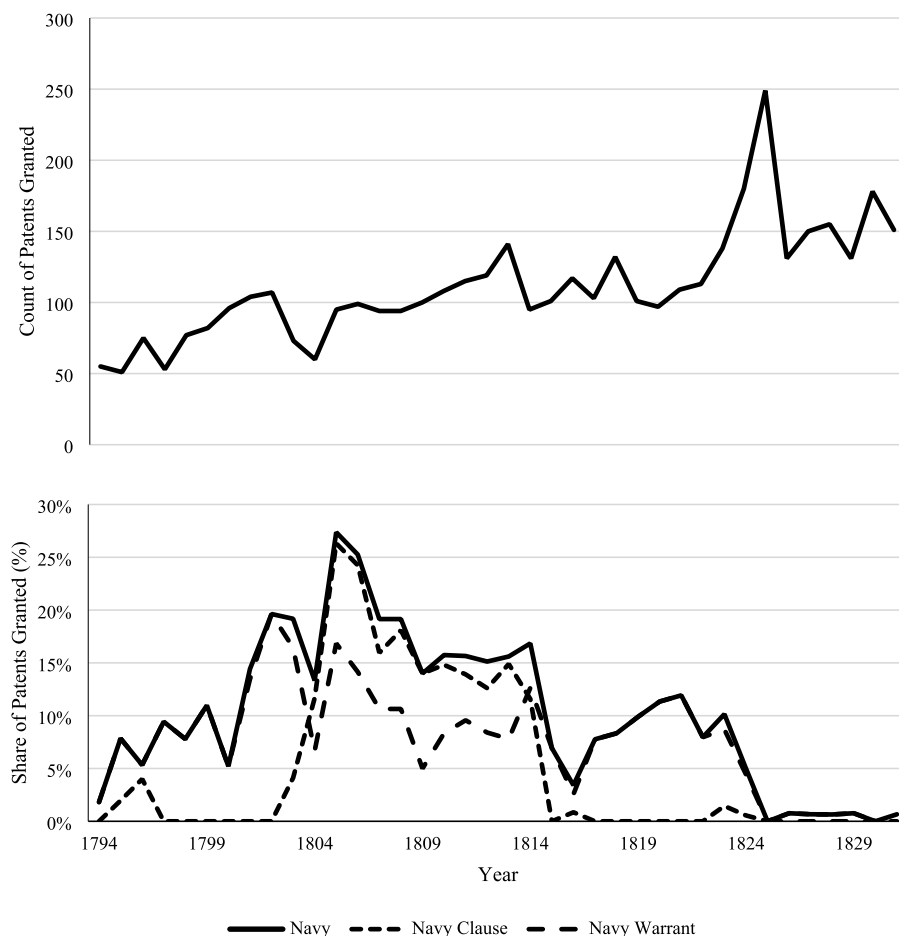


Figure 1. Time-series showing the share of “Navy,” “Navy Warrants” and “Navy Clause” and Total patents granted, 1794–1831. *Source:* Authors’ calculations using data from [Woodcroft \(1854a\)](#), HO 89.

later lighthouses ([Arrow, 1868](#)). The Trinity were likely experienced mariners with either mercantile or naval service, though they were regularly listed as a second adjudicator, suggesting they acted in conjunction with other branches rather than in their own capacity, perhaps as an oversight or advisory board. There were also few patents granted to other Commissioners who were responsible for supplying provisions (such as the Commissioners for Victualling) or collecting excise duty (such as the Commissioners of the Excise). In any case, most provisos list at least one adjudicator who held responsibility for supplying the service.

4.2 Examining Navy proviso patents

This section examines the kinds of inventions the State were actively procuring through their use of the Navy proviso. First, we examine whether the State was selecting inventions, which were high quality and therefore more economically or socially valuable. Second,

Table 2. *Secretary of State by usage of the Navy proviso, 1794–1831.*

Name	Position	Tenure (dates)	Tenure (years)	Warrants	Warrants per Year
Henry Dundas	Home	June 1791–July 1794	3	1	0.33
William Cavendish-Bentinck	Home	July 1794–July 1801	7	43	6.14
Thomas Pelham	Home	July 1801–August 1803	2	43	21.50
Charles Phillip Yorke	Home	August 1803–May 1804	1	4	4.00
Robert Jenkinson	Home	May 1804–February 1806	2	53	26.50
George Spencer	Home	February 1806–March 1807	1	29	29.00
Robert Jenkinson	Home	March 1807–November 1809	2	13	6.50
Henry Bathurst	Foreign	October 1809–December 1809	1	6	6.00
Richard Ryder	Home	November 1809–June 1812	3	50	16.67
Henry Addington	Home	June 1812–January 1822	10	122	12.20
Robert Peel	Home	January 1822–April 1827	5	40	8.00

Source: HO 89. Notes: “Tenure (years)” rounded up to nearest integer. Not all patents were matched with a warrant record, so the table includes only 404 of the 421 patents granted during our period. “Warrants” counts the number of patents where Navy proviso was inserted. “Position” denotes Home or Foreign Secretary.

Table 3. *List of Adjudicators on Navy proviso patents, 1794–1814.*

Adjudicator	Sole adjudicator	Patents total
Officers of the Ordnance	54	94
Board of Ordnance	5	5
Commissioners of the Navy	77	123
Commissioners of the Excise	2	2
The Trinity	0	13
Secretary of War	1	1
Commissioners for Victualling	2	2
Commissioners for executing the Office of the High Admiral	1	1
Commander-in-Chief	1	4
Total	143	245

Source: HO 89. Note: The last patent that includes a listed adjudicator is from July 1814. “Sole Adjudicator” counts those patents where only one adjudicator is listed. “Patents Total” counts all patents where an adjudicator is listed either as sole or joint adjudicator. Adjudicators are identified via warrant books and Woodcroft patent lists.

we examine the specific kinds of inventions the State regularly targeted. We restrict our period of observation to 1794–1824, as this covers the years when the proviso was regularly administered on a discretionary rather than universal basis.

4.2.1 Were patents chosen because of their quality? We employ OLS regression techniques to estimate the relationship outlined in equation 1. Here, the dependent variable is the

Bibliographic Composite Index (BCI), developed by Nuvolari, Tartari, and Tranchero (2021), which scores the quality of a patent along a continuous scale; a larger value indicating a higher quality invention. The measures comprising the BCI are: whether the patent's specification had been published in the contemporary scientific and trade literature; whether the patent embodied an influential and valuable technology (the patent's eminence); and whether the patentee was considered an influential innovator by modern scholars (the inventor's eminence).²¹ These measures of patent quality are also correlated with a patent's perceived economic or social value (Billington, 2021). We therefore interpret the quality measures as correlating with the patent's economic or social value.

$$BCI_{it} = \alpha + \beta_1 \text{Navy}_{it} + \beta_k Z_{ikt} + \varepsilon_{it} \quad (1)$$

The BCI score for a given patent i , patented in year t , is estimated as a function of whether that patent received the Navy proviso, measured by a dummy variable where a value of 1 indicates a patent had the proviso listed in either their warrant or their Woodcroft record. We control for a host of k control variables, including time and technology fixed effects. We report similar explanatory variables as Nuvolari and Tartari (2011), Nuvolari et al. (2021) and Billington (2021). "Metropolitan" is a dummy indicating that the patentee lived in a town with a population of 50,000 or greater; "Outsider" is a dummy whereby a score of 1 indicates the patentee's occupation clearly does not match the patent's subject matter; "Number of Inventors" reports the total number of persons named on each patent; "Engineer" is a dummy variable capturing patentee's reporting engineering occupations; the "Skilled" variables are dummies indicating occupations as aggregated into HISCLASS groupings; "Gentleman" indicates whether patentee's occupation was reported as either "gentleman" or "esquire"; "Previous Patent" is a dummy variable indicating whether a patentee held at least one prior patent grant; "Foreign" is a dummy variable indicating whether a patent was communicated from abroad; "Irish," and "Scottish" are dummy variables indicating the patentee's country of residence; and "Ireland" and "Scotland" are dummy variables indicating whether an English patent was extended to Ireland or Scotland, respectively.

Table 4 reports our results. The estimates show a negative but not statistically significant effect of a patent receiving the Navy proviso on its estimated quality. In other words, patents receiving the Navy proviso were neither more economically valuable than those which did not, nor did they appear to become more valuable after receiving the proviso. The estimates indicate the British State was not selecting patents based purely on their wider economic value.

We re-run our regression equation focusing on only one subset BCI measure: the number of references it received in the contemporary scientific and trade literature. This is estimated using the Woodcroft Reference Index (WRI), proposed as a measure of a patent's quality by Nuvolari and Tartari (2011), provides an indication of a patent's relative "visibility" amongst contemporaries. The argument being that more economically or socially important inventions would be more widely discussed, or, at the very least, the greater number of references indicating a more widely disseminated technology. To account for the artificial increase in the total number of references over time, we adopt the weighting scheme in

²¹ It is worth highlighting that each of the three measures comprising the BCI are skewed in some way. Most patents and inventors received eminence scores of zero, whilst the distribution of publications is heavily right-skewed. Similarly, the count of contemporary publications is biased upwards over time as the number of publishing bodies increases (see Nuvolari and Tartari, 2011).

Table 4. OLS estimates showing the effect of receiving a Navy proviso on a patent's estimated BCI score, 1794–1824.

	(1)	(2)	(3)	(4)	(5)
Navy	−0.018 (0.017)	−0.018 (0.017)	−0.018 (0.017)	−0.017 (0.017)	−0.019 (0.017)
Metropolitan	0.007 (0.010)	0.004 (0.010)	0.004 (0.010)	0.006 (0.010)	0.005 (0.010)
Engineer	0.067*** (0.020)	0.068*** (0.021)	0.065*** (0.020)	—	—
High skilled	—	—	—	(ref) (ref)	(ref) (ref)
Medium skilled	—	—	—	−0.050*** (0.011)	−0.047*** (0.011)
Low skilled	—	—	—	−0.015 (0.025)	−0.016 (0.025)
Unskilled	—	—	—	−0.056** (0.026)	−0.043 (0.027)
Gentleman	—	—	−0.013 (0.012)	−0.050*** (0.015)	−0.049*** (0.015)
Number of inventors	0.010 (0.019)	0.007 (0.019)	0.007 (0.019)	0.015 (0.020)	0.014 (0.019)
Previous patent	0.054*** (0.011)	0.054*** (0.010)	0.054*** (0.010)	0.058*** (0.010)	0.059*** (0.010)
Irish	—	−0.040** (0.019)	−0.039** (0.019)	−0.044** (0.019)	−0.045** (0.018)
Scottish	—	0.068 (0.049)	0.068 (0.049)	0.064 (0.049)	0.066 (0.050)
Foreign	0.031 (0.030)	0.028 (0.028)	0.028 (0.028)	0.025 (0.028)	0.025 (0.027)
Outsider	−0.010 (0.011)	−0.009 (0.011)	−0.012 (0.011)	−0.014 (0.012)	−0.015 (0.012)
Ireland	—	0.015 (0.030)	0.015 (0.030)	0.011 (0.029)	0.011 (0.029)
Scotland	—	0.050** (0.021)	0.051** (0.021)	0.051** (0.021)	0.053** (0.020)
Constant	0.093** (0.037)	0.089** (0.037)	0.092** (0.037)	0.123*** (0.038)	0.119*** (0.038)
Observations	3,082	3,082	3,082	3,082	3,082
Time	5-year	5-year	5-year	5-year	1-year
Technology	Y	Y	Y	Y	Y
R ²	0.063	0.074	0.074	0.074	0.084
Adjusted R ²	0.053	0.063	0.063	0.062	0.065
Residual Std. error	0.256	0.254	0.254	0.254	0.254
F statistic	6.235***	6.582***	6.437***	6.097***	4.330***

Notes: The table reports OLS estimates where the dependent variable is a patent's BCI score. We control for technology using the Nuvolari and Tartari (2011) classification scheme. We control for time-invariant characteristics in two ways: using 5-year dummies and using yearly dummies. Robust standard errors reported in brackets. * $P < 0.1$, ** $P < 0.05$, *** $P < 0.01$

Nuvolari and Tartari (2011): WRI scores are weighted relative to the average number of references received by patents granted in a similar period.

Table 5 reports our results that show a negative and statistically significant effect of the Navy proviso on a patent's visibility. Patents receiving the proviso were less likely to be referenced in the contemporary literature. We interpret the result as indicating that inventions which the State were interested in procuring did not interest editors or readers of contemporary journals, which may indicate a lower perceived economic or social value. These inventions may have had limited economic utility, or they may have been more experimental or speculative or less well developed, which may well have influenced their low likelihood of being published.

Consequently, Navy proviso patents were not of a significantly different economic value to non-Navy proviso patents, but were, to some extent, referenced less frequently by contemporaries. The evidence does not suggest the State was choosing patents of a high economic value. Rather, the State appeared to select technologies receiving little attention in the contemporary scientific literature, potentially aiding their development and dissemination.

4.2.2 Were patents chosen because of their function? The information available to Crown Officials in their administration of the Navy proviso was limited: the proposed title of the invention, and the patentee's name, occupation, and place of residence. Therefore, the choice to administer the proviso is likely a result of the functionality of the proposed invention, which, in turn, reveals what the State were using the proviso to procure.

To account for the functional nature of patented inventions, we adopt the Woodcroft subject-matter index (WSI): a contemporary classification schema applied to all granted patents up to 1852, originally published in 1854 in two volumes. Billington and Hanna (2021) describe such schemas as "functional-oriented"; patents are grouped based on the process or function they perform, rather than the industries the function was applicable to. The WSI classifies patents based solely on their patent titles and comprises 146 classes or 546 including subclasses.

Sullivan (1990) notes the WSI often assigns more than one class per patent. Figure 2 reports the average number of classes assigned per patent from 1760–1824. Prior to the introduction of the Navy proviso in 1794, the average number of WSI classes per patent was rising—albeit with considerable volatility—from a low of 1.35 in 1760 to a high of 3.15 in 1789. After 1794, there is a sharp decline in the average number of classes to a near constant trend rate of approximately 1.6–1.7 with much less volatility. Whether the outbreak of the French Wars or the introduction of the proviso itself contributed to this trend is not clear, though it is certainly noteworthy in its timing.

Sullivan (1990) argues Woodcroft's assignment of patents to multiple classes reflected the number of distinct inventions listed in any given patent. Alternatively, the assignment of multiple classes per patent might also reflect the range of functions a patented technology was alleged to perform. In either case, the number of classes assigned per patent provides an indication of the "broadness" of a patent's functionality. For the proceeding discussion, we draw a distinction between a "patent," which contains one or more classified functions, and a "function," which refers to an individual WSI class assigned to a patent.

Table 6 reports the breakdown of the WSI schema, showing the total number of functions in patents alongside the share of all functions receiving a Navy proviso between 1794 and 1824. For brevity, we report only those functions where the "Total Functions" column is greater than 5, and only those "Share of Navy Functions" classes with scores less than or

Table 5. OLS estimates showing the effect of receiving a Navy proviso on a patent's WRI score, 1794–1824.

	(1)	(2)	(3)	(4)	(5)
Navy	−0.067** (0.027)	−0.067*** (0.027)	−0.068** (0.027)	−0.067** (0.027)	−0.069*** (0.027)
Metropolitan	−0.003 (0.020)	−0.005 (0.020)	−0.005 (0.020)	−0.004 (0.020)	−0.003 (0.019)
Engineer	0.041 (0.031)	0.048 (0.031)	0.051* (0.031)	—	—
High skilled	—	—	—	(ref) (ref)	(ref) (ref)
Medium skilled	—	—	—	−0.060*** (0.022)	−0.060*** (0.022)
Low skilled	—	—	—	−0.033 (0.046)	−0.030 (0.047)
Unskilled	—	—	—	−0.046 (0.118)	−0.029 (0.117)
Gentleman	—	—	0.010 (0.026)	−0.031 (0.030)	−0.027 (0.030)
Number of inventors	0.032 (0.032)	0.026 (0.033)	0.026 (0.033)	0.031 (0.032)	0.033 (0.032)
Previous patent	−0.003 (0.022)	−0.008 (0.022)	−0.009 (0.022)	−0.007 (0.022)	−0.006 (0.022)
Irish	—	−0.048 (0.052)	−0.049 (0.052)	−0.054 (0.052)	−0.053 (0.052)
Scottish	—	0.040 (0.077)	0.040 (0.077)	0.037 (0.077)	0.021 (0.076)
Foreign	−0.0002 (0.041)	−0.016 (0.041)	−0.017 (0.041)	−0.016 (0.041)	−0.021 (0.040)
Outsider	−0.025 (0.024)	−0.021 (0.024)	−0.018 (0.025)	−0.018 (0.025)	−0.020 (0.025)
Ireland	—	0.112* (0.063)	0.112* (0.063)	0.108* (0.063)	0.107* (0.062)
Scotland	—	0.125*** (0.045)	0.124*** (0.045)	0.125*** (0.045)	0.126*** (0.045)
Constant	0.819*** (0.121)	0.815*** (0.122)	0.813*** (0.122)	0.853*** (0.121)	0.848*** (0.120)
Observations	3,082	3,082	3,082	3,082	3,082
Time	5-year	5-year	5-year	5-year	1-year
Technology	NT	NT	NT	NT	NT
R ²	0.026	0.042	0.042	0.043	0.062
Adjusted R ²	0.015	0.030	0.030	0.030	0.042
Residual Std. error	0.551	0.546	0.546	0.546	0.543
F statistic	2.435***	3.596***	3.504***	3.416***	3.125***

Notes: The table reports OLS estimates where the dependent variable is a patent's adjusted-WRI score. We control for technology using the [Nuvolari and Tartari \(2011\)](#) classification scheme. We control for time-invariant characteristics in two ways: using five-year dummies and using yearly dummies. Robust standard errors reported in brackets.

* $P < .1$, ** $P < .05$, *** $P < .01$.



Figure 2. Average WSI classes assigned per patent, 1760–1824. *Source:* authors' calculations using data from [Woodcroft \(1854b\)](#).

equal to 0.1, or greater than or equal to 0.5.²² This shows which types of inventions the State were seeking using the Navy proviso, as well as those which appeared not to interest them whatsoever. Expectedly, the State regularly procured technologies concerning “weapons of defense,” which comprises ordnance and gunpowder inventions, as well as “navigation (part 1),” which comprises shipbuilding.

Notably, five other classes report the application of the Navy proviso to at least half of the classified functions. These are “chains and cables,” “mathematical, nautical, and astronomical,” “preserving and curing provisions,” “rope manufacture,” and “telegraphs.” These technologies concern the State’s capacity to construct and repair ships, preserve supplies held onboard ships, and communicate with and aid the navigation of sea-borne vessels. To a lesser degree, the State was also procuring inventions for “hoisting machines” and “bearings, wheels, axles, and driving-bands.” The former would aid both a ship’s construction and repair in dockyards, but also their loading with provisions, while the latter were useful for improving the working of pumps and capstans onboard. “Turning” technologies were also sought, which comprise manufacturing processes used to produce firearms and pumps.

Other technologies, which interested the State include the accuracy of other instruments used onboard ships, such as “barometers and thermometers,” while “ventilating” relates to the health and quality-of-life onboard. In addition, “farm and dairy,” “casks and barrels,” and “farriery” technologies were being procured, the latter of which related to treatment of horses in the cavalry, while the former two comprise technologies to improve the storage and preservation of provisions. Lastly, the State procured technologies for “accidents, prevention of” which related to reducing accidental fire at sea to reduce the risk to ships when in combat.

Notably, the number of patents granted in each of these categories varies considerably. Only “navigation (part 1)” and “weapons of defense” inventions were being regularly patented, both of which had very clear utility to the State. By contrast, the low numbers of patents granted for other regularly sought inventions may either reflect their low propensity to be patented, or that they were developing or experimental technologies. Given many of the inventions highlighted comprise more mechanical or physical inventions, subject to reverse

²² We thank the reviewers for this suggestion. The bounds chosen are arbitrary and serve to highlight the more extreme tails of the distribution. The full table is reported in [Appendix A3](#).

Table 6. *Distribution of the WSI for select functions receiving a Navy proviso, 1794–1824.*

Woodcroft class	Share of navy functions	Total functions
Acids	0.000	7
Adhesive substances	0.000	17
Aerated liquors, mineral waters, &c.	0.000	8
Agricultural produce	0.045	67
Agriculture	0.016	63
Air wind; air and gas engines and windmills	0.026	38
Alarms, snares, and vermin traps	0.071	14
Alkalies	0.000	13
Alkaline lees and wash waters. Compositions for bleaching and washing	0.000	8
Baths and bathing-machines	0.000	7
Bleaching, washing, and scouring	0.000	27
Boilers and pans	0.056	36
Boots, shoes, clogs, pattens	0.000	21
Brewing, distilling, rectifying, and preparatory processes	0.000	88
Bridges, arches, viaducts, and aqueducts	0.000	19
Brushes	0.000	6
Building and relative processes	0.045	88
Building materials, building lime	0.000	50
Buttons, buckles, studs, and other dress-fastenings	0.000	18
Candle manufacture; preparing candle and other wicks	0.053	19
Casting	0.000	18
Chains and chain cables	0.500	10
Chemicals, salts, compositions, gases, and processes	0.000	26
Cloth fulling, dressing, cutting, and finishing	0.010	96
Coffee, cocoa, chocolate, and tea	0.000	8
Cooking; culinary apparatus	0.049	41
Cork cutting and preparing	0.000	6
Cutlery	0.000	25
Cutting, sawing, and shaping	0.075	53
Cylinders, rollers, pistons, and stuffing-boxes	0.000	24
Drawing and photography; exhibiting prints and painted scenery	0.000	8
Dyeing and coloring	0.056	36
Earthenware and porcelain manufacture	0.000	20
Fireplaces, stoves, furnaces, ovens, and kilns	0.088	113
Fuel	0.000	9
Furniture and cabinet-ware	0.063	48
Gas manufacture and consumption	0.000	34
Glass	0.000	15
Grinding, cutting, and crushing	0.000	35
Grinding, setting, polishing	0.000	7
Heat, heating, evaporating, and concentrating	0.056	72
Hinges, joints, and pulleys	0.000	11
Light and lighting; lamps and other luminaries; also matches	0.044	90
Locks and other fastenings	0.080	25
Mangling and ironing	0.000	12
Mathematical, nautical, and astronomical instruments	0.500	32

(Continued)

Table 6. *Continued.*

Woodcroft class	Share of navy functions	Total functions
Measuring and numbering	0.000	13
Medical and surgical treatment; dental and other surgery	0.028	72
Metals and metallica substances	0.044	91
Mining and quarrying	0.063	16
Musical instruments	0.030	101
Nails, bolts, nuts, and screws	0.080	25
Navigation (part 1); shipbuilding, rigging, and working	0.718	163
Oils and oiling	0.000	15
Packing and pressing	0.063	16
Painting, paints, and varnishes	0.063	32
Paper and pasteboard	0.022	45
Paving and roadmaking	0.000	12
Pins and needles	0.000	8
Pipes, tubes, and drain-tiles	0.026	38
Preserving and curing provisions and other substances and liquids	0.556	9
Printing	0.010	98
Railways and railway rolling-stock	0.000	22
Rope manufacture	0.700	40
Salt and saltpetre	0.000	16
Smoke prevention; consumption of fuel	0.056	126
Soap manufacture	0.000	17
Spinning and preparing for spinning	0.041	172
Springs and buffers	0.000	8
Stationary and bookbinding; filing and securing papers	0.048	21
Steam; steam-engines and boilers	0.035	144
Stone working; sculpturing; casting in plaster	0.000	19
Sugar manufacture	0.000	34
Tanning and preserving; treatment of skins; curriery	0.084	83
Taps and valves; regulating the flow of fluids	0.000	19
Tar, pitch, and resin; distilling bituminous and oleaginous substances	0.000	6
Tea and table service	0.083	12
Tobacco and snuff	0.000	9
Type, letters, and devices	0.000	19
Umbrellas, parasols, and walking-sticks	0.000	15
Upholstery	0.000	14
Water-closets, cesspools, and urinals	0.000	8
Weapons of defense; ammunition	0.701	154
Wearing apparel	0.073	55
Weaving, and preparing for weaving	0.046	151
Weighing; specific gravity	0.063	16
Winding, reeling, balling, finishing thread	0.000	7
Wire drawing and working; making sieves	0.000	8
Writing and copying	0.000	10

Notes: The table reports the total number of functions in patents, which were assigned to each of the 146 WSI classes. We report only those classes for which the “Share of Navy Functions” is either less than or equal to 0.1 or greater than or equal to 0.5, and where the “Total Functions” value is greater than 5. “Share of Navy Functions” reports the share of all functions listed in granted patents receiving a Navy proviso. “Total Functions” lists the total number of unique classes assigned to patents, which we consider as the total number of individual functions, which were assigned to WSI classes. *Sources:* authors’ calculations using data from HO 89 and [Woodcroft \(1854b\)](#).

engineering, then, as per Moser (2005), we would expect such technologies to have had an above-average propensity to patent. As such, the fewer numbers of patents granted for these technologies may reflect their more experimental or underdeveloped status.

The WSI also helps our identification of inventions the State did not procure, as identified by classes reporting scores of zero for “Share of Navy Functions.” The State did not intervene for a wide variety of technologies. In particular, it avoided inventions concerning chemical processes, or relating to household consumption, or purely machine processes. The largest single class from this group concerns “brewing,” which, perhaps unsurprisingly, was not something the State appeared desirable to obtain a regular supply. Notably, this collection of classes accounts for a total of 894 distinct patented functions in our period, out of a total of 4,408 total functions; technologies not procured by the State did not form the bulk of all patents granted.

Aside from those WSI technologies where the State did not opt to procure any patents, there are several technologies for which the State did procure supplies, albeit rarely. A cursory examination of WSI classes reporting scores greater than zero and less than or equal to 0.1 provides an indication of further technologies the Navy was not actively seeking. Two observations are noteworthy. First, this subset of classes accounts for 2,213 patented functions, which is half of all the functions patented in our period. Second, of the classes highlighted, several of them relate to the most economically important technologies of the Industrial Revolution: metals, mining, steam engines, and textiles.²³ The average share of these functions not receiving a proviso is 0.95. In addition, metals, steam engines, and textiles technologies are amongst the largest individual classes in terms of functions patented, comprising a total of 558 functions, or roughly 13 percent of all WSI assignments alone.

The State’s avoidance of key technologies may suggest two things. First, the State might have already had access to them through private markets. These technologies coincided with a considerable volume of patents and had sufficiently developed markets for commerce by the outbreak of the French Wars. Second, the State may have avoided such technologies because they did not provide direct utility to the capability for operational and logistical management of their forces. Both cases highlight the State was using the proviso to ensure access to supplies necessary for the war effort, rather than as a means of appropriating profitable inventions for their own gain. The cases also suggest the supplies the State did procure may not have been as easy to procure elsewhere.

Of the two classes that regularly received the Navy proviso—“navigation (part 1)” and “weapons of defense”—we can further examine their specific subclasses. Woodcroft’s schema provides up to two levels of sub-classification. Not all classes receive this kind of stratification, but those classes, which encompass a considerable number of inventions do. This subdivision allows us to clarify exactly what kinds of technologies the State sought.

Table 7 reports the breakdown of the “navigation (part 1)” and “weapons of defense” classes into their respective subclass categories. Considering inventions assigned to the “navigation (part 1)” class, the table shows the State was principally applying the proviso to “anchors,” “capstans and windlasses,” “sails, making, reefing, and working” and “steering, navigating, and working,” each of which relates to operational control over seaborne vessels and, to some extent, reflects the mechanization of ship-based activities previously undertaken

²³ Specifically, we are referring to the following classes: “metals and metallica substances,” “mining and quarrying,” “spinning and preparing for spinning,” “steam; steam-engines and boilers,” and “weaving and preparing for weaving.”

by manual labor. This supports the findings of [Voth, Caprettini, and Trew \(2023\)](#) that technologies substituting labor for capital were sought, given the State's considerable recruitment of manpower. By contrast, the State was procuring inventions relating to "masts and rigging" and "graving, coloring, sheathing," and "loading and preserving cargo" to a lesser degree. Two categories demonstrate no State intervention: lifeboats and ships bolts, though both had the fewest patents.

Similarly, examining the subclasses for "weapons of defense" inventions reveals the State were procuring inventions for "armor, bows, swords, and bayonets" and "guncarriages," as well as cartridges for ammunition. The categories receiving the lowest share of Navy provisos was firearms and gunpowder, both of which were already produced in-house by the State, and, as per [Section 3.2](#), also being regularly submitted to the Board privately. The State had already vertically integrated into the production of these items through the Royal Laboratory and powder mills ([Mauskopf, 1999](#); [West, 1991](#)).

The patent records also indicate the extent to which patents targeted by the State for inclusion of the Navy proviso referred explicitly to the utility of the patent at sea or in His Majesty's Navy. In particular, examination of the enrolled specifications for patents receiving the Navy proviso reveals not only the experimental nature of these technologies but of the 385 patents for which we have specifications, 209 made explicit mention of their use at sea or for the Navy, suggesting such inventions were invented or patented with the Navy in mind.²⁴ This also suggests patentees were aware and possibly desirable to obtain a proviso, thereby obtaining a possibly lucrative contract with the State. Indeed, they may well have opted to invent such technologies, or at the very least patent them, because of the Navy proviso itself.

Based on our analysis, we argue the Navy proviso was used strategically by the State to procure not only preferential access to supplies to enhance the State's capacity to wage war, but also to obtain access to more experimental inventions or technologies, which likely had less well-developed markets; the State was potentially using the proviso to obtain a regular supply of inventions that otherwise might have been undersupplied. Indeed, the WSI evidence demonstrates the State sought inventions that they either did not produce themselves, or they may not otherwise have been able to obtain supplies of outside the patent system.

Furthermore, the specifications reveal patentees were explicitly referring to the utility their inventions had for Britain's forces and Navy, to the extent that these individuals might have been advertising to the State. The State's terms of supply could be favorable and arguably resulted in patentees being able to procure returns to their innovations by contracting with the State.

Based on this new evidence, then, whilst it is not possible to conclusively determine the impact this intervention from the State had on the direction of technical change, it does provide new empirical evidence of a formalized effort on the part of the State and suggests influence of technical change was a likely result.

5. Conclusion

This paper examines an overlooked instance of State-based procurement of inventions by intervening directly into the patent system. Namely, we make two important contributions to our understanding of whether patents influenced the incentives to invent during the Industrial Revolution. First, we provide new evidence documenting the introduction of the

²⁴ See [Appendix A2](#) for an in-depth examination of these specifications.

Table 7. *Breakdown of the selected WSI classes, 1794–1824.*

Woodcroft class	Subclass	Sub-subclass	Share of navy	Total navy	Total patents
Navigation (part 1)	Anchors	—	0.86	12	14
	Building, fitting, and equipping	Lifeboats and rafts	—	0	1
	—	Sailing and steam vessels	0.66	19	29
	Capstans and windlasses	—	0.86	18	21
	Compasses and other nautical instruments	—	0.68	17	25
	Graving, coloring, sheathing, and compositions for preserving	—	0.58	7	12
	Loading and preserving cargo; also ballasting	—	0.57	4	7
	Logs; apparatus for measuring and sounding	—	0.71	5	7
	Masting and rigging, blocks and tackle	—	0.53	8	15
	Raising ships out of water; lowering ships boats	—	1.00	1	1
	Raising wrecks and goods sunk in the sea	—	1.00	2	2
	Sails, making, reefing, and working	—	0.85	6	7
	Ships bolts and other fastenings	—	—	0	2
	Steering, navigating, and working	—	0.90	18	20
	Armor, bows, swords, and bayonets	—	0.78	7	9
	Firearms and ordnance, including barrels and stocks	—	0.64	30	47
	Guncarriages	—	0.89	8	9
Weapons of defense	Gunpowder and cartridges; shot and other projectiles; fuses	—	0.58	7	12
	Loading, priming, and discharging, including locks, sights, and ramrods	—	0.70	47	67
	Powder-flasks, shot-belts, cartridge boxes, hoister-cases, and scabbards	—	0.90	9	10
			Total	225	317

Source: authors' calculations using data from [Woodcroft \(1854b\)](#) and HO 89.

Navy proviso through a considerable amount of new source material to demonstrate how the proviso originated and how it worked in practice. 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 of patent applications. We present and analyze this new dataset to identify the key characteristics of an invention that made it attractive to and thereby subject to intervention from the State.

We argue the Navy proviso resembles the more modern mechanisms of patent buyouts and compulsory licensing. Our evidence indicates the proviso was intended to ensure selected technologies would be actively worked, but also that the State incentivized patentees to provide them preferential access to output. Our examination of the technologies targeted by this proviso highlights that the State was not using it to gain access to articles they could already bargain for privately. Instead, the State appeared to target more experimental or speculative inventions, or technologies that might otherwise have been undersupplied. Indeed, our findings show the Navy proviso targeted technologies, which did not attract broader attention amongst the contemporary inventive community.

The implications of our findings shed light on the role of the State in potentially encouraging invention or patenting during the Industrial Revolution. By focusing on technologies that were not receiving significant attention in the contemporary literature, and, by extension, were unlikely to have seen widespread adoption or development, the use of the Navy proviso may have acted to help develop and disseminate these technologies. Given [Kremer \(1998\)](#) and [Moser and Voena \(2012\)](#) identify positive effects on the rate of innovation and cumulative innovation using patent buyouts and compulsory licenses, a similar kind of effect may have resulted from the State's use of the Navy proviso.

Our findings indicate that whilst Navy proviso patents may have been disseminated through compulsory licensing clauses, those same patents were being published in contemporary literature less often. It is worth noting dissemination through each of these mechanisms may have functioned differently. Contemporary literature was likely consumed by a general readership beyond just inventors. The Navy proviso's "compulsory licensing" mechanism, on the other hand, may well have disseminated technologies to a narrower group of inventors, but in such a way as to ensure the invention was being worked; publication in contemporary literature would not guarantee a similar outcome. Arguably, the proviso mechanism, rather than the contemporary literature mechanism, would be more likely to stimulate cumulative innovation.

Our evidence provides a strong indication the State was keen to ensure inventors were rewarded in proportion to the value of their invention, by allowing market mechanisms to act as a guiding principle in determining fair prices. Should the adoption of an above-market price premium have been widespread in settling terms of supply, then the Navy proviso would have helped patentees to successfully commercialize their inventions. Indeed, a notable criticism of the efficacy of Britain's patent system as a means of incentivizing innovation is that inventors were frequently bankrupted by their patents ([Clark, 2003](#)). By acting to ensure not only that a patent would be worked, with a large-scale buyer ready to procure supplies, but also by offering price premiums, then the State arguably aided in incentivizing the patenting of technologies for which the Navy proviso was regularly used.

Similarly, our findings complement [Satia \(2018\)](#), who argues the State's increasing demands on the private sector for supplies, obtained by the Board through extensive contracting, stimulated the incentives to invent and improve cost-saving technologies. Our evidence is consistent with this viewpoint; however, we highlight the State had a more direct role in incentivizing such innovation. It was already contracting for inventions privately, but

this operated through inventors self-selecting to supply the State in the first instance. The adoption of the Navy proviso then marks a direct intervention to gain access to articles either not being provided privately, or which were more difficult to procure through private markets.

Our findings also resonate with [Ashworth \(2017\)](#), who places the State as the focal point of Britain's Industrial Revolution, arguing the State's increasingly aggressive interventionism into private markets, particularly through their high tax burdens on consumers to finance the enlargement of the Royal Navy, incentivized cost-saving innovations. The State's use of the Navy proviso is consistent with this interventionist argument and may well have acted to directly influence what inventors invented and patented.

Before the Navy proviso, the State did intervene in the market for inventions irregularly. It did not, however, formalize the process and intervene in the patent system itself as a way of securing access to inventions until the Navy proviso was introduced after the outbreak of the French Revolutionary Wars. By this time, the State had prior experience in contracting with private suppliers of Ordnance and related goods. Essentially, what this means is the Navy proviso can be interpreted as a culmination of previous less-formalized practices. This was not a shock to the inventive system in Great Britain, but, in its fully fledged legal form as manifest in the insertion of the proviso, it represents a formalization of the act of private contracting to secure a national public good—the successful prosecution of war and the defense of the nation. The potential outcome of this act of procuring promising provisions may well have been the direction and stimulation of technical change during the Industrial Revolution.

Acknowledgments

Thanks to Gerben Bakker, Sean Bottomley, Chris Colvin, Chris Coyle, Alan Fernihough, Matthias Flückiger, Anton Howes, David Jordan, Zorina Khan, Patrick K. O'Brien, Rajneesh Narula, Peter Scott, and John Turner for comments and encouragement. Thanks also to Alessandro Nuvolari and the two anonymous referees for their invaluable feedback. Thanks also to seminar 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).

Supplementary material

[Supplementary material](#) is available at the *European Review of Economic History* online.

Conflict of interest

None declared.

Data availability

The data and methods underlying this article are available in the online supplementary material.

Primary sources

"Admiralty," WO 44/498, National Archives, London.

"Home Office: Invention Warrant Books," HO 89, National Archives, London.

Journals of the House of Commons. (1803). United Kingdom: By order of the House of Commons. Volume 35.

Mechanics' Magazine. (1847). United Kingdom: Knight & Lacey.

"New method of combining timbers applicable to naval architecture: Recognizance pursuant to a proviso in his patent," TS 21/25, National Archives, London.

"Ordnance Office and Office of the Commander in Chief: Reference Books to Correspondence," WO 45, National Archives, London.

"Ordnance Office: Out-letters," WO 46, National Archives, London.

"Ordnance Office: Board of Ordnance: Minutes," WO 47, National Archives, London.

PP. 1815 (314) IX. Estimates of Effective and Non-effective Army Services.

PP. 1829 (415) III. Select Committee on State of Law and Practice relative to Granting of Patents for Inventions: Report, Minutes of Evidence, Appendix.

PP. 1845 (351) XLVIII. Sixth report of the Deputy Keeper of the Public Records.

PP. 1849 (453) XXII. Committee of Treasury on Signet and Privy Seal Offices, Report, Minutes of Evidence, Appendix.

PP. 1851 (233) XVIII. Select Committee of House of Lords to consider Bills for Amendment of Law touching Letters Patent for Inventions. Report, Minutes of Evidence, Appendix, Index.

PP. 1864 (35) XXXV. Reports of the Commissioners Appointed to Inquire into the Working of the Law Relating to Letters Patent for Inventions.

References

- Arrow, Frederick. 1868. *The Corporation of Trinity House of Deptford Strond: A Memoir of its Origin, History, & Functions*. Smith & Ebbs: London.
- Ashworth, W.J. 2017. *The industrial revolution: The state, knowledge and global trade*. Bloomsbury Publishing.
- Baten, J., N. Bianchi, and P. Moser. 2017. "Compulsory licensing and innovation—historical evidence from German patents after WWI." *Journal of Development Economics* 126:231–42.
- Billington, S.D. 2021. "What explains patenting behaviour during Britain's industrial revolution?" *Explorations in Economic History* 82:1–10.
- Billington, S.D., and A.J. Hanna. 2021. "That's classified! Inventing a new patent taxonomy." *Industrial and Corporate Change* 30:678–705.
- Bottomley, S. 2014a. "Patenting in England, Scotland and Ireland during the industrial revolution, 1700–1852." *Explorations in Economic History* 54:48–63.
- Bottomley, S. 2014b. *The British patent system during the Industrial Revolution 1700–1852: From privilege to property*. Cambridge: Cambridge University Press.
- Bottomley, S. 2019. "The returns to invention during the British industrial revolution." *The Economic History Review* 72:510–30.
- Brunt, L., J. Lerner, and T. Nicholas. 2012. "Inducement prizes and innovation." *The Journal of Industrial Economics* 60:657–96.
- Burton, M.D., and T. Nicholas. 2017. "Prizes, patents and the search for longitude." *Explorations in Economic History* 64:21–36.
- Carpmael, W. 1842. *The law of patents for inventions, familiarly explained for the use of inventors and patentees*. Simpkin, Marshall, Co., Stationer's-Hall Court; and Weale, High Holborn: London.
- Chari, V.V., M. Golosov, and A. Tsyvinski. 2012. "Prizes and patents: using market signals to provide incentives for innovations." *Journal of Economic Theory* 147:781–801.
- Clark, G. 2003. *The great escape: The industrial revolution in theory and history*. Davis: UC Davis, Department of Economics.
- Cox, G.W. 2020. "Patent disclosure and England's early industrial revolution." *European Review of Economic History* 24:447–67.

- David, P.A. 1993. "Intellectual property institutions and the panda's thumb: patents, copyrights, and trade secrets in economic theory and history." In *Global dimensions of intellectual property rights in science and technology*, edited by M. Wallerstein, M. Mogee and R. Schoen, 19–61. Washington DC: National Academy Press.
- Dutton, H.I. 1984. *The patent system and inventive activity during the Industrial Revolution, 1750–1852*. Manchester: Manchester University Press.
- Galasso, A., M. Mitchell, and G. Virag. 2016. "Market outcomes and dynamic patent buyouts." *International Journal of Industrial Organization* 48:207–43.
- Galasso, A., M. Mitchell, and G. Virag. 2018. "A theory of grand innovation prizes." *Research Policy* 47:343–62.
- Howes, A. 2021. *Arts & Minds: How the Royal Society of Arts Changed a Nation*. Princeton: Princeton University Press.
- Khan, B.Z. 2005. *The Democratization of Invention: patents and copyrights in American economic development, 1790–1920*. Cambridge: Cambridge University Press.
- Kremer, M. 1998. "Patent buyouts: a mechanism for encouraging innovation." *The Quarterly Journal of Economics* 113:1137–67.
- LeClair, D.R. 2015. *Supervising a revolution: British ordnance committees, private inventors, and military technology in the Victorian era*. (Doctoral dissertation), Houston: University of Houston.
- MacLeod, C. 1988. *Inventing the Industrial Revolution: The English patent system, 1660–1800*. Cambridge: Cambridge University Press.
- Mauskopf, S. 1999. "From an instrument of war to an instrument of the laboratory: the affinities certainly do not change' chemists and the development of munitions 1785–1885." *Bulletin for the History of Chemistry* 24:1–15.
- Moser, P. 2005. "How do patent laws influence innovation? Evidence from nineteenth-century world's fairs." *American Economic Review* 95:1214–36.
- Moser, P., and T. Nicholas. 2013. "Prizes, publicity and patents: non-monetary awards as a mechanism to encourage innovation." *The Journal of Industrial Economics* 61:763–88.
- Moser, P., and A. Voena. 2012. "Compulsory licensing: evidence from the trading with the enemy act." *American Economic Review* 102:396–427.
- Moss, M. 2012. "From cannon to steam propulsion: the origins of Clyde marine engineering." *The Mariner's Mirror* 98:467–88.
- Nuvolari, A. 2004. "Collective invention during the British industrial revolution: the case of the Cornish pumping engine." *Cambridge Journal of Economics* 28:347–63.
- Nuvolari, A., and J. Sumner. 2013. "Inventors, patents, and inventive activities in the English brewing industry, 1634–1850." *Business History Review* 87:95–120.
- Nuvolari, A., and V. Tartari. 2011. "Bennet Woodcroft and the value of English patents, 1617–1841." *Explorations in Economic History* 48:97–115.
- Nuvolari, A., V. Tartari, and M. Tranchero. 2021. "Patterns of innovation during the industrial revolution: a reappraisal using a composite indicator of patent quality." *Explorations in Economic History* 82:101419.
- Raudzens, G. 1979. "The British ordnance department, 1815–1855." *Journal of the Society for Army Historical Research* 57:88–107.
- Satia, P. 2018. *Empire of guns: The violent making of the Industrial Revolution*. Duckworth Overlook: London.
- Skentelbery, N. 1964. *Arrows to Atom Bombs: A History of the Ordnance Board*. Ordnance Board Press: London.
- Sullivan, R.J. 1990. "The revolution of ideas: widespread patenting and invention during the English industrial revolution." *The Journal of Economic History* 50:349–62.
- Torres-Sánchez, R., and P. Brandon. 2018. "War and economy. Rediscovering the eighteenth-century military entrepreneur." *Business History* 60:4–22.
- Voth, H.J., B. Caprettini, and A. Trew. 2023. "Fighting for growth: labor scarcity and technological progress during the British industrial revolution." CEPR Discussion Papers, (17881).

- West, J. 1991. *Gunpowder, Government, and War in the mid-eighteenth century*. Boydell Press: London.
- Weyl, E.G., and J. Tirole. 2012. "Market power screens willingness-to-pay." *Quarterly Journal of Economics* **127**:1971–2003.
- Woodcroft, B. 1854a. *Titles of patents of invention chronologically arranged, 1617–1852*. G.E. Eyre & W. Spottiswoode: London.
- Woodcroft, B. 1854b. *Subject-matter Index (made from Titles Only) of Patents of Invention: From March 2, 1617 (14 James I.) to October 1, 1852 (16 Victoriae). A to M (Vol. 1)*. London: The Queen's Printing Office.