Explorations in Economic History 64 (2017) 21–36

Contents lists available at ScienceDirect

Explorations in Economic History

journal homepage: www.elsevier.com/locate/eeh

Prizes, patents and the search for longitude☆

M. Diane Burton[a], Tom Nicholas[b,*]

[a] ILR School, Cornell University, 170 Ives Hall, Ithaca, NY 14853, USA
[b] Harvard Business School, Soldiers Field Road, Boston, MA 02163, USA

ARTICLE INFO

Keywords:
Prizes
Patents
Innovation

ABSTRACT

The 1714 Longitude Act created the Board of Longitude to administer a large monetary prize and progress payments for the precise determination of a ship's longitude. However, the prize did not prohibit patenting. We use a new dataset of marine chronometer inventors to show that the propensity to patent was high. We argue that while the prize spurred entry by key inventors, and progress payments facilitated research investment in an area of significant social value, patents promoted disclosure. Our findings highlight the importance of complementarities between prize and patent-based incentives in the design of innovation inducement contests.

1. Introduction

In response to a prominent navigation disaster and growing demand for a solution to the problem of identifying a ship's position at sea, a 1714 British Act of Parliament created a substantial award for the precise determination of longitude.[1] Using a prize of up to £20,000 (around £2.5 million today) a commission of adjudicating experts (the Board of Longitude) and resources for inventors to engage in experimentation, the government aimed to encourage knowledge accumulation in an area of high social value but relatively low private investment. By the early 1770s following a long and acrimonious dispute with the Board of Longitude, John Harrison (1693–1776), an English clockmaker, was awarded monetary values approximately equivalent to the prize.[2] Mokyr (2010, p. 42) describes Harrison's marine chronometer as "one of the epochal innovations of the eighteenth century."

The longitude prize is frequently cited in the innovation literature as a prominent example of a non-patent based mechanism designed to spur technological development (Wright, 1983; Kremer, 1998; Kalil, 2006; Kremer and Williams, 2010, 2012; Brunt et al. 2012; Moser and Nicholas, 2013; Murray et al. 2014). It has motivated a range of modern prize competitions such as the recent X-Prize contests for space innovation, developments in super-efficient vehicles or cost-effective gene sequencing. The America COMPETES Act passed by Congress in 2010 provides Federal agencies with the necessary authority to conduct prize competitions.

☆ We are very grateful to anonymous referees, Ran Abramitsky, Steve Broadberry, Zorina Khan, Naomi Lamoreaux, Ramana Nanda and Joachim Voth for very helpful comments and to Richard Dunn and Rory McEvoy from the Royal Observatory Greenwich for sharing their expertise on chronometers and for invaluable help with data sources. The Division of Research and Faculty Development at Harvard Business School provided funding.

* Corresponding author.
E-mail addresses: burton@cornell.edu (M.D. Burton), tnicholas@hbs.edu (T. Nicholas).

[1] In 1707 during the War of the Spanish Succession, Admiral Sir Cloudesley Shovell led a fleet of British naval ships back to England from Gibraltar but the fleet lost its position in fog around the Isles of Scilly off the Cornish peninsula of Britain, leading to the loss of four ships and almost 2000 lives. Also, in July 1713 two mathematicians William Whiston and Humphrey Ditton published an idea in *The Guardian* newspaper whereby ships in set locations in sea trade channels would explode a mortar at a set height and time to allow location by other ships to be determined by calculating the time elapsing between the explosion flash and the corresponding sound. They also engineered a petition submitted to Parliament seeking to establish an award for a method to establish longitude.

[2] It is important to note that the longitude prize was not actually awarded. The monetary amounts given to Harrison represented only a tacit admission that the navigational problem had been solved.

http://dx.doi.org/10.1016/j.eeh.2016.09.001
Received 18 April 2016; Received in revised form 4 August 2016; Accepted 6 September 2016
Available online 05 October 2016

In the spirit of the 1714 Act, the 2014 Longitude Prize supported by the British government consists of a £10 million prize fund in an effort to solve the problem of global antibiotic resistance. This is an area with substantial social value that has not been addressed through patent-based incentives.

We examine the effect of the longitude prize and the patent system on the process of technological development. We use a new dataset of chronometer inventors assembled from *Chronometer Makers of the World* (CMW) compiled by Tony Mercer (1919–2012), the grandson of the founder of Thomas Mercer Ltd., a prominent English watch and chronometer manufacturer established in London in 1858. These new data are novel and informative. Several studies have analyzed the search for longitude from an historical or a legal perspective (e.g., Sobel, 1996; Siegel, 2009), but quantitative analysis has been lacking. While Harrison's efforts are especially well-documented, and there is considerable debate about the Board of Longitude's decision to refuse payment to him (e.g., Betts, 1996), no empirical analysis has been conducted on the inventors who actually developed marine chronometers.

An advantage of our data is that we can examine the full life cycle of the industry. The period we consider from 1714 to 1939 covers the duration of the prize competition under the Board of Longitude, the rise of the industry as "the British turned the marine chronometer into an object of industrial manufacture and commercial use" (Landes, 1998, p. 171), and its interwar decline when radio signals displaced navigation by chronometers. Moreover, because the longitude prize did not preclude patenting, we are able to take a long run perspective on the development of the chronometer in the context of the interplay between prizes and patents. For this purpose we hand-matched CMW entries against a data base containing all British patents granted from 1714 to 1939 to determine the extent to which inventors used the patent system.

Our empirical analysis has four main parts. First, we analyze the extent to which the Board of Longitude was able to spur the effort of inventors. We show that the monetary prize offered by the British government encouraged entry and led to intense competition by a small group of key inventors, including John Harrison. At the same time, we show that the number of active chronometer makers and craftsmen did not peak until the 1870s and 1880s, more than 150 years after the Longitude Act had been passed. We argue that the prize initiated a protracted process of cumulative innovation as the marine chronometer design was perfected over time.

Second, we show that the Board of Longitude paid out a substantial amount in interim progress payments to inventors for successful developments. These payments, totaling £52,535 or around £6.6 million today, are often neglected in the literature, but they provided crucial capital for research investment, improvement and experimentation. For example, Harrison received a series of payments in-between his first marine chronometer (called H1) completed in 1735 and his final H4 chronometer completed in 1759. Interestingly, however, we show that these progress payments do not predict the timing of entry or patenting. That is, the progress payments likely changed the allocation of resources to innovation for individuals like Harrison, but they did not increase the underlying supply of inventors or patents more generally.

Third, we examine the determinants of patenting in the cross section of inventors during, and after, the Board of Longitude era. We find a particularly high propensity to patent among marine chronometer inventors relative to benchmarks in the literature. In line with recent work on the British patent system (Bottomley, 2014), we argue that patents had private benefits by helping inventors to appropriate from their ideas while being socially beneficial by promoting the disclosure of useful knowledge. Notably, inventors like Harrison who opted to use secrecy, impeded the Board's efforts to ensure knowledge diffusion across innovators.

Finally, we show that prize and patent-based incentives continued to be important at a time when further developments to chronometers to improve accuracy became a focus of attention. Between 1823 and 1835, prize competitions conducted by the British Admiralty at the Royal Observatory in Greenwich to promote cumulative improvements to Harrison's basic marine chronometer design coincide with a large spike in the level of patenting. Difference-in-difference estimates suggest that the mean number of chronometer patents increased by between 59 and 174 percent during the 1820s and 1830s relative to a control group of scientific instrument patents.

Overall we argue that the development of the marine chronometer reflected a complementary relationship between prize and patent-based incentives. One measure of a prize competition's impact is its ability to change the allocation of resources to problem-solving. Our evidence suggests that the longitude prize provided a catalyst for skilled inventors to direct their efforts towards solving the longitude problem because patents alone had not generated sufficient incentives for private investment. On the other hand, because the patent system mandated inventors to disclose, we maintain that it corrected for a defect in the design of the longitude prize, where a lack of disclosure created a barrier to incremental invention. An extensive body of theoretical work on innovation has discussed the efficiency of using prizes as substitutes to remove the deadweight loss associated with patents (e.g., Wright, 1983; Kremer, 1998; Chari et al. 2012). We emphasize the potential significance of attributes like disclosure, which are already built into patents, in the design of innovation inducement policies.

The remainder of the paper is structured as follows. In the next section we provide a brief historical background on the longitude prize. Section three describes our dataset. Section four presents our analysis of the effect of the Board of Longitude's progress payments. Section five focuses on the propensity of inventors to patent chronometer inventions and on inventor-level determinants of patenting. Section six provides further evidence on the relationship between prizes and patents. Section seven concludes.

2. Historical background: aspects of the longitude prize

The British were not the first to offer a prize for longitude. The race for global trade and maritime supremacy led the Spanish monarchy to offer a prize for the discovery of longitude at sea during the late 1590s, to be followed in the early 1600s by the Dutch