Economic Inquiry

LIGHTHOUSE PROVISION IN PREMODERN JAPAN

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We investigate how lighthouses were provided in premodern Japan, with a specific focus on the role of the private sector. Using national survey data on lighthouses collected by the government in 1883, we find that lighthouses constructed by the private sector in the Edo period (1603–1868) accounted for nearly 70% of lighthouses existing at the time of the survey and that there was no significant difference in technical features between private and public lighthouses. However, we observe that almost all private lighthouses were located at ports, and additional case studies indicate that the public authorities endorsed the operation of some lighthouses, which might have contributed to their profits and improved their long-term survival. We also find that various factors, including the formation of merchant coalitions and whether users were identifiable, influenced whether a private organization could circumvent the free rider problem. (*JEL* H41, L97, N45)

I. INTRODUCTION

In his classic article, Coase (1974) described how, prior to the 19th century, many lighthouses in England and Wales were constructed and operated by private organizations.[1] He claimed that "(i)n those days, shipowners and shippers could petition the Crown to allow a private individual to construct a lighthouse and to levy a (specified) toll on ships benefiting from it. The lighthouses were built, operated, financed, and owned by private individuals, who could sell the lighthouse or dispose of it by bequest. The role of the government was limited to the establishment and enforcement of property rights in the lighthouse" (375). Coase then concluded that "economists should not use the lighthouse as an example of a service which could only be provided by the government" (376) and stated that the extensive misuse of lighthouses as an example of public goods arises from the fact that "no economist, to my knowledge, has ever made a comprehensive study of lighthouse finance and administration" (375).

Coase's study attracted substantial interest, but his argument has received some criticism.[2] Van Zandt (1993) claimed that the definitions of "government" and "private" are too ambiguous in Coase's article. He argued that all patents were issued to Trinity House after 1679 and described that a patent had three elements: (1) "it granted to the entrepreneur the exclusive right for a term

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1. Hague and Rosemary (1975) mentioned that most early British lighthouses were privately owned, and that the operation of private lighthouses generated a significant amount of profits. According to Taylor (2001), until 1836, many of England's lighthouses were privately owned. Lighthouses were then established as a public service and the government made Trinity House the only lighthouse authority in England.

2. The best-selling reference work by Samuelson and Nordhaus (2010), an older edition of which was criticized by Coase, stated "(p)erhaps, we might conclude, lighthouses are not really public goods" (37). At the same time, however, Skousen (1997) reported that when Samuelson was asked about Coase's lighthouse argument, he answered that "(i)f you read carefully the Coase article on lighthouses, you will see that the historical examples he described are not able to conquer the 'free-rider' problem. When scrambling devices become available to meet that problem, there still remains the deadweight inefficiency intrinsic to positive pricing for the marginal use of something that involves only zero or derisory marginal cost" (personal correspondence, August 9, 1995) (145, footnote 5).

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of years to build and maintain a lighthouse for a specific area in exchange for a fixed annual rent," (2) "the patent fixed the light dues or charges that the entrepreneur was entitled to collect from ships that benefited from the light either directly or indirectly," and (iii) "the patent entitled the holder to invoke the power of the Crown to enforce the payment of the light dues" (65–6). Van Zandt argued that these features of the patent system suggest, in contrast to Coase's argument, that the government's role was more than simple property protection and contract enforcement,[3] and he concluded that "(h)istorically, the institutions that provided lighthouse services relied more on governmental assistance than is the case with other services and goods" (71).

Bertrand (2006) also cast doubt on Coase's analysis by claiming that lighthouses should be understood as the result of a mixed production system and arguing that the efficiency of lighthouse provision was improved by a strong government.[4] More recently, Lindberg's (2015) historical analyses showed that lighthouses were constructed and maintained privately in Sweden, but the supply of lighthouses relied largely on the public sector, with private lighthouses playing only a marginal role. A somewhat different viewpoint was put forward by Carnis (2013), who claimed that lighthouses should be considered an economic asset subject to political rent seeking.

Despite the long-standing debate, most studies rely on qualitative analyses and quantitative studies are scarce. Also, little is known about how lighthouses were provided and operated in the regions other than Europe.[5] This study contributes to the literature by providing both qualitative and quantitative evidence on (a) how many lighthouses were provided by private sector actors, (b) what enabled private sector actors to surmount the free-rider problem, and (c) the limitations or shortcomings of the private provision. Using a national survey conducted by the Japanese government in 1883 and various other sources, we first describe how lighthouses were provided and then attempt to provide theories that explain the observations. Our findings can be summarized as follows. First, private sector actors played a significant role in lighthouse provision in terms of quantity. Of the lighthouses that existed in 1883, 53.8% (70 out of 130 in our observations) were constructed by (groups of) private individuals. This percentage is even higher when limited to the lighthouses constructed in the Edo period when governmental provision did not occur. Second, for the lighthouses constructed in the Edo period, we found no significant difference in the technological aspects between private and public lighthouses, although the modern lighthouses built by the Meiji government were of substantially better quality in terms of height and reachable light distance. Along with the insights from our case studies, we conjecture that the free-rider problem was mitigated because the geographic features of the port and repeated use by the same group of merchants helped the lighthouse owners to identify its users, and because the internal punishment system of the merchant coalition compensated for the immature legal system. In addition, we conjecture that, as indicated by the theory of local public goods, the competition among port operators to attract many ships contributed to the provision of enough lighthouses, in terms of both lighthouse quantity and quality. Third, however, almost all private lighthouses were located at ports along the major shipping routes and the lighthouses located at straits or capes were constructed by the Meiji government after the opening of Japan. Our case study (Case 2) shows that various factors made it difficult for a private individual to provide a lighthouse at straits or capes, despite the strong need for them. Fourth, the public authorities sometimes played a significant role in the "private" provision of lighthouses. In another case study (Case 1), a lighthouse was originally built by a private organization but, 45 years later, the local authority gave endorsement to the lighthouse service, which might have played essentially the same role as a patent.

We believe that Japanese lighthouses provide an ideal opportunity to analyze the role of the private sector in public goods provision for the following three reasons. First, many lighthouses were constructed by the private sector in the Edo period (1603–1868) and in the early Meiji era. This situation is quite different from, for example, the situation in Sweden, where "private provision generally played a marginal role in the expansion of sea safety arrangements" (Lindberg 2015, 454). Second, Japan had no official regulations or

3. Coase wrote that the "lighthouses were built, operated, financed and owned by private individuals, who could sell the lighthouse or dispose of it by bequest. The role of the government was limited to the establishment and enforcement of property rights in the lighthouse" (375).

4. Barnett and Block (2007) and Block and Barnett (2009) refuted these studies by pointing out that lighthouses were historically supplied and operated by private organizations.

5. Bickers (2013) is a rare exception that examines the lighthouses along the coast of China.

public institutions until lighthouse provision and maintenance became controlled by the government during the Meiji era commencing in 1868. In the British case, Trinity House had "many miscellaneous responsibilities, for example, the inspection and regulation of 'local lights' and the provision of Nautical Assessors or Trinity Masters at the hearing of marine cases in the Law Courts" (Coase 1974, 362). The Japanese case is free from such institutions and thus, offers a good opportunity to examine how the market operated (or did not operate) without any regulations or official institutions. Finally, Japan had only immature legal rules regarding contract enforcement, especially in the Edo period. As will be discussed in more detail in Section II, the plaintiff's rights were relatively weak in the case of civil affairs, which might have made it difficult for lighthouse owners to collect fees from ship owners. These observations provoke the questions of how and why private sector entities could provide lighthouses despite the potential threat of a free-rider problem.

From a broader perspective, this paper is related to the literature on the private provision of public goods. The introductory economics of market failure explains that markets may not be able to achieve efficient outcomes if a good or service exhibits characteristics of nonexcludability and nonrivalry, but this does not necessarily mean that only the government can produce public goods. Tiebout (1956) provided an important perspective on this topic using the concept of "local public goods." As simply explained by Atkinson and Stiglitz (2015), Tiebout (1956) argued that, "if there were enough communities, individuals would reveal their true preference for public goods by the choice of community in which to live" (435) and "it is often asserted that such a local public goods equilibrium would be Pareto-efficient" (435). This theory of local public goods is often referred to in the context of voting, but it is likely to fit well in the case of lighthouses, given a sufficient number of lighthouses and low costs for choosing a port. Of course, charity is another method of private production of public goods. Van Zandt (1993) argued that "(a)s part of the communities' religious duties, members might voluntarily maintain a lighthouse for use by passing mariners without reliance on mandatory payments" (59).[6] Many empirical studies have provided evidence on the voluntary provision of public goods in such fields as urban infrastructure (Beito and Smith 1990), police (Davies 2002), firefighting (McChesney 1986; Wilson 1989), education (High and Ellig 1988), turnpikes (Klein 1990), and various other fields (Beito, Gordon, and Tabarrok 2002; Cowen 1988).[7]

The rest of the paper is organized as follows. In Section II, we provide some historical background regarding lighthouses and legal systems in the Edo period and the early Meiji era. In Section III, we introduce our dataset and analyze how many lighthouses were provided by which type of founder. In Section IV, we investigate the technical and locational differences between private and public lighthouses. In Section V, two case studies are examined, one of which was very successful and the other was unsuccessful. Concluding remarks are presented in Section VI.

II. LIGHTHOUSE PROVISION AND THE LEGAL SYSTEM IN THE EDO PERIOD

In the late 16th century, Japan began to close itself off to the rest of the world, a process that was completed in 1639 when trade with Portugal was banned. Communications with foreign countries were limited to certain designated countries at four special gateways (Nagasaki, Tsushima, Satsuma, and Ezo); therefore, seafaring was mostly limited to domestic shipping along the coast. However, as the economy grew and three major shipping routes, that is, the South, East, and West routes, were established, more and more ships navigated around the adjacent coastlines.

Because Japan is surrounded by rocky reefs and shallow water and has many typhoons and storms, accidents at sea are common occurrences. To prevent them, small and simple lighthouses, called *to-myo-dai* or *jo-yato*, were constructed across the country. They burned oil—typically canola, fruit, or fossil oil—in a burning system on a base made of wood, stone, or iron. It should be noted that they had a significantly simpler structure than did the European lighthouses of that age. For example, the four local

6. However, Van Zandt (1993) also writes that "(a)lthough legends abound about lonely hermits or religious orders providing lighthouse services gratis or in the hopes of contributions, the discernible historical examples are few and far between" (59).

7. Varian (1993) criticized essays in Cowen (1988) by claiming that "several of the essays overstate their case and misrepresent the standard theory of public goods and externalities" (539).

lighthouses erected in Liverpool in 1763 and 1764 were between 15.24 to 36.6 m (50′–120′) in height (Stevenson 2002, 150), but the highest lighthouse in our Japanese dataset is 9.1 m high.[8] The major lighthouses governed by Trinity House in England were even higher and had more complex structures. Although some would argue that our study is about seamarks rather than lighthouses, we claim that the basic issues relating to the private provision of lighthouses could be applied to *to-myo-dai* or *jo-yato*, because our interest is in their public good characteristics, rather than their physical appearance.[9]

In the Edo period, lighthouses were constructed by various entities, such as domain heads, wholesalers in ports, and individuals. There were no regulations or institutions that governed lighthouse operations,[10] which means that this period provides us with an ideal situation for investigating how lighthouses could (or could not) be supplied in a market where no restrictions were imposed.

Regarding contract enforcement, public enforcement did not always work well in the Edo period.[11] Lawsuits were classified into criminal affairs and civil affairs, as in the modern legal system, and the latter were classified into three categories: *honkuji* (main suits), *kanekuji* (money suits), and *nakamagoto* (mutual affairs). Among these, *honkuji* were most likely to be protected by government authorities but, in the case of *kanekuji* and *nakamagoto*, the plaintiff's rights were relatively weak, and the latter were usually settled within the organization to which the plaintiff belonged. Because the country was closed, no international maritime laws were established. Instead, the customs law used among the wholesale shipping merchants, the *kaisen ton'ya*, was in effect. In particular, the customs law of one of the largest groups of *kaisen ton'ya,* the *higaki kaisen tsumi ton'ya nakama*, played a strong role in settling disputes. For example, if a member of the *kaisen ton'ya* had a sea accident and cargo was lost, their customs law was applied to handle the accident (Ohtake and Maki 1975, 220).

The role of Japanese lighthouses changed soon after Japan opened to the world again in 1854.[12] Because lighthouses in the Edo period had a simple structure, many of them could not be used for open ocean navigation. Therefore, the Western countries placed pressure on the Japanese government to construct modern lighthouses to enable foreign ships to navigate safely, mainly because they were eager to establish ocean lanes in East Asia, given the rising demand for imports and exports in Asian countries. Given this background, the government established a new lighthouse department called *toudai kyoku* at the start of the Meiji era and spent a great deal of money on lighthouse construction. It also invited foreign engineers to use modern lighthouse-building techniques.

In the Meiji era, the government banned the building of any new private lighthouses because it considered that they were of mixed quality and often faced financial difficulties, which lowered their reliability as seamarks (Teishin-sho 1941). The first circular notice of this ban was in 1871, 4 years after the Meiji era started, but the government could not ban private lighthouse construction completely, partly because public lighthouse construction did not proceed smoothly enough to replace the existing lighthouses and also because the government prioritized responding to the demands of the Western countries, putting off responding to domestic needs. Thus, many private sector entities continued to erect lighthouses until the government strictly prohibited the construction of private lighthouses in 1885 (Teishin-sho 1941, 1271).[13] Given these historical events, we focus on the lighthouses built in the Edo period and in the early Meiji era (1868–1883).

8. Stevenson (2002) examined the world's lighthouses from ancient times to 1820; however, he only referred to Japan as follows: "In Japan, he (Ogilby) found seamarks in use. They were timber beacons carrying lanterns" (42).

9. Mill (1970) made no distinction between lighthouses and buoys, stating that "it is a proper office of government to build and maintain lighthouses, establish buoys, etc. for the security of navigation" (342–3).

10. Hirohata (1931, 16).

11. See Henderson (1965) and Ohtake and Maki (1975).

12. The country opened gradually. Two ports, Shimoda and Hakodate, opened first, following the Convention of Kanagawa. Shimoda later closed but an additional four ports, Kanagawa (Yokohama), Nagasaki, Niigata, and Hyogo (Kobe) were opened, following the Treaty of Amity and Commerce in 1858. Despite the opening of several ports, however, there was strong resistance in Japan to Westerners visiting the ports, which was called *Jyo-i*. The *Jyo-i* movement peaked when the Choshu Domain attacked commercial ships in the Kanmon Strait in 1863 (Shimonoseki Campaign). In the following year, the navies of four Western countries, the United Kingdom, France, Netherlands, and the United States, defeated the Choshu Domain. In 1866, the article of Keizai Yakusho (tariff convention) was established between the Tokugawa Shogunate and the Western powers to settle the situation. It ordered that Japan construct lighthouses in eight locations: Satamisaki, Iojima, Shionomisaki, Kashinozaki, Mikomotoshima, Kannonzaki, Tsurugizaki, and Nojimazaki. These were the first modern lighthouses constructed in Japan.

13. In 1885, the government also ordered the closure of any existing private lighthouses that were not collecting fees before the designated deadline (Teishin-sho 1941, 1304).

TABLE 1
Number of Founders' Lighthouses

Founders	Number of Lighthouses Constructed in the Edo Period (1603–1868)	Number of Lighthouses Constructed in the Early Meiji Era (1868–1883)
Individuals, a group of private citizens, such as villagers and shipping traders	28 (68.3%)	42 (47.2%)
Present or past domain head and magistrate officer (Edo) or prefecture and Hokkaido Development Commissioner (Meiji)	13 (31.7%)	4 (4.5%)
Government (Edo *bakufu* or Meiji government)	0	43 (48.3%)
Total	41 (100%)	89 (100%)

Note: This table shows examples of founders in each group and the number of lighthouses that existed as of 1883.
Source: Koubu-sho (1884) and Koubu-sho (1885). Founder information is based on *To-myo-dai Nendo Hyo* (Lighthouse Annual) volume 1 (3–10).

III. QUANTITY

We begin by investigating how many lighthouses were constructed by which type of founder. To do this, we refer to data from a survey conducted by the Japanese government. In 1883, 15 years after the Meiji era started, *Koubu-sho* (the Ministry of Industry) ordered each prefecture to collect information about the existing lighthouses and other seamarks. The government urgently required a full picture of the exact location and specification of all lighthouses because, despite the increase in the number of visiting ships after Japan was opened, it did not have a comprehensive list of all lighthouses and seamarks across the country. Furthermore, the Western countries pressured the Japanese government to improve the lighthouse system so that they could establish new markets in Asian countries. The survey was the first national survey on lighthouses made at the request of the government and it covered most major lighthouses as at December 31, 1883.[14] The survey, *Koubu Toukei-shi*, was published as two volumes, volume 1 in 1884 and volume 2 in 1885.

We construct our dataset using these two volumes. The original data provide information on 144 lighthouses, including both public and private ones constructed in the Edo and the early Meiji period.[15] After eliminating the observations that lack sufficient information for regression analyses in Section IV, we have 130 observations, 41 constructed in the Edo period and 89 in the early Meiji era.[16]

We first classify lighthouses using the information about the type of the original founder: (a) an individual or a group of private citizens, such as local villagers and shipping traders; (b) a *hanshu* (domain head) or *bugyo* (magistrate's officer); and (c) *Edo bakufu* (the national government).

Table 1 shows examples of founders in each group and the number of lighthouses that existed at the time of the survey in 1883. It shows that 68.3% of all lighthouses constructed in the Edo period and existing at the time of the survey were established by individual founders. Present or past domain heads and magistrate officers account for 31.7% of total lighthouse provision and the Edo *bakufu* provided no lighthouses. As for the lighthouses constructed in the early Meiji era, 47.2% of lighthouses were founded by individuals, 4.5% by prefectures or the Hokkaido Development Commissioner, and 48.3% by the Meiji government. These figures provide clear evidence that individuals or groups of individuals played a significant role in lighthouse provision, at least in terms of quantity.

Of course, the existence of many private lighthouses does not indicate that the number of private lighthouses was socially efficient. Rather, it may be that it was below the optimum level as

14. *Koubu Toukei-shi*, volume 2, 131.

15. More precisely, we constructed the dataset using two tables in *Koubu Toukei-shi* volumes 1 and 2. One is the table in volume 2 (4–24) that lists 53 public lighthouses. The other is the table in volume 2 (132–68) that lists 91 private lighthouses. These tables include detailed information about each lighthouse, including technical information and the financial performance of each lighthouse. However, as they do not include information about founders, we also referred to *To-myo-dai Nendo Hyo* (Lighthouse Annual), volume 1 (3–10), which includes information about the founders of each lighthouse.

16. The Kurasaki (no. 43 on page 20) and Tatotsu Higashi (no. 72 on page 160) lighthouses were excluded.

the sea around Japan was called the "dark sea" after ships from several Western countries visited Japan, possibly because of the limited number of lighthouses.

Some caveats should be mentioned regarding the interpretation of the figures in Table 1. First, the number of lighthouses in the table could be affected by a survivor bias: lighthouses of lower quality and poorer financial performance were more likely to be closed and thus drop out of the sample. At the same time, however, low-end and financially distressed lighthouses could be constructed more easily than high-end lighthouses. Therefore, how such characteristics affect the number of lighthouses in the table is uncertain. Second, in some cases, the operator could have changed over time. Because it is impossible to check the entire history of each lighthouse to track the transition of the operator, we refer only to the original founder of the lighthouse. Finally, even if the operator did not change over time, private operators could have had some authoritative power to collect fees. Indeed, recent studies on Japanese economic history argue that local governors sometimes delegated their public responsibilities, including collecting taxes, to rich farmers or merchants in a port. For example, Nakabayashi and Moriguchi (2017) wrote that "(t)he huge development in the 17th century generated the increase in the operation and maintenance cost of social capital, but Edo *bakufu* and the feudal domains introduced the policy that they delegated the maintenance work of the social infrastructures, such as rivers, to villages and broader local public authorities, which was called *jifushin*" (31). Although they did not directly refer to lighthouse operations in the Edo period, a document issue by the telecommunication department indicated the possibility that some private lighthouses were operated using funds collected as taxes:

> As for private seamarks, both construction and maintenance fees were owed by the founders and, in many cases, they collected fees from ship owners who used the port to finance the maintenance cost. If they did not, they asked the domain office, ship owners, or oil manufacturer for *myoga-kin*, a kind of compulsory tax, or used accumulated funds collected from local fishermen. It often happened that the budget did not balance, which resulted not only in incomplete facilities but also in having difficulty in maintaining the facility, resulting in the abolishment of the lighthouses. (Teishin-sho 1941, vol. 6, 1303)

These documents suggest that we should be careful about using the term "private" because it might include some "public" aspects in the sense that private institutions were helped by public authorities in some way. We will investigate this point closely in Case 1 in Section V.[17]

IV. QUALITY

A. Technical Features

In the previous section, we illustrated that private sector actors played a significant role in the provision of lighthouse in terms of quantity. In this section, we examine whether there is a difference in terms of quality between private and public lighthouses. First, we focus on the technical features of the lighthouse. The underlying hypothesis here is that if a lighthouse had the characteristics of nonexcludability, and thus suffered from the free-rider problem, other things being equal, a private lighthouse would have inferior technical features than a public one because of more severe financial problems. We test this hypothesis using three technical features of the lighthouse: (1) lighthouse material (wood or stone/metal), (2) height of lighthouse, and (3) reachable light distance. Here, it is assumed that a lighthouse is better quality if (1) it is made of stone or metal (in general, lighthouses made of stone or metal are more expensive and involve more construction time than those made of wood), (2) it is taller, and (3) it has a longer reachable light distance.[18]

To determine whether quality is associated with the type of founder, we estimate the following model:

$$(1) \qquad Quality_i = \alpha + \beta \times Public_i + \boldsymbol{X}_i\boldsymbol{\gamma} + \varepsilon_i,$$

where subscript i denotes lighthouse, $Quality_i$ is defined by either material, height, or reachable light distance, $Public_i$ is a dummy variable that equals one if the lighthouse is founded by a public organization, as defined in Table 1, and zero if it is founded by a private organization,

17. We will use the terms "private" or "public" lighthouse on the following pages, but this simply means that the founders were private or public entities, respectively. Careful attention should be paid to this wording because, as we will see in Case 1, the type of the founder does not necessarily reflect how the lighthouse was operated.

18. Among these characteristics, the height of a lighthouse might not be an appropriate proxy for lighthouse quality. If it is constructed on the top of a hill, the tip of a cape, or on an island with good visibility, a lighthouse does not need to be tall to be effective. Despite this possibility, we include the height information because it conveys some technical information about lighthouses. Furthermore, we control the height from sea level in the regression model.

TABLE 2
Variable Definitions

Variable	Definition	Unit
Proxies of quality		
Material	Wood (=0), Stone/Metal (=1)	Lighthouse
Height	Height from the base	Meter
Light_distance	Reachable light distance	Kilometer
Control variables:		
Longevity	Years from the first lighting as of 1883	Year
Oil	Oil consumption per year	Gallons/year
Sea_level	Height above sea level	Meter
Rain	Total amount of rainfall	mm/year
Wind_speed	Average speed of wind	Meters/second
Snow	Number of days with snowfall	Days/year
Fog	Number of days with fog	Days/year

Notes: This table shows the definitions of the variables used in Model 1. We use the climatic information recorded at the observation point that is the closest to each lighthouse. The climatic information is the annual average during 1981–2010.

Source: Variables concerning lighthouse information and *Sea_level* come from Koubu-sho (1884) and Koubu-sho (1885). The climate information (*Rain*, *Wind_speed*, *Snow*, and *Fog*) comes from the National Institutes of Natural Sciences (2018) website.

vector $\boldsymbol{X}_i$ denotes the control variables that could affect lighthouse quality, such as the height of a lighthouse above sea level and various climatic factors, and ε_i is an error term. Tables 2 and 3 provide the variable definitions and the summary statistics, respectively, for the variables used in Model 1.

Table 4 shows the estimation results for Model 1. We adopt the probit estimation technique for the equation in which the dependent variable is *Material*, and for the other models we apply an ordinary least squares regression with White's robust standard errors. For the lighthouses constructed in the Edo period, shown in columns 1–3, the dummy variable *Public* has no statistically significant association with our variables of interest, which indicates that the quality of private lighthouses was not significantly different from that of the public ones.[19] Again, we have to be careful about the survivor bias: if lighthouses of poor quality due to financial difficulties are more likely to drop from the sample, the remaining sample will consist of better quality lighthouses.

19. Lindberg (2013) reported that "(e)vidence supporting the idea that private lighthouses delivered services of low quality is difficult to obtain. Although the committee of 1834 expressed its criticism of high dues and private profits made under government grants, it had few complaints about the quality of English lighthouses" (552).

When we focus on the lighthouses constructed in the early Meiji era, shown in columns 4–6, the coefficients for *Public* are all statistically significant, suggesting that public lighthouses were of better quality than private ones in terms of material, height, and reachable light distance. Calculation of the marginal effect, that is, the discrete change in the probability for the dummy variable *Public* as $P(Material = 1|\,Public = 1) - P(Material = 1|\,Public = 0)$ shows that public lighthouses were 35.2% more likely to be made of stone/metal than private ones. Also, the estimated coefficients on *Height* and *Light_distande* indicate that, on average, public lighthouses were 3.21 m higher and their reachable light distance was 7.82 km longer than private lights. This observation might seem obvious because the Meiji government constructed modern lighthouses at considerable public expense in response to pressure from the Western powers. The estimation results using all observations, columns 7–9, convey a similar finding, except for *Material*.

These results suggest that private and public lighthouses had similar technical profiles when considering those constructed in the Edo period, although the modern lighthouses constructed by the Meiji government were of significantly better quality than the private ones.

B. Location

We now investigate whether there was a difference in location between private and public lighthouses, because location is another important aspect of lighthouse quality.

Figure 1 illustrates the location of lighthouses constructed by private (left-hand side) and public (right-hand side) institutions. A close look at the two maps suggests that the lighthouses constructed by private entities were located along the three major shipping routes and that most of them are located at ports. However, public lighthouses were constructed at both ports and straits or capes.

Table 5 reports the location of founders' lighthouses. Lighthouses constructed in the Edo period are located at ports, with one exception, Hijirizaki lighthouse in Hiroshima Prefecture, which is still actively used. According to *To-myodai Nendo Hyo* in Koubu-sho, it was constructed by a domain head named Shichibei Okada in 1844 (1883, 3–10). Little is known about the operation of this lighthouse, but the location and what little information is available suggest that

TABLE 3
Summary Statistics for the Lighthouses Constructed in the Edo Period and the Early Meiji Era

	Lighthouses Constructed in Edo Period					Lighthouses Constructed in Early Meiji Era				
Variable	**Obs.**	**Mean**	***SD***	**Min.**	**Max.**	**Obs.**	**Mean**	***SD***	**Min.**	**Max.**
Material (wood)	23	—	—	—	—	52	—	—	—	—
(stone/metal)	18	—	—	—	—	37	—	—	—	—
Light_distance	41	6.6	5.5	0.04	31.5	89	17.5	11.2	.3.7	42.6
Height	41	4.9	2.0	1.5	9.1	89	8.7	5.7	1.2	30.0
Oil	41	40.4	48.4	0.5	229	89	216.9	299.4	4	1,337
Longevity	41	85.2	76.1	16	276	89	7.7	4.1	0	15
Sea_level	41	11.2	16.5	2.7	109.1	89	27.6	22.8	2.1	120.3
Rain	41	1,445.5	227.4	1,105.9	2,100.4	89	1,597.7	373.9	787.6	2,547.5
Wind_speed	41	3.2	0.7	2.2	3.8	89	3.1	0.7	1.8	5.7
Snow	41	20.1	17.4	5.5	109.2	89	30.2	33.8	2.6	124.9
Fog	41	5.3	3.1	1.3	12.2	89	8.3	9.3	1	43.7

Note: This table shows the summary statistics for the variables used in Model 1.

TABLE 4
Estimation Results for Model (1)

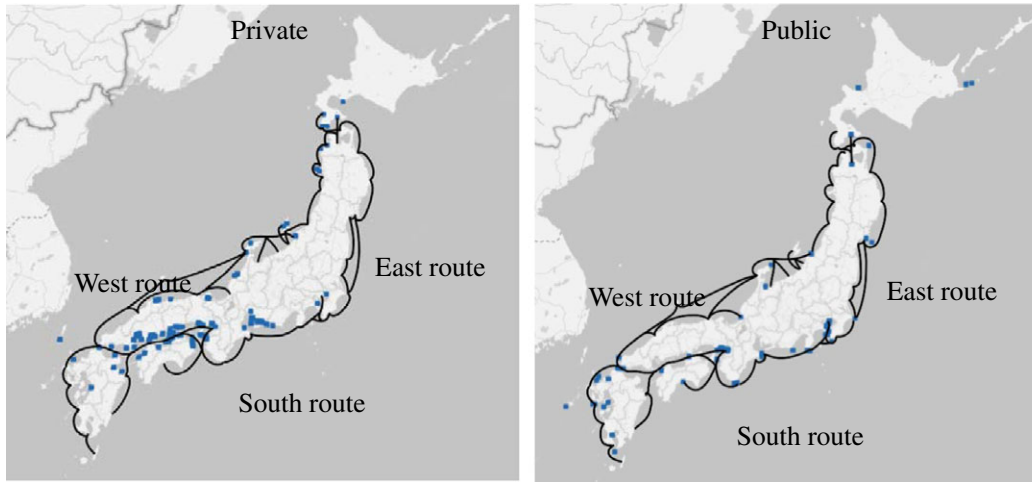
	Lighthouses Constructed in Edo Period			Lighthouses Constructed in Early Meiji Era			All Samples		
	(1) ***Material***	**(2)** ***Height***	**(3)** ***Light_distance***	**(4)** ***Material***	**(5)** ***Height***	**(6)** ***Light_distance***	**(7)** ***Material***	**(8)** ***Height***	**(9)** ***Light_distance***
Public	−0.6215	0.3070	1.9426	0.9281**	3.2146***	7.8217***	0.2407	1.7274**	5.2745***
	(0.6185)	(0.7413)	(2.7248)	(0.4337)	(1.0344)	(1.499)	(0.3046)	(0.6789)	(1.2875)
Longevity	−0.0014	−0.0048	−0.0130	0.0322	−0.2371*	−0.2589*	0.0021	−0.0175***	−0.0265***
	(0.0047)	(0.0043)	(0.0109)	(0.0532)	(0.1230)	(0.136)	(0.0023)	(0.0043)	(0.0093)
Oil	−0.0230	−0.0025	0.0180	0.0037***	0.0092***	0.0210***	0.0037***	0.0091***	0.0224***
	(0.0145)	(0.0080)	(0.0187)	(0.0013)	(0.0030)	(0.003)	(0.0010)	(0.0028)	(0.0035)
Sea_level	−0.0823	−0.0049	0.0542	0.0019	−0.0770***	0.0949***	−0.0032	−0.0541***	0.1061***
	(0.0520)	(0.0140)	(0.0420)	(0.0102)	(0.0197)	(0.032)	(0.0074)	(0.0156)	(0.0335)
Rain	−0.0017	−0.0029	0.0072	−0.0001	0.0021	−0.0000	−0.0001	0.0023**	0.0024
	(0.0015)	(0.0017)	(0.0062)	(0.0006)	(0.0013)	(0.001)	(0.0004)	(0.0010)	(0.0014)
Wind_speed	−0.1299	1.0449*	−0.1640	−0.5474	1.0840	−0.2949	−0.4396**	0.9958	−0.1755
	(0.4068)	(0.5710)	(1.8240)	(0.3395)	(0.7853)	(0.794)	(0.2154)	(0.6091)	(0.7317)
Snow	−0.0017	0.0018	−0.0648**	−0.0172***	−0.0028	−0.0322	−0.0159***	0.0020	−0.0186
	(0.0112)	(0.0104)	(0.0260)	(0.0048)	(0.0199)	(0.020)	(0.0041)	(0.0173)	(0.0194)
Fog	0.0521	−0.0522	−0.1946	0.0198	0.1968***	−0.0221	0.0173	0.1813***	−0.0103
	(0.0806)	(0.0803)	(0.2155)	(0.0192)	(0.0743)	(0.048)	(0.0172)	(0.0658)	(0.0463)
Observations	41	41	41	89	89	89	130	130	130
R-squared	—	0.189	0.158	—	0.438	0.823	—	0.447	0.772

Notes: Robust standard errors in parentheses. Results for constant terms are not shown.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

it should be regarded as an exceptional case. The lighthouse is located near Itsukushima, an island on which one of the most important Shinto shrines in Japan is located. The words carved on the lighthouse say it is an offering and request prayers for allegiance and national prosperity. Thus, this lighthouse might have worked as a votive lighthouse rather than a lighthouse for maritime safety. If we regard this case as an exception, all lighthouses were constructed at ports in the Edo period.

Turning now to lighthouses constructed in the early Meiji era, 58 lighthouses were constructed at ports and 31 were on the coast. Of the 31 nonport lighthouses, 29 were provided by the government. Only two were by provided groups of individuals, namely Seto and Sengenyama, located in Hiroshima and Chiba prefectures, respectively. The only available information about Seto lighthouse is that it was constructed by an unknown person, Tokubei Onishi, and five other people (Koubu-sho 1885, 146) and that it is located at one of the most dangerous straits in Seto Inland Sea, which has long been known as an accident-prone area because of its narrowness, rocky reefs, and fast tidal changes. However, more information is available about Sengenyama lighthouse's funding and operation. According to Koubu-sho (1885), Tsunekichi Katori and another person constructed a lighthouse in 1880

FIGURE 1
Location of Lighthouses Constructed by Private (Left) and Public (Right) Institutions



Note: The lines indicate the three major shipping routes in the Edo period: the South route (between Edo [Tokyo] and Osaka); the East route (between Mutsu [Tohoku district] and Edo); and the West route (between Dewa [Akita and Yamagata prefectures] and Osaka or Edo) (Yamakawa 2011). Each square spot indicates a lighthouse. Because the coordinates of latitude and longitude were not accurate in the original survey, *Koubu Toukei-shi*, we consulted various sources to specify the exact location of each lighthouse as accurately as possible.

TABLE 5
Founders' Lighthouse Locations

	Lighthouses Constructed in the Edo Period				Lighthouses Constructed in the Early Meiji Era			
Location	**Individuals**	**Domain Head**	**Bakufu**	**Total**	**Individuals**	**Prefecture**	**Government**	**Total**
Port	28	12	0	40	40	4	14	58
Not port	0	1	0	1	2	0	29	31
Total	28	13	0	41	42	4	43	89

Note: This table reports the location of founders' lighthouses. The definition of founders is the same as in Table 1.
Source: Koubu-sho (1884) and Koubu-sho (1885).

at a Shinto shrine named Oohijinja in Chiba Prefecture, with approval from the government.[20] Donations, which amounted to 420 yen, were collected from ship owners, fishermen, and villagers in a nearby coastal area.[21] The operation cost was about 334 yen per year, which consisted of 2.52 yen for lighting, 135.30 yen for fuel, 172.0703 yen for preservation, and 24 yen for salaries for lighthouse keepers.[22] Koubu-sho (1885) wrote that the fuel and other costs were funded by the interest generated from the donation every year (135), but the cost figures suggest that this interest was not sufficient to cover the entire cost, which must have been compensated for in some other way. From these observations, we regard this lighthouse as a charitable lighthouse and conjecture that the explanation by Van Zandt (1993) applies to this case: "While they did not have the support of the government to exclude free riders, they could call on a range of nonlegal social and religious sanctions to support their work. Particularly with respect to local lights, the social pressure to contribute to lights intended to protect the lives and livelihoods of family and friends must have been great. It also appears that the alms or beaconage dues

20. I would like to thank a staff member at the city government of Funabashi for answering my questions.

21. The list of donators' names is preserved at Oohijinja, according to the education board of the Funabashi city (Response to my personal question, May 10, 2017).

22. These figures come from Koubu-sho (1885, 135).

were not negotiated on a ship-by-ship basis but, instead, were either standard or based on a giver's desire to support the local religious charity that maintained the lighthouse. While it is impossible to determine whether these lighthouses had effective local monopolies, there is no indication that any of these charitable lights had any direct competition" (61).

To summarize, almost all lighthouses constructed by private sector entities were located at ports. There were some exceptional cases, but two of these involved charitable provisions and only in one case (Seto lighthouse) was a private sector lighthouse provided at a location other than a port. These observations indicate that private organizations had difficulties in providing lighthouses at coastal locations and that the public organizations played a significant role in compensating for this shortcoming of the market. As we will argue in more detail when considering Case 2 below, we contend that there are at least three factors that explain these findings: (1) port lights were repeatedly used by the same group of merchants, which enabled the lighthouse owners to identify the users and to collect fees, (2) the internal punishment system among the merchant coalition, called *kabu nakama*, compensated for the immature legal system and assisted in lowering the incentive to free ride, and (3) there was competition among ports to attract commercial ships, which resulted in strong incentives to provide lighthouses as local public goods.

V. CASES

In this section, we focus on two case studies that supplement the analyses so far. Case 1 investigates why and how one private lighthouse (Fukura lighthouse) was operated successfully over a very long period. Case 2 provides an example that supports our claim that location matters; it involves the efforts of an individual to construct a lighthouse at a strait, which was only able to be completed after an injection of government funds.

A. Case 1. Fukura Lighthouse

The first case study is an example of the private sector successfully providing a lighthouse. We examine Fukura lighthouse in Ishikawa Prefecture simply because it has the longest life of all the lighthouses in our data, but the data reveal that this case is particularly suitable for considering the meaning of "private" provision.

The origins of Fukura lighthouse began when a villager, Yoshisaburo Hino, made a smoke signal in 1608 (Koro Hyoshiki Kanrisho 1905, 29).[23] His descendants continued to produce a smoke signal and in 1693, Chobei Hino XI erected a simple lighthouse that burned canola oil in an oil paper sash that was placed on a base tower (Seto 2004, 125). It was then repaired and maintained by his descendants, and this operation continued for nearly 300 years until control of the lighthouse was transferred to the village in 1908. The lighthouse is famous for being one of the longest operating private lighthouses in Japan.

Fukura port became famous as part of a commercial shipping route, the West route, which had been established and prospered.[24] The main users of the port were wholesalers, called *kaisen ton'ya*, who operated ships called *kitamae bune* that traded daily commodities and sea products between Hokkaido and Osaka via the Japan Sea. A *kitamae bune* was comparatively large, with a capacity ranging from 90,000 to 180,000 L. A typical *kitamae bune* departed Hokkaido in late July, sailing south through the Japan Sea from August to October and arriving in Osaka in early November. There were no large consuming cities near Fukura port, but it was a relay point because its geographic location was ideal, with a natural harbor useful for avoiding storms or waiting for the wind. Sometimes sailors called into the port to obtain the sacred water at a shrine famous for providing protection against sea accidents or to meet prostitutes.

We investigated how and why the Hino family were able to operate Fukura lighthouse for such a long period. According to the history book of the town, Togi Machi (1974, 968–77), the lighthouse service began when a smoke signal on a rock was welcomed by ships because it helped to reduce navigational hazards at night. An important event occurred when two magistrates, Ito and Maeda, visited the port and heard about the family's provision of a lighthouse service in March 1653. They reported what they found to the retired domain head, Toshitsune Maeda, and gave the Hino family an official document, including the signatures and stamps of the two magistrates, that praised its long-standing lighting service (Togi Machi 1974, 971).

23. Seto (2004) traced Hino's genealogy back and argued that the founder should be Notonosuke Sukenobu rather than Yoshisaburo Hino (126).

24. The information about Fukura port comes from Tagawa (1991) and Seto (2004).

The role of the public authority is similar to the role of Trinity House in England in issuing patents. As Van Zandt (1993) explained, each patent "granted to the entrepreneur the exclusive right for a term of years to build and maintain a lighthouse for a specific area in exchange for a fixed annual rent" (65). Although the public authorities did not issue any patents in premodern Japan, the authorities' official endorsement played essentially the same role as a patent. However, it is still not clear why the local government provided a certificate of lighthouse service provision. It could be simply because the authority wanted to encourage the public service by praising the activity, or because Fukura lighthouse was in financial difficulty because of the free-rider problem and the authority wished to improve this situation.

As for lighthouse fees, no information is available until 1692, which probably means that the lighthouse was operated independently by the Hino family without any assistance from the local government. According to Togi Machi (1974), Chobei Hino XI reported that the family charged one *bu* per sailor per year in 1692 (968). This is the first available information about fees for Fukura lighthouse. Later, in 1739, the fee was raised to two *bu* in silver per sailor per year. In 1815, the same amount was charged per sailor per arrival in harbor and later Chobei Hino XVII raised it to 50 *mon* per sailor per year (Tagawa 1991, 112).[25] According to Koubu-sho (1885), from the first lighting, average revenue was 90 yen/year, while the total cost of operation was 48 yen/year, suggesting that profits were generated by the operation of the lighthouse.[26]

The fact that Fukura lighthouse was a private facility, at least at the beginning, and that the operation generated positive profits suggests that there may have been competition among port operators along the shipping routes to construct an attractive lighthouse and to collect light dues from the users.[27] The provision of a lighthouse service at a port is likely to satisfy the key assumptions regarding local public goods provision, in that there were many ship owners and they were certainly fully mobile. A lighthouse being a local public good is a possible explanation for the existence of many private lighthouses in premodern Japan.

An important issue that we must consider is what enabled the Hino family to mitigate the free-rider problem. Although the local government endorsed the family's lighting service, this does not necessarily mean that the family was unaffected by the free-rider problem; the opportunity for ship owners to free ride still existed. We argue that at least two factors played a significant role in mitigating the free-rider problem. First, the port was repeatedly used by the same group of large wholesalers. Because the number of wholesalers was limited and each wholesaler was easily identifiable, the Hino family was able to collect dues from ship owners. At some ports, wholesaler lists and detailed transaction content information were recorded on documents called *kyakusen cho*. Repeated transactions with the same group of wholesalers should have reduced the incentives to avoid paying the light dues and enhanced cooperation, as explained by repeated-game theory and laboratory experiments (see, for instance, Fehr, Gachter, and Kirchsteiger 1997; Fehr and Gachter 2000). In addition, the continuing growth of the West route suggested large future profits, which further reduced the incentive to free ride.

Second, as discussed by Okazaki (2005), *kabu nakama*, a coalition of merchants who were given licenses for business by the public authorities, may have contributed to the enforcement of contracts.[28] As mentioned in Section II, although Japan in the Edo period had no formal business laws or officially sanctioned business practices, important components of the maritime law were strongly influenced by common practices among wholesalers in ports.[29] *Kabu nakama*, often formed by the same industry peers, had various punishments for members who committed fraudulent activities, such as default of contract.[30]

25. Three types of currencies were used in the Edo period; gold, silver, and coins. *Bu* and *mon* were the units for silver and coins, respectively. Because the conversion rate between the two units always fluctuated, the relationship between *bu* and *mon* is not clear.

26. The salaries of lighthouse keepers were not described, perhaps because the lighthouse was operated as a family business. If we assume that the salary of the lighthouse keeper at Fukura lighthouse was 32 yen/year, which was the salary of the lighthouse keeper of the second longest-lived lighthouse, Wakayama lighthouse, then Fukura lighthouse still earned a profit.

27. An investigation of our survey dataset suggests that private lighthouses, such as Wajima (Ishikawa), Shikama (Hyogo), Futami (Hyogo), and Takasago (Hyogo) lighthouses also generated positive profits.

28. For more information about *kabu nakama*, see Section 3 of Okazaki (2005). This view of the merchants' coalition originally comes from Greif (1993) and Greif, Milgrom, and Weingast (1994), who argued that the European medieval *merchant guilds* helped to enforce contracts.

29. Ohtake and Maki (1975, 220).

30. From a theoretical viewpoint, Pöder (2010) argued that "besides a reward system, some kind of punishing mechanism for ship owners is also needed" (343).

Such a coalition could have enabled the Hino family to successfully collect lighthouse dues, and this is supported by evidence from laboratory experiments, such as Ostrom, Walker, and Gardner (1992) and Bochet, Page, and Putterman (2006). Thus, there were fortunate conditions influencing Fukura lighthouse that helped mitigate the free-rider problem and may have contributed to its survival for nearly 300 years. This observation suggests that a lighthouse can be operated without any social and religious sanctions. As Van Zandt (1993) argued in the case of medieval and early modern lighthouses, "a range of nonlegal social and religious sanctions" (61) supported lighthouse operation.

B. Case 2. Shirasu Lighthouse

The second case study, on Shirasu lighthouse, illustrates a case in which the private sector failed to provide a lighthouse despite the strong need for one. It provides concrete evidence that location matters, as discussed in Section IV, and that various factors other than location also influence the availability of a private lighthouse.

Shirasu lighthouse in Fukuoka Prefecture is famous for its story of Sukezaemon Iwamatsu (1804–1872), who was concerned about the many sea accidents in the Shirasu area and desired to construct a lighthouse. For 10 years, he struggled to collect enough donations, but he was only able to build the base before he died, and it was only after a government subsidy was introduced in 1871 that the construction of the lighthouse was realized. The story is famous among prewar school students because it was included in the textbooks of elementary school students published in 1931 and 1938 as a biography of a great man.[31] We consider this case not as an example of a heroic person, but as an example in which the market did not work well enough for a private individual to construct a new lighthouse, despite his earnest efforts and the substantial demand for a lighthouse.

The story is as follows. The Shirasu area is located at the entrance of Kanmon Strait. Many ships from abroad or from domestic cities along the coast of the Japan Sea enter and depart the strait; according to the Fukuoka Prefecture Educational Office (1939), over 20,000 ships per year passed the strait at the end of the Edo period.[32] The area is shallow with rocky reefs and many ships have been wrecked on the reefs. Indeed, the area is so dangerous that it was used for national defense.[33] Because of his concern about the numerous sea accidents in the area, Sukezaemon Iwamatsu initially asked the local domain to build a lighthouse, but this request was unsuccessful. He then decided to use his private fortune to fund the project but, because his funds were well short of the estimated cost of the lighthouse, he asked for voluntary contributions from the shipping merchants and residents in the area. As noted above, he attempted to raise sufficient funds over a 10-year period but, at the time of his death, only the base had been constructed, and it was only after the government injected public funds that the lighthouse was completed.

We raise two questions regarding this case. First, we ask, was the lighthouse necessary? If the lighthouse was not required, failing to construct a lighthouse does not constitute a market failure. Second, why did Sukezaemon Iwamatsu fail to construct a new lighthouse? The standard economic answer to this question concerns the free-rider problem but, as we will see, it seems that other factors played an important role.

To answer the first question, the benefits of a new lighthouse clearly exceeded the cost of constructing one. Shallow water and hidden rocks mean that the Shirasu area is one of the most dangerous coastal areas in west Japan. Although we do not have accident data during the Edo period, data on major sea accidents for the period 1872–1882 show that even after the construction of Shirasu lighthouse, 13 sea accidents occurred around Shirasu lighthouse in these 10 years, resulting in the loss of four lives and various commodities, such as soybeans and caustic lime.[34] Therefore, we conclude that a lighthouse was needed for the Shirasu area.

Next, we ask why Sukezaemon Iwamatsu failed to construct a new lighthouse. His biography, published by Fukuoka Prefecture Educational Office (1939), listed several groups that prevented him from financing the construction of the lighthouse.[35] First, some people opposed a lighthouse because they benefited from the ship

31. Tanigawa (2016, 20).

32. Yonezu (1963, 5).

33. Fukuoka Prefecture Educational Office (1939, 16, 20).

34. These figures come from the table in Koubu-sho (1884) volume 1 (129) that shows the details of the shipwrecks near lighthouses.

35. Fukuoka Prefecture Educational Office (1939) also mentioned the possibility that construction of a lighthouse in the Shirasu area was opposed to prevent invasion by foreign ships (16).

accidents. When a maritime accident occurred, people living near the accident site had a chance to obtain floating debris and others had the opportunity to work as sea rescuers. Because Shirasu was located along the West route and many ships ran aground on the rocks, sea disasters would have benefited these people considerably. According to Fukuoka Prefecture Educational Office (1939), some people regarded wrecked ships as the only way to make their living. There would have been strong incentives for these people to oppose the construction of a new lighthouse. Many of those concerned came from 14 families in Aijima, 160 in Nagahama, and 100 in Hiramatsu.

People living in other ports also opposed the construction of a new lighthouse. The construction of a lighthouse would have made Shirasu port a safer and more attractive harbor, which would have made it difficult for the other ports to attract ships. This situation resulted in even more people who opposed a lighthouse in Shirasu.

When compared with Fukura lighthouse, an important difference is that the users of Shirasu lighthouse were more heterogenous than those of Fukura lighthouse. As we have noted, the users of Fukura port were mainly the wholesalers at the port who repeatedly used it and formed a coalition called *kabu nakama*, which made it difficult for a member merchant to engage in dishonest activities. The lighthouse keeper was able to obtain detailed information about sailing and trade. In contrast, Shirasu lighthouse was located on a strait through which many anonymous ships passed, and it was to be constructed on a rocky reef that was roughly 5 km off the coast.[36] These features could have made it impossible to identify the users and collect light dues.

VI. CONCLUSION

Using the nationwide lighthouse survey conducted in 1883 at the request of the government, as well as various other sources, this paper analyzes how lighthouses were provided in the premodern Edo period and the early Meiji era in Japan, with a specific focus on the role of the private sector. We found that private organizations provided a significant portion of lighthouses and that they compared well with public lighthouses in terms of their technological aspects during the Edo period—although the modern lighthouses built by the Meiji government were substantially better. We found that several factors helped to surmount the free-rider problem, such as repeated use by the same group of merchants and the internal punishment system among the merchant coalition. The competition among port operators to attract ships might have also contributed to the provision of better lighthouses. However, analysis of the location of lighthouses indicates that almost all private lighthouses were located at ports along the major shipping routes and that coastal lighthouses were very few, which is a significant limitation on the private provision of lighthouses. Our second case study suggests this is because, at a strait or cape, the heterogeneity and anonymity of the potential users made it difficult to identify the users and collect light dues. Finally, our first case study raises an important caveat about the use of the word "private," which suggests that the public authorities sometimes provided an endorsement that might have had the same effect as a patent and may have contributed to prolonging the life of a private lighthouse. To summarize, private organizations made a significant contribution to enhancing navigational safety in premodern Japan, but they often failed to provide a lighthouse despite a strong need for one. Public provision of lighthouses after the opening of the country might have compensated for the shortcomings of the market and contributed to underpinning the globalization process, as discussed by Bickers (2013) in relation to the Chinese experience.

We conclude the paper with an important issue that is not fully addressed in the literature. Although we have showed that markets sometimes fail to provide sufficient lighthouse services, the failure of the market does not necessarily mean that government intervention is a panacea, and it can even create a significant amount of inefficiency. One important advantage of the private sector was its ability to identify locations where lighthouses were required. As we mentioned, with the commencement of the Meiji era in 1868, the government created a department called *todai kyoku*, and invested a significant amount of money in the construction of modern lighthouses. However, initially at least, the public lighthouses did not reflect domestic demands. Fujioka (2015) wrote that "(i)n November 1884, the Ministry of the Navy and the Ministry of Agriculture and Commerce submitted a report to the Ministry of Industry regarding the selection of lighthouse construction

36. Therefore, whether the location is a strait or a harbor could also matter for the availability of a private lighthouse.

locations. In the report, there was criticism for the selection of the existing lighthouse locations that favored the intentions of foreigners or provincial governors. There was also an attached list of locations that required lighthouses, accompanied by six-level evaluations based on the degree of urgency. This indicates that the previously built lighthouses did not meet domestic demands, and the extent to which lighthouses were valued for the safe navigation of ships, because these were virtually the only reliable means of transporting humans and goods" (135–7).[37] This observation reminds us of the "local knowledge problem" discussed by Hayek (1945).

With the advent of radar and global positioning systems, the traditional role of lighthouses is no longer required. However, the advantages and disadvantages of the market and government intervention discussed throughout the paper can contribute to the appropriate allocation of roles between the public and private sectors in considering how to provide goods and services with various characteristics.

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37. Coase (1974) also referred to the problems associated with public production. He described how Trinity House was reluctant to build a new lighthouse after having established two lighthouses at Caister and Lowestoft. Coase cited relevant people, including G. G. Harris, as follows: "With the completion of the lighthouse at Lowestoft, the Brethren rested content and did no more … when in February 1614 they were asked to do something positive, and erect a lighthouse at Winterton in response to a petition by some three hundred shipmasters, owners and fisherman, they seem to have done nothing. Failure to respond to demands of this sort not only shook confidence in the Corporation; since there was a prospect of profit, it was tantamount to inviting private speculators to intervene. They soon did so" (363–4).

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